APPENDIX B
RANKING OF FIRE-RESCUE ISSUES BY CITIZENS OF THE COUNTY'S REGIONAL SERVICE AREAS

	Composite Rankings by Regional Service Area				
Fire-Rescue Issue	**Western Communities**	**Silver Spring**	**East-County**	**Mid-County**	**Up-County**
Emergency Medical Services	1	1	1	1	1
Residential Fires	4	1	2	4	4
High-rise Fires	2	1	9	7	N/A
Fires in Businesses, Institutions and Community Buildings	3	1	6	8	3
Woodland/Brush Fires	N/A	N/A		N/A	8
Water Supply in Areas Lacking Fire Hydrants	N/A	N/A	10	N/A	6
Pedestrian Safety	7	2	7	3	
Homeland Security	6	3	5	6	10
Preparedness for Weather-related Emergencies		2	4	5	
Response Time	5	1	3	2	2
Level of Staffing	8	2	8	10	5
Public Education on Fire Safety and Injury Prevention		2			
Fire Code Inspections and Enforcement		2			
Providing Service to Populations Having Special Needs		2			9
Impact of New Development on Service Delivery	9	3		9	7
Impact of County's New Residential Sprinkler Ordinance		3			
Impact of County's Fiscal Crisis on Fire-Rescue CIP Projects	10	3			

Note 1: Surveys issued to the five Citizen Advisory Boards (CABs) were tailored to each Regional Service Area (RSA); thus the list of issues was slightly different from area to area although most issues were identical. For example, CABs in RSAs having rural characteristics were given surveys including issues concerning rural water supply and woodland/brush fires, whereas surveys for CABs in RSAs having urban characteristics did not include these issues but did include high-rise fires.

Note 2: The Silver Spring CAB chose to rank all issues within 1st, 2nd or 3rd priorities

APPENDIX C

ANNUAL FIRE DEATH RATES IN MONTGOMERY COUNTY OVER 30-YEAR PERIOD

1972-2002

Year	# Fire Deaths	County Population	# Deaths/100,000 Residents
1972	13	544,900	2.4
1973	11	561,100	2.0
1974	6	579,600	1.0
1975	16	589,400	2.7
1976	10	585,800	1.7
1977	11	581,100	1.9
1978*☜	6	579,100	1.0
1979	11	578,300	1.9
1980	5	579,100	0.9
1981	6	585,000	1.0
1982	8	593,000	1.4
1983	6	600,000	1.0
1984	6	610,000	1.0
1985	0	628,000	0
1986	10**	645,000	1.6
1987	5	680,000	0.7
1988	2	710,000	0.3
1989	4	735,000	0.5
1990	7	757,000	0.9
1991	5	765,000	0.7

1992	3	773,000	0.4
1993	4	785,000	0.5
1994	11	798,000	1.4
1995	10	810,000	1.2
1996	14***	822,800	1.7
1997	8	829,400	1.0
1998	3	842,900	0.4
1999	4	854,100	0.5
2000	6	869,500	0.7
2001	11	886,000	1.3
2002	8	903,000	0.9
Totals/Averages	230 (Avg 7.4/yr)	N/A	Avg 1.15/yr/100,000 residents

* Montgomery County's Residential Smoke Detector Law became effective in 1978
** Includes 6 fatalities in a house fire in Boyds
*** Includes 8 fire-related fatalities from a MARC train wreck in Silver Spring

<u>Note 1</u>: Fire death rates were rounded to the nearest tenth (0.1), and population figures were rounded to the nearest 100.

<u>Note 2</u>: Average annual fire death rate for the 6-year period (1972-77) prior to the smoke detector law becoming effective was 11.2 deaths per year, compared to a rate of 6.8 deaths per year after the effective date of the law (i.e., 1978-2002). These statistics indicate that the average annual fire death rate dropped by nearly 40% when comparing the latter time period to the earlier time period.

<u>Note 3</u>: When considering county population increases between 1972 and 2002, the average annual fire death rate **per 100,000 residents** was 1.95 prior to the smoke detector law becoming effective (i.e., 6-year period of 1972-77) compared to an average annual rate of 0.96 deaths per 100,000 residents per year after the effective date of the law (i.e., 1978-2002). These statistics indicate that the average annual fire death rate **per 100,000 residents** dropped by almost 51% when comparing the latter time period to the earlier time period.

<u>Data Sources</u>:
Annual fire death history (2nd column above) provided by Montgomery County Fire & Rescue Service
Annual population figures (3rd column above) provided by Maryland-National Capital Park & Planning Commission

APPENDIX D
INCIDENT PROBABILITIES AND AREA OF IMPACT IN MONTGOMERY COUNTY

	← Probability of Occurrence on **Daily** Basis →					
Incident Type	Very High	High	Medium	Low	Very Low	Impact Area[1]
BLS, one patient, non-PIC	X					L
ALS, one patient, non-PIC	X					L
PIC, one patient	X					L
PIC, multiple patients	X					L
Structure fire		X				L
Vehicle fire		X				L
Brush/woods/mulch fire		X Summer	X Winter			L
Rubbish/debris fire		X				L
Hazardous condition[2]		X				L
Destructive device			X			L
Suspicious package			X			L
HazMat, fixed facility			X			L
HazMat, in transport			X			L
Water rescue			X Summer		X Winter	L
PIC, bus, w/ mass casualties			X			L
Thunderstorm, w/o tornado			X Summer		X Winter	L-C
Snow/ice storm, w/o blizzard			X			C
Extended temperature extreme			X			C
Extended drought			X			C
Pipeline leak/fire				X		L
Hurricane				X		C
Tornado				X		L
Blizzard				X		C
Flooding				X		L-C
Rescue, structural collapse				X		L
Rescue, confined space				X		L
Rescue, high angle				X		L

Note: All incident types are <u>non-terrorism related</u> unless stated specifically as terrorism

[1] L - Locally C – County-wide L-C Locally or County-wide

[2] Includes incidents such as downed/arcing wires, downed trees, natural gas leak, electrical short, odor of smoke, unknown odor, lockout with food on stove, etc.

