The Tools

Fire Fighting Water

An adequate and uninterrupted water supply is fundamental to the effective control of fire. Simply stated, water must be applied at rates (GPM) capable of absorbing heat faster than the fire can generate heat. In doing so, fire suppression forces lower the temperature of the fuel below its ignition point. For most fires in Montgomery County, this is accomplished with several hundred gallons of water applied quickly through pre-connected hand lines. In a smaller number of incidents, large amounts of water must be quickly delivered at rates necessary to overwhelm growing and rapidly spreading fires. In either case the MCFRS must be capable of delivering larger quantities of water rapidly when challenged with well-developed structure fires that threaten occupants and or adjacent exposures.

The WSWG has applied the requirements of two nationally recognized models to MCFRS operations to evaluate the ability to deliver fire-fighting water. These models are the Insurance Services Office Fire Suppression Rating Schedule and NFPA 1231-1993, “The Standard for Rural and Suburban Fire Fighting Operations”.

The majority of fire fighting in Montgomery County is done with fire hydrants in areas where more than ample water is available underground. In fact, a close review of our operations would identify that the fire department is limited not by the lack of water, but rather the ability to move the water above ground once it leaves the water source[1].

There are several reasons for this. First and foremost, fire departments are limited by their ability to move water through hose primarily due to the effects of friction loss. Secondly, the distance between the water source and the fire ground determines the number of pumpers necessary to move the water efficiently.

The WSWG submits that it is a logical and desirable approach to utilize water supply as the basis for fire suppression planning and deployment. To date, Montgomery County has relied heavily upon past significant incidents, historical data, and opinion surveys to determine resource allocation. The result is the continuation of past practices, some good and some not so good.

Fire Department Pumpers

The operational purpose of a pumper and its crew is to establish a continuous water supply and apply water to a fire. A variety of attack hose and

[1] In most instances where municipal fire hydrants are available, the fire department does not maximize the available water from the hydrant. Typically, the above ground hose lay is the limiting factor, not the available water supply when the fire fighter hollers “I’m out of water”.

nozzle configurations that produce both spray (fog), and straight (solid bore) fire streams are carried to maximize versatility. Larger hose (supply line) is carried in sufficient quantities to deliver water from a wide variety of sources to the attack pumper(s). In some cases this requires the use of multiple pumpers over considerable distances to achieve the end result.

All pumpers manufactured for fire department use are rated, tested, and certified by a third party at the time they are built. Pumps are typically sized from 500 GPM to 2000 GPM based upon the purchaser's specifications. Beginning at 500 GPM, pumps are available in 250 GPM increments. A typical Montgomery County spec pumper is equipped with a 1250 GPM, two-stage, (dual impeller) mid-ship mounted pump and a 750-gallon water tank.

While Montgomery County purchases attack pumpers with a rated capacity of 1250 GPM, some specialty apparatus like the three front-mount pumpers in service at Fire Stations 13, 14, and 17 are equipped with 750 GPM pumps. Ironically, these are the units planned for use at drafting sites in rural areas. Is is well known that the largest capacity pump must be placed at the water source to maximize the available water supply and to adequately supply pumpers down the line in a relay. The WSWG believes that a water supply delivery system built around these pumpers is doomed to failure by design. At the very least, two pumpers of similar capacity will have to be placed at the source to achieve higher flows at the end of the line.

Operating with apparatus that is minimally staffed, Montgomery County should strive to get the maximum use from each piece of apparatus. In other words, each pumper would be placed to deliver as much water as possible. In addition, each pumper should be capable of delivering their rated capacity at the lowest RPM's possible. A typical large scale fire in Montgomery County utilizes at least three attack lines averaging 150-200 GPM each, and one or more master streams that average 500-1000 GPM each. If exposure protection is required, this increases the demand further.

Understanding rated pump capacity is fundamental to the water supply delivery system. The ability of a given pump to deliver the rated capacity of water changes when operating from draft or hydrant pressure. Essentially, operating from draft is a worse case scenario. The pump is rated to deliver 100% of its rated capacity at draft at 150 PSI pump discharge pressure. At 200 PSI, the pump is rated to deliver only 70% of its rated capacity, and at 250 PSI, the rated capacity drops to 50%. Therefore it is critical to design evolutions and SOP'S that will limit the discharge pressure of pumpers to 150 PSI. This assures that quantities up to the rated capacity of the pump will be guaranteed when establishing water supply. However, when operating from hydrant pressure, or within a relay, the fire department pumper only needs to make up the pressure difference between what is already available and what is required. This is how a 1,000 GPM pump can, at times, deliver more than 1,000 GPM. For example, if a hydrant supplies 50 PSI to the pumper, and 150 PSI is required, the fire pump needs only to generate the difference, or 100 PSI. As a result, pumps can deliver in excess of their rated capacity when operating from positive pressure.