Incident Type	**Very High**	**High**	**Med.**	**Low**	**Very Low**	**Impact Area**
Metro Rail incident				X		L
Passenger train incident				X		L
Passenger airline incident				X		L
Terrorism, WMD[3]				X		L-C
Terrorism, other (i.e., non-WMD such as shootings)				X		L-C
Utility disruption, water				X		L
Utility disruption, power				X		L
Utility disruption, gas				X		L
Utility disruption, phone				X		L-C
Pollution emergency			X Summer	X Winter		C
Disease/health epidemic				X		L-C
Civil disturbance				X		L-C
Commodity shortage				X		C
Dam failure					X	L
Earthquake					X	C
Sinkhole					X	L
Mudslide					X	L
Conflagration					X	L
Act of war					X	C

L- Locally
C- County-wide

Note: All incident types are <u>non-terrorism related</u> unless stated specifically as terrorism

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[3] Weapons of Mass Destruction – biological, radiological, nuclear, incendiary, chemical, and/or explosive weapons used by terrorists. The likelihood of nuclear terrorism (i.e., involving nuclear fission and nuclear blast) is remote whereas the likelihood of radiological terrorism (e.g., “dirty bomb”) is much higher.

APPENDIX E
Hazardous Material Incidents 1990 – 2002

	1990 – 1999										2000-2002			
Incidents Type	90	91	92	93	94	95	96	97	98	99	00	01	02	Tot
Explosives			**3**			**2**	**8**	**5**	**41**	**21**	**14**	**29**	**19**	**142**
Gases	**1**	**2**			**7**	**16**		**14**	**8**		**4**	**4**	**14**	**70**
Flammable and Combustible Liquids / Solids	**46**	**37**	**47**	**50**	**51**	**27**	**27**	**33**	**54**	**50**	**45**	**64**	**34**	**565**
Oxidizer and Organic Peroxides				**1**	**4**		**2**	**5**	**4**	**3**	**2**	**1**		**22**
Toxic	**11**	**27**	**19**	**11**	**19**	**22**	**6**	**13**	**25**	**17**	**36**	**75**	**49**	**330**
Radioactive					**1**							**2**		**3**
Corrosive	**2**	**3**	**3**	**6**	**6**	**6**	**1**	**6**	**8**		**1**	**10**	**5**	**57**
Miscellaneous	**5**	**8**	**31**	**8**	**35**	**27**	**24**	**12**	**7**	**6**	**13**	**31**	**25**	**232**
Avg. Total 109.3	**65**	**77**	**103**	**76**	**123**	**100**	**68**	**88**	**147**	**97**	**115**	**216**	**146**	**1421**
%	**4.6**	**5.4**	**7.2**	**5.3**	**8.7**	**7.0**	**4.8**	**6.2**	**10.3**	**6.9**	**8.1**	**15.2**	**10.3**	**100**
495 65%	**4**	**5**	**11**	**9**	**2**	**6**	**4**	**2**	**12**	**7**	**2**	**4**	**6**	**79**
270 32%	**1**	**1**	**5**	**2**	**6**	**2**	**4**	**3**	**1**	**5**	**1**	**4**	**4**	**39**
370 3%			**1**		**1**		**1**	**1**						**4**
Total	**5**	**6**	**17**	**11**	**9**	**8**	**9**	**6**	**13**	**12**	**8**	**8**	**10**	**122**

APPENDIX F
STATUS OF WATER SUPPLY STUDY RECOMMENDATIONS

A significant number of the recommendations presented in the Water Supply Study (dated April 2000) have been implemented or their implementation was in progress as of 2003.

The following Water Supply Study recommendations have been <u>fully implemented</u>:

a. The legislation to mandate **sprinkler systems in new single-family detached dwellings** became effective on January 1, 2004.

b. **3500-gallon tankers** have been placed in service at Fire Stations 4 (Sandy Spring), 9 (Hyattstown), 30 (Cabin John) and 31 (Rockville-North Potomac).

c. In 2002 and 2003, the pumps on all 65 front-line and reserve engines were tested. **Pump testing** will continue on an annual basis.

d. Annual **testing of hose** is being accomplished.

e. From 2003 onward, all new engines will be equipped with **1500 gpm pumps**.

f. The **specifications for new tankers have been standardized**, including elliptical-shaped tanks and electronic dump controls such as those on Tankers 14 and 17.

g. Coordination has been accomplished with the SHA to include **dry vertical standpipes** on all future overpasses and interchanges along limited-access highways. The planned overpasses along Route 29 are designed to include dry standpipes.

h. MCFRS Interim Directive 03-13 established a **comprehensive new policy for water supply** in both rural and urban areas of the County.

i. **Tankers** have been assigned to the structure fire response assignment for all streets lacking fire hydrants.

j. Suppression forces are now able to deliver at least **3000 gpm for townhouses, garden apartments** and other groups of dwellings. This capability is largely due to utilization of large diameter supply lines.

k. The concept of the **"Water Supply Task Force"** (i.e., 2 tankers, a pumper deployed at a water fill site, and a water supply command officer) has been implemented through issuing of MCFRS Interim Directive 03-13.

l. Under the assumption that mandatory water restrictions would be imposed quickly on all WSSC customers when their water pumping/filtration plants were shut down, there appears to be sufficient gravity tank capacity in the WSSC system to accommodate fire suppression demand during short-term **water system shut-downs**. The stored water capacity of the Rockville and Poolesville water systems is not believed to be equally robust as that within the WSSC system.

m. The FRC has taken action to **correct non-compliance with EMBRS** on the part of a few LFRDs and to correct the process for estimating fire loss.

n. MCFRS has, and will continue to take, steps to **improve the working relationships** with the three municipal water authorities serving the County.

As of 2004, the following *2000 Water Supply Study* recommendations were <u>in the process of being implemented or had been partially implemented</u>:

a. Legislation was being developed to require **retrofitting of existing high-rise apartment buildings lacking sprinkler systems** with automatic sprinkler protection. The Fire Code Enforcement Office was working cooperatively with owners of these high rise apartment buildings, and their association, to draft language and requirements acceptable to all parties.

b. Equipping all MCFRS pumpers with **standard hose and hose appliances** had been partially completed in 2004. Efforts to complete this action were underway.

c. The capability for providing a **fire flow of 500 gpm for the initial 30 minutes** of a structure fire anywhere in the County had not yet been fully realized. This capability, however, was attainable in approximately 90% of the County. The exception was the non-hydranted rural areas primarily located on the extreme periphery of the County.

d. Establishing **ISO-certified drafting points** throughout non-hydranted areas was in progress but had not yet been completed.

e. An assessment of the **MCFRS Class B foam capabilities** has been completed, and it offers recommendations for greatly enhancing these capabilities. By 2004, these recommendations had not yet been addressed, nor had a County-wide Class B foam strategy been fully developed.

f. Although a **comprehensive MCFRS-wide risk analysis** of station first due response areas, or fire box areas, has not been conducted as of 2004, a firefighter assigned to the Code Enforcement Office was in the process of completing a database of target hazards throughout the County. When completed, the database will assist in planning efforts as well as operational strategy in response to incidents involving these fire and EMS target hazards. The database will also be used for homeland security purposes. This database, based upon research by this lone individual, will contain much of the risk assessment information that would have otherwise been obtained had a large number of MCFRS personnel participated. In the future it is anticipated that all MCFRS personnel will be asked to contribute to this effort so that all risks and target hazards throughout the County are completely identified and assessed.

g. The MCFRS continues to monitor and influence the expansion and **looping of water mains** in the Clarksburg and Damascus areas. This activity will continue until these WSSC water expansion projects are completed.

h. All but one front line engine had been outfitted with **4-inch diameter supply lines** in 2004, and the lone engine was to be outfitted in 2005. A small percentage of reserve engines had been equipped with 4-inch supply hose by 2004, as well.

As of 2004, efforts to implement the following *2000 Water Supply Study* recommendations had <u>not yet been initiated</u> due to higher MCFRS priorities and/or funding issues.

a. A **reserve tanker** had not yet been acquired in 2004. Engines 41, 141 and 331 had not yet been replaced with **engine-tankers** due largely to repeated deferral of apparatus purchases. [Rather than replacing Engines 41, 141 and 331 with engine-tankers, the MCFRS will likely purchase CAFS-equipped pumpers to replace these engines as part of a new strategy to deploy CAFS-equipped pumpers in stations located within rural and suburban/rural interface areas of the County.]

b. As of 2004, only one frontline engine had not yet been outfitted with **4-inch large-diameter supply lines**. Engines without 4-inch hose carry 3-inch to 4-inch adapters, enabling 3-inch supply lines to be connected to other engines' 4-inch supply lines when necessary. The replacement of supply hose has been funded entirely by Senator Amoss funds provided by the State to each LFRD.

c. The purchase and deployment of a pumper equipped with a **compressed-air foam system**, (as a pilot test), had not occurred by 2004. [A pilot test will not be conducted by MCFRS, as substantial effectiveness/efficiency information is available from fire departments throughout the U.S. that have used CAFS-equipped engines as frontline units for up to six years.]

d. Although attempts have been made by MCFRS to address the problem with the State Highway Administration, as of 2004, the SHA had not performed needed **maintenance to standpipe connections through sound barriers** along interstate highways.

e. As of 2004, there had been no progress made in the **identification of alternate water supply sources** by means of reflective signs along roadways in the vicinity of the water sources.

f. By 2004, the MCFRS has not adopted tactical use of **dry vertical standpipes** to establish expanded water supply relays on limited-access highways because these systems have not yet been installed by the SHA. When these dry vertical standpipes are in place at new interchanges along Route 29 and other future locations, the MCFRS will adopt an SOP for their use.

g. As of 2004, a pilot test has not yet been conducted to assess **fire hydrant marking systems**, although a few ideas for pilot testing had been identified (see Section 4, "Apparatus and Equipment" heading).

h. While **GIS hydrant maps** had been completed, the maps had not been placed onto the mobile data computer system in MCFRS apparatus as of 2004. This action is expected to occur between 2005 and 2006.

i. By 2004, the MCFRS had not developed an **inspection procedure** for use by in-service fire-rescue units based upon NFPA Standard 25-“Standard for the Inspection, Testing and Maintenance of Water Based Fire Protection Systems.” Presently, in-service units simply check (during inspections) the maintenance and testing records of sprinkler systems and fire pumps kept by building managers.

j. As of 2004, the program to expand the use of **dry hydrants**, incorporating guidelines set forth in NFPA Standard 1142, (formerly NFPA 1231 as referenced in the *2000 Water Supply Report*), had not begun.

k. As of 2004, no progress had been made in coordinating the review of **hydrant flow records** with the three municipal water authorities operating in Montgomery County – WSSC, City of Rockville, and Town of Poolesville.

l. By 2004, no progress had been made in encouraging WSSC to improve **maintenance of hydrants** and in improving the process whereby WSSC notifies the MCFRS when WSSC hydrants are out of service.

The problems associated with the use of the **horizontal dry standpipe running the length of the American Legion Bridge** had been determined to be too great to attempt to address them in a cost effective and tactically feasible manner. Other water supply strategies for fighting fires on this bridge (e.g., water shuttle involving tankers) need to be examined and exercised.

APPENDIX I

COMPRESSED-AIR FOAM

WHAT IS COMPRESSED-AIR FOAM?

Compressed-air foam (CAF) consists of Class-A foam concentrate, water and compressed air. Class-A foam concentrate is a chemical additive that, when mixed with water, forms a foam solution that is more effective than water alone in suppressing fires. By adding compressed air to Class-A foam by means of a CAF System (CAFS), the foam's effectiveness is much greater. The air compressor provides energy to propel the foam farther than aspirated or standard water nozzles.

To produce CAF, a foam-proportioning system is used to generate the desired Class-A foam solution of water and Class-A foam concentrate. Compressed air is then injected into the solution on the discharge side of the pump. As the foam solution and compressed air travel through the hose line, they mix to form a light-weight, frothy foam that coats burning materials and can cling to vertical surfaces such as walls. The CAF extinguishes burning Class-A material[4] by cutting off the supply of oxygen to the fire and cooling the burning material.