A typical Montgomery County pumper is equipped with two beds of 3" diameter supply hose, 800' long. This system is intended for crews to establish a water supply going in from the hydrant via one or two supply lines. A second pumper then picks up these lines and pumps them to maximize the potential of the delivery system. This works well in the vast majority of incidents where fire flows less than 800 GPM are required. However, fire flows greater than that amount, and or in situations where the length of hose needed is greater than 600-800 feet create obstacles that are difficult to overcome. In most cases, much more water is available in the hydrant system that is not utilized. Expansion of the water supply at this point in an incident usually relies upon relays from hydrants further away from the incident.

To achieve the maximum use of each pumper on the fire ground, several factors must be considered and planned for: available water supply, adequate pump capacity, hose diameters large enough to meet the required fire flows, and utilization of proper hose lays to deliver the required fire flow. Therefore, ***the WSWG recommends that future pumpers be purchased with 1500 GPM PUMPS with state of the art full flow valves.*** These pumps and valves are equipped with improved pressure control devices designed specifically for large diameter hose. Later in this report, conversion to 4-inch supply line will be recommended. 1500 GPM pumps will permit each pumper to supply two, 1,000-foot long 4-inch supply lines from draft.

Other potential enhancements that should be considered by those having authority include direct tank fills for all pumpers, and the addition of a third crosslay attack line for deployment of the mandated rapid intervention line. The direct tank fill will enable pumpers to be more effectively used to shuttle water in rural areas and on limited access highways. The addition of the third crosslay will permit easier deployment of a rapid intervention line that is now required by policy.

Fire Fighting Foam

Presently, most county spec pumpers are equipped with forty gallons of Class B fire fighting foam that can be applied through a single attack line no greater than 200 feet long[2]. The application rate for these foam lines limit the ability to handle anything involving more than an area of about 25 feet by 25 feet.

[2] Class B foam refers to products that are specifically designed to attack, extinguish and seal flammable liquid pool fires.

Units in the county have successfully used foam for small incidents for years. Improvements in foam technology have increased the extinguishment and hazard control ability for these smaller foam systems. However, they are not suitable for larger incidents where a well developed fire is in progress, or where large quantities of product is spilled and needs to be sealed. The MCFRS typically requests assistance from one of the regional airports when large scale incidents occur.

Several units within the MCFRS have additional around-the-pump foam capabilities. These units were developed to mitigate incidents where it is believed that additional flammable liquid hazards exist, and where greater foam resources are necessary. Bethesda E-261, Chevy Chase E-71, Gaithersburg E-281, and E-81 all have enhanced foam systems that will permit application of Class B foam for extended periods at greater rates. These units can be utilized to apply foam through multiple attack lines, including the master stream device. They are equipped with one hundred gallons of foam concentrate (E-71 has 250 gallons) and an auxiliary pick-up tube that permits drafting foam from other containers. However, the available foam for large application rates is severely limited unless additional foam concentrate resources can be provided rapidly. This is not presently available. Additional foam concentrate resources are delivered in five-gallon buckets that must be manually handled to deploy; severely compromising speed and efficiency.

The WSWG recommends that the MCFRS explore available Class B foam strategies and develop a plan to improve Class B fire fighting foam capabilities. It is certain that our last flammable liquid fire will not be our last.

Although foam and foam systems are not the primary focus of this report, the WSWG would like to share knowledge of one system presently in use in Dade County, Florida and other jurisdictions that provide additional foam coverage without the use of dedicated specialty vehicles designed for that purpose.

Foam is purchased in 275-gallon skid packs that are handled with tow motors and transported on utility type pick up trucks. These utilities respond with strategically located pumpers equipped with around the pump proportioners described above. They position adjacent to the pumpers, providing large quantities of concentrate through the auxiliary pick up tube eliminating the need to manually unload and dump foam buckets. On large incidents, all of the available units are deployed and utilized in concert.