CAFS produce foam ranging in consistencies from wet to very dry; therefore, the ideal foam type can be applied to each type of fire and to each tactical phase of the fire suppression operation to maximize effectiveness. IFSTA categorizes foam consistencies for Class-A Foam that has been generated into five types as follows:

- Type 1 Foam (Very Dry). The air to foam solution ratio is 44:1. Proportioning rates are between 0.6 and 1.0 percent. Finished foam proportioned at this rate will produce a very "dry," fluffy-textured blanket of foam that easily clings to vertical surfaces and will be slow to drain, but it can be adversely affected by winds.

- Type 2 Foam (Dry). The air to foam solution ratio is 22:1. The foam is proportioned at rates between 0.5 to 0.6 percent. The finished foam will have a consistency close to shaving cream. This foam will not immediately run on vertical surfaces, but will drain quicker than Type 1 foam.

- Type 3 Foam (Medium). The air to foam solution ratio is 15:1. Foam is proportioned at rates between 0.3 and 0.5 percent. This foam will have the consistency of watery shaving cream and will not readily cling to vertical surfaces. Type 3 foam is

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[4] Class-A fires involve ordinary combustibles such as wood, paper, vegetation, fabric, etc.

considered the best compromise for all-around use if switching to different foam consistencies during suppression operations is not desired.

- Type 4 Foam (Medium-Wet). The air to foam solution ratio is 11:1. Proportioning rates are between 0.2 and 0.3 percent. This finished foam will have little if any body or shape. The very fluid consistency has an excellent ability to penetrate porous materials.

- Type 5 Foam (Wet). The air to foam solution ratio is 8:1. Foam is proportioned at rates of 0.1 to 0.2 percent. This is very watery and will readily run off of vertical surfaces. This consistency is generally considered best for overhaul operations.

ADVANTAGES OF CAF IN FIRE SUPRESSION

Effectiveness:
1. Up to 5 times more effective than water alone
2. Far less water is required to extinguish the fire
3. Penetrates fuels more effectively than water to reach deep-seated fires
4. Forms a vapor barrier around fuels to choke off oxygen supply to the burning fuel
5. Absorbs heat more rapidly than water
6. Faster knockdown to contain the spread of fire
7. Reduces the potential for rekindle
8. Can be pumped twice as high as water under equal pressure
9. CAF is visible to firefighters so they can see where it has been applied
10. Coats wood, metal, concrete, brick, glass and vegetation
11. Clings to vertical surfaces
12. Seals in products of combustion

Improved Safety:
1. Longer streams can be produced, allowing greater distance between firefighters and the fire
2. Greatly reduces the weight of hose lines
3. Reduces the chance of structural collapse from accumulated water
4. Reduces the production of smoke and steam
5. Lowers the risk of heat stress during interior attack
6. Reduces on-scene time, resulting in less fatigue and less opportunity for injury

Reduced Property Damage:
1. Reduces water and smoke damage to structures and their contents
2. Greatly reduces the potential for flooded lower floors of the fire building
3. Reduces contaminated water runoff to the environment
4. Aids fire investigators by preserving more evidence

Reduced Damage to Apparatus and Equipment:

1. Fewer water refills of tankers and other apparatus results in less wear and tear on these units
2. Reduces pressure drop in hose so pump can operate at a lower discharge pressure, resulting in lower engine RPM and less wear
3. Reduces loading on aerial devices from the weight of filled waterways for elevated master streams

DISADVANTAGES OF CAF

1. Additional expense when purchasing new suppression units equipped with CAFS
2. Expense of Class-A foam concentrate over life of each CAFS-equipped unit
3. Increased maintenance costs for pump and air compressor
4. Produces a large pressure thrust when nozzle is first opened
5. When not fully pressurized, CAF hose lines may kink
6. CAF creates slippery surfaces that could result in falls and injuries to firefighters
7. Full protective gear must be worn when working in the vicinity of CAF as it can cause eye and skin irritation, respiratory problems, and diarrhea (if ingested).
8. May encourage firefighters to use smaller hose lines or lower flow rates than that required. [Use of CAF still requires appropriately sized lines and flow rates.]
9. Runoff, if any is generated, can kill fish and other aquatic animals due to its impact on the surface tension of water. [It is not toxic.]
10. CAFS requires considerable electrical power, up to 50 amps.
11. CAF blanket may hide hazards such as small openings in floors, changes in floor elevation, or weakened areas in floors, thus creating unseen dangers for fire fighters and fire investigators.
12. CAF blanket delays fire investigators from performing origin and cause examination. [Investigators must wait for foam to dissipate, or action must be taken to remove foam from areas that must be examined.]
13. Arson detection canine may be reluctant to work in the foam.

CAF EXPERIENCE BY FIRE DEPARTMENTS IN U.S.

Travis County Emergency District 2, Pflugerville, Texas: This department, located near Austin, has used CAFS-equipped suppression apparatus at all four of its stations since 1998. Water must be used sparingly in this part of Texas, one of the reasons the department switched over to CAF. The department exclusively uses the Hercules CAFS manufactured by Pierce. Based on the overwhelmingly positive experience of this department, the Texas Legislature signed into law a bill requiring that insurance companies give homeowners a reduced rate on insurance premiums in cities/areas protected by CAFS-equipped apparatus. Quotes from Pflugerville Fire Department's Chief Moellenburg: "After having seen how effective CAFS is, it is inconceivable that our department would ever give it up." "If your department uses CAF, the total fire damage during the year will be less; therefore the amount that insurance companies will have to pay [out] will be less."

Los Angeles County Fire Department: Deputy Chief Larry Miller stated that the department has had positive results using CAF on structure fires, brush fires and a fire involving a five-acre pile of shredded tires. He was quoted as saying: "We currently purchase all engines and quints with Class-A Foam, and we intend to purchase more engines with compressed-air foam systems in the near future."

Phoenix Fire Department: The department has a large fleet of CAFS-equipped pumpers. Chief Alan Brunacini was quoted as saying: "If you buy an engine without CAFS, it's obsolete."

Other Fire Departments: Some of the other Fire Departments operating CAFS-equipped apparatus (either entire fleets or specific apparatus) include:

- Los Angeles City
- Tacoma, Washington
- Manchester, New Hampshire
- Nashville, Tennessee
- Fairfax County, Virginia
- Emmitsburg, Maryland
- Hartsville, Pennsylvania
- Conshohocken, PA
- Plano, Texas
- El Paso, Texas
- Westlake, Texas

CAF EXPERIENCE OF FIRE DEPARTMENTS OUTSIDE OF U.S.

CAFS has gained popularity internationally as evidenced by the following comments:

- Leicestershire, U.K. Fire Brigade website states that compared with plain water, CAFS is "much better, quicker to get to work, easier to maneuver, hose lines are lighter, finished foam produced means less water is used, and extremely versatile in that you can use the foam on just about any incident.

- Country Fire Authority, Victoria, Australia: Troy Thornton, Fire Project Officer, says of CAFS: "There are applications for both the firefighter who may have to drive to a distant water source, and the rural homeowner who may have a finite water supply. High agent concentrations and low mix ratios (3 liters per 1000 liters) permit adequate on-board storage without reducing appliance capacity. Hoses filled with foam are also lighter and more maneuverable -- perhaps its most effective application. Compressed air provides the distance to reach, and the agitation to cling to walls, eaves, roofs, and trees."

RESEARCH AND TESTING INVOLVING CAF/CAFS

In recent years, several tests have been conducted involving the use of CAF/CAFS. A summary of each test is presented below.

MCFRS Study

As part of a 2002 training project in Montgomery County, a vacant high-rise office building was used to conduct test burns using CAF, Class-A foam solution (without compressed air) and water as the extinguishing agents. A comparison of the effectiveness of each agent in a high-rise setting was the purpose of the study. In preparation for the test burns, MCFRS personnel had outfitted each of the top three floors with burn rooms, "safe" rooms, ventilation openings, etc. to bring the site into compliance with NFPA 1403 - Standard on Live Training Evolutions. The building used in the test, an office building located at 818 Roeder Road in Silver Spring, was of Type I - fire resistive construction, with concrete slabs and reinforced concrete columns. A full NFPA command, accountability, and safety team was in place throughout the test burns.

Unique to this research effort, a large burn room was constructed on the fifth floor of the structure to accommodate a series of controlled burns. This room was 29 ft x 9 ft x 9.5 ft (2480 cubic ft) and constructed of a double layer of one-half inch gypsum wallboard over two by four wood studs. The ceiling was lined with one-half inch plywood under one-half inch gypsum board held in place by ceiling anchors to allow repeat burns without affecting the buildings structural integrity.

The goals of the tests were to conduct a series of 12-16 test burns and comparing the effectiveness of plain water, Class-A solution, and CAFS as extinguishing agents. The results could be used to compare the extinguishing characteristics of the three agents and determine if CAFS would degrade during transit through the above ground hose layout, standpipe riser, and attack line layout in a high rise application. Review of the available literature had failed to identify the use of CAFS in this manner; therefore, these tests would contribute to the overall body of knowledge regarding CAFS.

The eight independent burns that were conducted were recorded using thermal imaging technology provided by Bullard Industries and later transferred to video tape. In addition, the MCFRS photo team was able to capture some video of initial burning on VHS equipment. Needed fire flow requirements for the burn room were calculated prior to the tests and established at 50 gpm. A combination fog nozzle was used for the plain water and Class-A solution test burns. A solid bore 1- 3/8 inch nozzle was used to deliver CAFS. Agent usage for water and foam concentrate was calculated and recorded using the "FoamPro" microprocessor on a CAFS equipped pumper provided by the Conshohocken Fire Company #2 of Conshohocken, PA.

Temperature changes were recorded using a strip chart recorder fed by eight thermocouples placed throughout the burn room. Two were placed on the ceiling (9.5 ft), positioned 5.5 ft from each end, and 4.5 ft from the opposite walls. Two were placed on the interior wall mounted 3 ft and 4 ft from the floor, one adjacent to the doorway at the 2- ft level, and one at the 1-ft level located 7 ft from the end of the room. Two additional thermocouples were positioned at the1.5-ft and 3-ft levels 7 feet from the end walls of the room. Time-to-extinguishment parameters were recorded by the operator of the strip chart recorder in an adjacent safe room. Information was provided via portable radio from an observer adjacent to the attack team to record when the nozzle was opened, when it was closed, and fire extinguishment benchmarks.

Water supply and delivery to the burn room was accomplished as follows: A CAFS equipped pumper was connected to a hydrant adjacent to the building. Two-100 ft long sections of 3-inch hose with 2½-inch couplings fed a standard fire department connection on the front of the building. A gated wye and 150 ft of 1¾-inch attack line was connected to the single, dry, six-inch standpipe riser located in the stairwell of the 5th floor. Each test fires was extinguished using either plain water, 0.3% CAF solution, or 0.3% CAFS through the attack line.

The nozzle technique was identical for all burns. It was agreed that to protect the ceiling for the maximum number of burns, a “Z pattern” followed by an “inverted T pattern” would be used to attack the fires. This was accomplished from a position on the floor just outside of the room through a standard 3-ft wide doorway.

The fuel package consisted of three identical sets of six wood pallets and three bales of straw arranged in a pyramid fashion to achieve flashover conditions. These fuel packages were equally spaced left to right and front to back throughout the room. Each fire was ignited using a flare near the base of the three fuel packages. Burning rates and ceiling temperatures were monitored until a peak was reached. When the fire began to decay, the attack team was directed to open the nozzle and extinguish the fire. On plain water burns, the nozzle had to be opened and closed several times. On each test fire, the attack team stopped flowing when the fire was successfully extinguished. Data was recorded and preparation for the next burn began that included ventilation of the burn floor, total removal of the fuel package, and re-stocking of three completely fresh fuel packages. When extinguishing agents were changed, the riser and attack line were flushed to remove any residual foam from the riser and lines.

Test goals were not fully achieved for a number of reasons. Most importantly, only eight test burns were conducted due to the study leader underestimating the time required to complete the desired number of test burns and the logistics necessary to completely restock the burn room, flush and calibrate the agents between burns, and ventilate the structure after each burn. Secondly, the personnel and CAF/CAFS equipment on loan from Conshohocken Fire Company #2 were only available for a single day, not nearly sufficient to gather the desired amount of data. Thirdly, the building had to be available the next day for scheduled training, the primary mission of the overall MCFRS project. Finally, coordinators responsible for the building could not allow any synthetic fuels to be used in the structure because NFPA Standard 1403 prohibits the use of synthetic fuels. Approximately sixty personnel were involved with the tests, and their safety could not be compromised.