This system is only one of many strategies that could be deployed at minimal expense to the service. Nonetheless, additional foam capabilities are required to mitigate larger, less frequently encountered incidents.

Tankers

The county's four tankers are housed in stations with predominantly non-hydranted first due response areas. Currently, tankers are housed at Hyattstown FS-9, Upper Montgomery FS-14, and Laytonsville FS-17, (two tankers are available from this location). The WSWG obtained data regarding the number of responses made by these four tankers for calendar years 1994-1998. The results are displayed in the following table.

CY94-98 Tanker Responses To Fire Incidents*

Tanker	1994	1995	1996	1997	1998	94-98 Total	94-98 Avg
9	N/A	N/A	N/A	46	43	89**	44.5**
14	35	55	34	70	22	216	43.2
17-1	54	56	45	75	61	291	58.2
17-2	N/A	N/A	N/A	18	27	45**	22.5**
Totals	89	111	79	209	153	641	128.2

N/A – Not applicable or not available
* Non-fire incidents (e.g., service calls) not included
** Figure based on less than 5 years data

On May 1, 1999 the Fire Rescue Commission enacted a change in the structure fire response that will increase tanker usage. Two tankers will automatically be dispatched on all rural structure fire responses in Montgomery County. Prior to that date, a single tanker could be dispatched at the discretion of the local fire rescue department[3].

Tanker Evaluations

To help identify gaps in tanker coverage, and evaluate our current tanker fleet, the WSWG sought the assistance of Captain Mark E. Davis, (DFRS FS-3A). Captain Davis has performed similar work in other portions of the country as a consultant, and was instrumental in designing improvements in Carroll County, MD that have been used to achieve better ISO ratings in an all rural portion of that county[4].

[3] The WSWG believes that the addition of the second tanker on structure fire responses will increase the number of tanker responses substantially.
[4] The Winfield VFD (Carroll County, MD), has undertaken a multi-year project to meet the ISO rural rating expectation of an uninterrupted 500 GPM continuous fire flow for two-hours using tankers in a shuttle operation supplied from multiple fill sites.

There are four tankers operated by three local fire rescue departments in Montgomery County. Hyattstown Tanker 9 is a 1992 KME with a 1500-gallon T-shaped tank, a 1250 GPM midship-mounted pump, and a 10 inch rear gravity dump. Upper Montgomery County Tanker 14 is a 1993 Freightliner/Walker with a 3000-gallon elliptical tank, a 1250 GPM midship-mounted pump, two air-operated 8 inch side gravity dumps and a 10 inch rear gravity dump. Laytonsville Tanker 17-1 is a 1993 Freightliner/Walker with a 3500-gallon elliptical tank, a 1250 GPM midship-mounted pump, two air-operated 8 inch side gravity dumps, and a 10 inch rear gravity dump. Tanker 17-2 is a 1984 Ford/Four Guys with a 1500-gallon elliptical tank, a 1000 GPM front-mounted pump, and a 10 inch rear gravity dump.

During December, 1998, Tankers 9, 14, 17-1 and 17-2 were each evaluated at the PEPCO Power Station test site in Dickerson. The PEPCO facility offered an ideal site for all test-related evolutions, including weighing (on-site scales), filling, off-loading, and traveling along a looped, measured course. Each tanker was put through four distinct tests, each having multiple test runs: ISO Fill Test, Continuous Flow Test, One-Minute Increment Off Load Test, and ISO Dump Test.

Four tests were conducted with each of the four Montgomery County Tankers at the PEPCO facility in FS-14's area. The gross vehicle weight of each tanker was assessed. An off-load weight test was performed to determine the critical dump time for each unit, followed by the ISO dump test. An ISO fill test was conducted using two different fill methods; directly from a hydrant, and from a pumper connected to a water source. Finally, a continuous flow test was performed to evaluate each tanker in a real life water shuttle that accounts for travel time. This final test was run twice to gather data for a 1.6, and 3.2 mile run. This data was then extrapolated to predict continuous flow capabilities for 4.8, 6.4, and 8.0-mile round trips.

Gross Vehicle Weight (GVW) Assessment

An important safety issue with any large fire department vehicle is weight distribution. Weight distribution becomes critical with tanker vehicles because of the large quantity of water a tanker can carry and the expectation that the tanker must be able to operate safely under full-load, partial-load, and no-load conditions. As axle weights increase, so do the concerns over braking and handling ability. These weight concerns are important in the rural setting because tanker drivers are often faced with long response times, winding and narrow roads, and additional travel during shuttle operations. An overweight tanker can quickly develop braking problems given the nature of these operations.

Each of the four tankers was evaluated using a full tank of water and a one-person crew. Three weight measurements were obtained for each tanker, front axle, rear axle(s), and all axles combined. The tests were done using the certified scale at Montgomery County's composting facility next to the PEPCO power plant in Dickerson. The weight measurements on all four tankers were within reasonable limits, however, Tanker 9 had the highest rear axle weight: 26,420 lbs. which was 5000 lbs. more than the next highest weight (Tanker 17-1).

Off-Load Weight Test

The one-minute increment off-load weight test is used to evaluate a tanker's ability to off-load its total capacity as quickly as possible. The test shows that a full tanker off-loading in the gravity mode will initially start with a high off-load GPM, but as the off-load process continues, head pressure drops as does the off-loading GPM. During the test, a tanker is weighed full and then dumps water for one minute. The tanker is then re-weighed and a GPM flow is calculated. The tanker dumps for another minute and is then re-weighed and a second GPM flow is calculated. The test continues in one-minute increments until the tanker is empty. For example, if a 2000-gallon tanker dumps 1700 gallons in the first 1-1/2 minutes and it takes another 1 minute to dump the remaining 300 gallons, then the critical dump time for the tanker is 1-1/2 minutes. Using this concept in a continuous flow operation, the driver/operator of the tanker should only dump for 1-1/2 minutes before heading to the fill site.

Based upon test results, the following critical dump times (CDT) are recommended:

	CDT	Method	Total	% Dumped	Avg.Rate
T-9	1 min.	rear dump	1265 gallons	84.3%	1265 GPM
T-14	2 mins.	rear dump	2692 gallons	89.7%	1346 GPM
	1.5 mins.	side dump	2688 gallons	89.6%	1075 GPM
T-17-1	2 mins.	rear dump	3176 gallons	90.7%	1588 GPM
	3 mins.	side dump	3095 gallons	88.4%	1032 GPM
T-17-2	3 mins.	rear 4-1/2"	1243 gallons	82.9%	414 GPM
	2 mins.	rear 6"	1315 gallons	87.7%	658 GPM

Test results show that with the exception of Tanker 17-2, the tankers can easily dump at rates greater than 1000 GPM provided the driver/operators stop dumping at the critical dump times. Tanker 17-2 had two significant problems. First, the built-in "jet dump" was out of service and the driver indicated that no effort was being made to have the feature repaired. With the jet dump in-service, off-load time would be significantly reduced. Second, the rear gravity dump appeared to be 10 inches in diameter but was reduced down to 6-inches, then to 4-1/2-inches. The tanker was tested using the 4-1/2 inch and 6-inch openings but the adapter could not be loosened in order to test the 10-inch opening. The 10-inch opening would most certainly improve off-load time to a value similar to Tanker 9. Unfortunately, this hypothesis could not be tested, therefore, it cannot be expected to happen at the fire scene either.

ISO Dump Test

The purpose of the ISO dump test is to see how long it takes to dump the contents of the tanker when operating in the water shuttle mode. The ISO dump test is a national model used in the evaluation of a fire department's ability to deliver a fire flow in a non-hydranted area. The test time starts 200-feet prior to the dump site and ends 200-feet past the dump site so that the "making and breaking" of hose and adapter connections is factored into the overall dump time. Therefore, if a tanker has to connect to a threaded hose and pump-off its load of water, one can expect to see a longer dump time than a tanker that simply gravity dumps off the side of the vehicle. A tanker that is slow to dump and slow to fill will adversely affect the overall shuttle operation regardless of its tank size.

The ISO dump test was conducted at PEPCO's Dickerson power plant using a measured course. Tankers with both side and rear dumps were evaluated using a simulated off-load scenario. Testing the rear dumps required the drivers to stop and back the vehicles to a designated spot prior to off-loading water. This operation was used to simulate the time taken when using rear dumps at portable drafting tank sites. Side dumps were evaluated by simply pulling next to the designated spot prior to off-loading water.