The coordinators of the high-rise training project had an agreement with the local business community that promised the exterior glass wall panels would remain intact throughout the ninety day training effort. In addition, they had agreed that excessive release of the products of combustion into the environment would be limited. Therefore, the test burns stopped short of the high-challenge fires that would normally be associated with a similar scenario. As a result of these limitations, tests were limited to eight burns that failed to produce statistically significant data.

To compound these problems, construction of a tightly sealed, large burn room with a single doorway restricted fresh air entrainment to the burning fuel. It was the authors assessment that all of the test burns were under ventilated, failing to maximize the fuel potential of the designed fuel packages. Because the fires remained largely fuel controlled, the flow rates for the tests may have been higher than necessary.

Through the series of eight burns, the test team consistently struggled to bring the fires to the full ventilation-controlled burning rate. There were two adverse impacts as a result. First, although peak ceiling temperatures reached 1150-1420^{o}F, they did not remain there long. Second, because the room was under-ventilated, the fuel package for the various burns failed to completely ignite, flashover, and burn as planned. In an attempt to deal with these issues, additional forced ventilation was provided by positive pressure ventilation blowers. Although the burn rate increased along with the maximum ceiling temperatures, room-wide flashover was not fully achieved.

The results of the first four tests were thrown out due to the problems encountered with ventilation, fuel loading, and heat stress on the building. In all cases, low temperatures, consistent with lack of free burning fuel packages resulted in high total agent flows to extinguish smoldering fuels prior to removal from the burn room.

Test Burn #5 was the hottest fire where plain water was applied. 60 gallons of water was used after the ceiling thermocouple reached a peak temperature of 1420^{o}F. This fire was allowed to free burn for approximately 300 seconds before extinguishment began. The nozzle had to be opened and closed three times to achieve complete suppression. Total nozzle flow time was 80 seconds. The strip chart recorder was prematurely stopped during this test prior to the temperatures in the room dropping to 212^{o}; however, the ceiling temperature dropped to 300^{o}F at the 150 second mark. The temperature four feet from the floor where fire fighters operate dropped to 212^{o}F in approximately 95 seconds.

Test Burn #7 was the hottest fire where CAFS was applied. This fire was extinguished with 18 gallons of water and 0.1 gallon of Class-A foam concentrate proportioned at 0.3%. The peak ceiling temperature was 1390^{o}F. This fire free burned for approximately 340 seconds before suppression was initiated. The nozzle was opened and closed once with a total open nozzle time of about 25 seconds. The temperature drop for all eight thermocouples was similar; however, the rate of temperature drop was significantly faster than the test burn involving plain water agent. The ceiling temperature was reduced to

212°F in approximately 65 seconds, while the temperature drop to that level at four feet occurred in slightly less than 40 seconds.

Test Burn #6 was noteworthy in that it was the only burn where non air-aspirated Class-A solution was successfully tested. Using the same 50 gpm application rate, at 0.4% solution, 43 gallons of water was required for extinguishment. For undetermined reasons, this fire began to decay quickly when the peak ceiling temperature reached 1200°F. Extinguishment was quickly initiated, resulting in nearly identical temperature drops as recorded with the hottest test burn involving CAFS.

Test Burn #8 involved CAFS. The peak ceiling temperature only reached 1160°F. This fire was extinguished using 22 gals of water and 0.3 % CAFS. Significant deterioration of the ceiling board and walls were observed at this point. A decision was made to suspend testing after an exhausting effort.

While the tests failed to produce scientifically verifiable data, direct comparison of the best test fire using plain water agent (Test #5) and the best test fire using CAFS (Test #7) verified results produced in tests conducted by others across the U.S. and the world.

Los Angeles County Test

The most compelling CAF research was conducted by the Los Angeles County Fire Department (LACFD) in 2001. Three 1,105 sq. ft., one-story frame single-family dwellings were furnished with identical new furniture to simulate a real world fuel package. Windows were replaced with plywood and composition shingle roofing was left in place. The interior of the structures were equipped with thermocouples to record temperatures at various locations.

All fire attacks during the testing used the same LACFD structure pumper equipped with a CAFS unit. The tests were designed to compare plain water, Class-A foam solution, and CAFS. A combination nozzle was used in the plain water and Class-A solution tests, and a 1-inch smooth-bore nozzle was used in the CAFS tests. The attack line was a standard 200 ft long 1-3/4 inch hose line. Attack flow rates were based upon the Iowa formula which calculated 90 gpm. The CAFS attack was 90 gpm with 30 cubic ft of air per minute (cfm). Foam concentrations were set at 0.5 percent for the Class-A solution and 0.2 percent for CAFS. The results are summarized in the following table:

LACFD Foam Test Results (2001)			
	Water	**Class-A**	**CAFS**
Foam Setting (percent)	**n/a**	**0.5**	**0.2**
Water Flow (gpm)	**90**	**90**	**90**
Air Flow (cfm)	**n/a**	**n/a**	**30**
Knockdown (sec)	**50**	**25**	**11**
Water Used (gal)	**75**	**44**	**16**
Temperature Drop to 200 °F (min:sec)	**6:03**	**1:45**	**1:28**

The test results were conclusive. CAFS knocked down the fire in approximately one-fifth the time as plain water. Due to the extended reach of the CAFS fire stream, the fire could be attacked earlier; in this case from the curb, thirty-five feet away from the dwelling. When compared to CAFS, it took 4.7 times the amount of plain water to extinguish the fire. Most importantly, CAFS cooled the interior from 600^{o}F to 200^{o}F four times faster and with a significantly larger initial temperature drop. In addition, the test team noted several other benefits of the foam that were not quantitatively measured. First, faster knockdown resulted in less products of combustion both inside and outside the dwelling. Secondly, less water used resulted in less damage to the building and contents and less contaminated water runoff. Thirdly, the increased standoff distance (because of stream reach) enhanced fire fighter safety.

Oatman, Arizona Test

The Oatman, Arizona Fire District conducted a series of tests on both wood cribs and tires. The results revealed that by using CAFS, as compared to plain water, the wood cribs were extinguished in one-fourth the time using less than one-fourth the amount of water. When extinguishing burning tires, the fire was extinguished 4.5 times faster with CAFS using less than one-fourth the amount of water.

USFA Study

In 1996, Jeff Stern and J. Gordon Routley published a report titled “Class-A Foam for Structural Firefighting.” This U.S. Fire Administration report focused on hands-on evaluations by several fire departments that were using Class-A foam systems in structural or wild land fire situations. Departments included in the study included Nashville, Phoenix, Fairfax County, and Westlake, Texas. All departments surveyed concluded that Class-A Foam and CAFS are tools that increased the efficiency and effectiveness of their fire suppression operations. Collectively, the departments reported quicker fire extinguishment, faster overhaul time, less damage to buildings, and reduced fatigue on fire fire-fighting personnel due to quicker mop-up after the fire is out.

Results of 12 Independent Studies on CAF/CAFS

An Executive Fire Officer Applied Research Project titled: “Compressed Air Foam Systems in Limited Staffing Conditions” was completed by Robert G. Taylor of the Morristown, New Jersey Fire Bureau. In a review of twelve different studies on CAF/CAFS conducted over a seven year period, Mr. Taylor identified several common test results, as follows:

- Compared to both plain water, and non air-aspirated Class-A foam solution, application of CAFS required the lowest quantity of extinguishing agent, resulting in the quickest fire suppression time in all cases.

- The rate of temperature drop at the 4-ft level in test structures was dramatically enhanced using CAFS. This is particularly important since the survivability of trapped occupants and the tenability of fire fighters would be most affected at this level.

- Large high-challenge fires with calculated fire flows ranging from 250 gpm to 1600 gpm could be quickly extinguished with CAFS at flows of 7 gpm to 120 gpm rates.

- Application of CAFS as an ignition retardation agent on exposures yielded test results that were up to twenty times as effective as plain water

NIST Test

Researchers at the National Institute of Science and Technology, (NIST) Fire Safety Division demonstrated that protein-based compressed air foam can protect building exteriors from ignition. Using identical L-shaped wood-frame walls covered with exterior vinyl siding, one test wall was coated with the protective foam one hour prior to ignition. Both test samples were exposed to a fifty kilowatt fire for ten minutes. Within three minutes of ignition, the untreated corner was burning into the eaves and roof area. After ten minutes of fire exposure, the treated corner had received only minor damage. No fire spread was recorded on the treated corner. The results as presented in the abstract of the study conclude:

The agents, both as solution and as CAF, were more effective than plain water at remaining on or in the plywood but less effective than plain water on the vinyl. The penetrating/wetting ability of the agents may be the characteristic which most affects the increase time to ignition.

New Zealand Test

In studies at the University of Canterbury, Christchurch New Zealand the fire fighting effectiveness of CAFS has been compared with plain water using high pressure delivery (HPD). The HPD method uses a flow rate of 16-63 gpm at 400-500 psi. The high pressure produces a fine mist that has proven to be very effective and efficient method to extinguish a single post flashover compartment fire. These experiments concluded that the CAFS attack was as effective as the HPD attack. An additional advantage was noted with the CAFS attack method. Fire fighters could operate from a much greater distance, protecting themselves from the high temperatures and smoke exiting the compartment.

CAFS SOP DEVELOPMENT AND TRAINING REQUIREMENTS

Standard Operating Procedures (SOPs) must be developed, practiced and fully understood to ensure that CAFS can be used proficiently and safely by suppression crews. The additional CAFS-related training requirements for personnel at all operational levels must be determined and implemented, as well. A good starting point in the development of CAFS SOPs and an effective CAFS training program would be to contact those departments having considerable experience in CAFS deployment such as the Pflugerville, Texas Fire Department.

CAFS MAINTENANCE REQUIREMENTS

The ability to properly maintain the equipment is essential. The extra costs associated with additional maintenance should be included in the plan to implement CAFS. Little information is available in the literature regarding the long-term costs associated with the maintenance and reliability of CAFS; however, much can be learned from contacting those departments that are experienced in using CAFS. Based on the rave reviews on CAFS from the fire departments that have been using CAFS for several years such as the Pflugerville Fire Department, it would appear that the benefits of CAFS deployment far outweigh the associated maintenance costs.

LESSONS LEARNED (from Los Angeles County Fire Department)

1. Interior CAF attack should be made at the flow rate required for the structure. CAF saves water by knocking down the fire faster than water, not by knocking down the fire with a lower flow rate.

2. A fully charged CAF line has a very strong nozzle reaction. Pistol grip nozzles are recommended for better control.

3. An interior CAF attack can often be made by directing the stream through a door or window. Firefighters should aim at the ceiling for best results.

4. When CAF initially comes in contact with the fire, it generates a large volume of steam which will fill the structure and vent forcefully through any exterior openings. Firefighters working in the vicinity must take appropriate precautions.

5. Even though CAF reduces interior temperatures faster than water, the upper portions of rooms will still be hot following knockdown of the fire. Attack teams should stay low until heat dissipates.

6. During overhaul, firefighters should use a low foam concentration to produce a “wet” CAF. A “dry” CAF does not penetrate as well.

WHY SHOULD CAFS BE DEPLOYED IN MONTGOMERY COUNTY?

In July 2000, the Montgomery County Fire Rescue Service (MCFRS) approved a fire suppression policy to “deploy resources to achieve a minimum stated fire flow goal of 500 gallons per minute (gpm) for 30 minutes in all areas of the county.” This policy was derived from a similar recommendation appearing in the “Final Report of the Water Supply Study Implementation Work Group,” dated April 2000.

Approximately 40-45 percent of the county's land mass lacks fire hydrants. This lack of hydrants, primarily in rural areas of the county, is compounded by the continual addition of very large, single-family dwellings that have resulted in high-challenge fires that stress available suppression resources to their maximum potential. Unfortunately, the MCFRS is unable to deliver the fire flow goal of 500 gpm for the initial 30 minutes of a structure fire in many areas of the county lacking hydrants.

As of 2004, the distribution of fire-rescue stations located throughout the county is unbalanced, with a disproportionate number of stations located in the urban areas. The consequence of this station distribution is increased response times to areas of the county where fire fighting water is a precious commodity. The increase in response time to fires in outlying areas has repeatedly allowed for fire growth beyond the room or compartment of origin prior to the arrival of suppression forces. As a result, first-arriving suppression units are confronted with high-challenge fires that are increasingly beyond their capability to control with existing resources. Modern lightweight construction of single-family dwellings in these areas produce fires that burn with unusually high rates of heat release. These quickly-developing, high-intensity fires extend to other areas of the structure very rapidly. Consequently, initial fire suppression forces can be easily overwhelmed. The average size of most of the new homes in non-hydranted areas is frequently in excess of 3000 sq. ft. It is not unusual for fire fighters to encounter single-family dwellings in Montgomery County that are in excess of 4,000 sq. ft., nor is it unusual to find estate homes that are two to five times that size.

Efforts already underway to minimize the impacts of these developing problems include the passage of residential sprinkler legislation for new construction, revision of rural water delivery standard operating procedures, computerized mapping and pre-planning of static water sources, and standardization of large diameter hose (LDH) and appliance inventories throughout the county. Recent apparatus purchases have included three additional 3500-gallon water tankers and an engine-tanker. The standard MCFRS pumper specification has been enhanced to increase pump capacity, provide additional discharges, and provide other equipment to take full advantage of four-inch large diameter supply hose.

In addition, four planned fire-rescue stations (see Section 5) in Montgomery County will improve service delivery to fast-growing up-county areas beginning in FY07. The addition of these four stations will provide pumper service in 35 of the 37 fire rescue stations. When completed, the ability to provide faster response times to many areas of the county will be improved, as will the ability to assemble both equipment and personnel at a given incident. Nonetheless, it is unlikely that future staffing levels will be increased in the foreseeable future. New technologies such as CAF offer the opportunity for improved fire fighting performance and increased efficiency while maximizing fire fighter safety.

Clearly, CAFS affords the opportunity to extinguish large fires with less water, using fewer resources. This is the primary conclusion of interest to the MCFRS where high-challenge fire potential exists in areas without fire fighting water available in sufficient quantities to meet fire flow mandates. In areas where water and personnel resources cannot be assembled quickly enough to produce consistent success, CAFS will play a key role.

References - Informational sources for this appendix include the following:

- "The Use of Compressed Air Foam to Enhance Fire Fighting Water Supplies in Montgomery County, MD," Applied Research Project June 2002, Steven E. Lohr.
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- "CAFS: So Effective It Changed the Rules, So We Changed the Laws," *Firehouse*, May 2000, Chief Ron Moellenburg.
- "Bubbles Beat Water," *Fire Chief*, July 2001, Chris Cavette.
- *Class-A Foam For Structural Firefighting*, U.S. Fire Administration, December 1996

APPENDIX M

ENVIRONMENTALLY-COMPATIBLE FACILITIES AND EQUIPMENT

There are several measures that the MCFRS should consider implementing with regard to its facilities and everyday operations to become more environmentally compatible and to meet the intent of the MCFRS System of Environmental Management. Some measures are more easily incorporated into new or renovated facilities, while others can be easily incorporated into existing facilities and operations.

Many of these environmental measures can be implemented at nominal or no cost and can save money on electric and natural gas bills. Some measures will also reduce exposure to chemicals,thus reducing adverse health effects on staff.

<u>Construction/Renovation-Related Measures</u>:

1. Construct all new facilities and perform major renovations of existing facilities in accordance with the County's "Energy Design Guidelines" and, whenever possible, "Leadership in Energy Environmental Design (LEED)" guidelines.
2. Consider solar power for hot water or for heating
3. When installing or replacing roofs, use highly-reflective surfacing
4. When installing or replacing driveways, use concrete to reduce the amount of heat released from deflected sunlight
5. Use recycled-content materials such as flooring, carpeting, countertops, etc.
6. Direct storm water from downspouts to grassy areas via underground pipes
7. Install medians covered with plantings to minimize the impervious surface of parking areas to reduce runoff
8. Plant trees on the south, east and west sides of stations, when possible, to keep the stations shaded
9. Caulk around all outside doors and windows
10. Install high efficiency doors and windows
11. Install insulation with the highest R-value recommended
12. Install drains in apparatus bays that are connected to the sanitary sewer
13. Install motion sensors and dimmer switches on lights
14. Install low-flow shower heads and toilets
15. Install only "energy star" appliances

Post-Construction Measures:

1. Install motion sensors and dimmer switches on lights, if not already accomplished during construction
2. Install low-flow shower heads and toilets, if not already accomplished during construction
3. Purchase only "energy star" appliances when replacing appliances
4. Reduce the temperature on hot water heaters, when possible
5. Set thermostats to a slightly higher setting in the summer and slightly lower setting in the winter than normally set
6. Open shades during the winter to allow sunlight inside (i.e., warms the room). Close them in the summer to keep sunlight out.
7. Maintain all systems and appliances in accordance with the manufacturers' specs.
8. Disconnect or shut off unnecessary lighting, both indoors and outside
9. Replace windows and doors with high efficiency doors and windows, if not already installed during construction
10. Upgrade insulation to a higher R-value, if needed
11. Set computers to go into the "sleep mode" when not in use
12. Reduce copying and printing, and print on both sides of the paper when possible
13. Issue and enforce policies concerning the unnecessary use of appliances and electronic equipment (e.g., turn off TV and coffee pot when not in use)
14. Replace incandescent light bulbs with compact fluorescent lights
15. Wash all apparatus and equipment inside the apparatus room and make sure the area has drains that lead to the sewer system, not storm drains
16. Disconnect the use of down spouts that empty onto impervious surfaces. Instead, redirect storm water to grassy areas via underground pipes. If this cannot be accomplished, then place rain barrels under down spouts to collect water for watering plants and other non-potable water uses.
17. When repainting, use low- or non-volatile organic compound paints
18. Use natural cleaning products instead of harsh chemicals
19. Establish, maintain and enforce a recycling program in each station
20. Use recycled-content furnishings
21. Do not use lawn chemicals; use organic alternatives
22. Do not bag grass cuttings; leave them on the ground whenever possible