Testing results show that none of the tankers match their off-loading abilities as indicated in the one-minute off-load weight test results. Tanker 9's best ISO off-load was 756 GPM. Delays were encountered in having to stop and back-up the vehicle. Tanker 14's best ISO off-load was 994 GPM using the rear gravity dump. Delays were encountered in having to stop and back-up the vehicle as well as attach a discharge chute. Tanker 17-1's best ISO off-load was 921 GPM using the officer's side, air-operated, gravity dump. Tanker 17-1's rear gravity dump would most likely have been quicker, but the driver had some difficulty attaching the discharge chute. Tanker 17-2's best ISO off-load was 431 GPM using the rear 6-inch dump. The rear 4-1/2-inch dump provided poor performance during this test.

In general, the ISO off-load test is a realistic model that takes into consideration the actions of the driver/operator, the layout of the dump valves, and the processes by which water is off-loaded. The test serves as a standard by which tanker performance can be fairly compared. No special preparations were made for the Montgomery County's tests, each unit arrived at the PEPCO site and was tested based upon a "what you see is what will occur at the fire scene" principle. With training and some modifications to the rear dump systems, the ISO off-load times for each tanker could be improved.

ISO Fill Test

The purpose of the ISO fill-test is to see how long it takes to completely fill the tanker when operating in the water shuttle mode. Like the dump test, the ISO fill test is a national model for comparing tanker performance. The test time starts 200-feet prior to the fill site and ends 200-feet past the fill site so that the making and breaking of connections is factored into the overall fill time. Therefore, if a tanker has to use threaded connections to load its water, filling will be delayed. Some departments are equipped to fill "over the top" using some type of fill pipe into a tank vent. It is important to note for this test, "full" meant the evaluator saw water discharging from the tank overflow.

Test results show that all four tankers were unable to refill faster than they had dumped during the ISO off-load test. These results indicate that in an extended shuttle operation, the tankers would end up in line waiting to refill at the fill site, the least efficient place to be in a continuous flow operation. <u>Tankers need to be able to fill as fast, or faster, than they dump</u>. Tankers are meant to be in motion, otherwise their overall GPM contribution is significantly reduced. It is important to note one exception, however, during a continuous flow operation, the shuttle capacity may actually exceed the fire flow needed, therefore tankers may be lined-up waiting to dump; this is preferred.

All four tankers were tested using two methods. The first method used a hydrant only as the fill supply and the second method used a pumper as the fill supply. The hydrant method simulated the tankers refilling directly from a hydrant without the assistance of a pumper while using the tanker driver only to make and break connections. The second method simulated the tankers filling at a drafting site with a pumper providing the necessary flow and pressure. The second method allowed both the pumper driver and the tanker driver to assist in the making and breaking of connections. The ISO fill tests were conducted at PEPCO's Dickerson power plant using a measured course.

	Hydrant Direct Fill	**Pumper Fill Through Pump**
Tanker 9	*303 GPM	337 GPM
Tanker 14	507 GPM	343 GPM
Tanker 17-1	614 GPM	422 GPM
Tanker 17-2	342 GPM	236 GPM

*Tanker 9 has no direct fill capability. Instead, its 2-inch pump-to-tank fill line must be used to fill the tank.

Tanker 9 was the slowest tanker to fill, with a 303 GPM rate using the hydrant method. The problem with quickly refilling Tanker 9 is that there is no method to directly fill the tank. Refill operations must use the 2-inch pump-to-tank fill line via the midship mounted fire pump, the restriction in the piping and valving significantly impacts the ability for a quick refill. In addition, though the unit carries 4" LDH, it came to the test with no adapters to allow for a 4-inch line to feed from the hydrant (or pumper) to the tanker. When asked about using LDH to refill, Tanker 9's driver advised that Engine 91 had to be present to make that work. This is another example of the need for rural water supply training; it is not guaranteed that Engine 91 will always be the fill site engine filling Tanker 9. All connections made used threaded connections that took considerable time to make and break. Because of these problems, there was no significant difference between the hydrant fill and the pumper fill for Tanker 9.

Tanker 14's best ISO fill rate was 507 GPM using a 4-inch line from the hydrant into the rear direct fill connection. Again, threaded connections caused considerable delay in the filling process.

Tanker 17-1's best ISO fill rate was 636 GPM using a single, 3-inch line pumped into the rear direct fill connection. However, it must be noted that the 4-inch line from the hydrant into the rear direct fill resulted in a 614 GPM ISO fill rate. Again, the use of threaded connections caused considerable delay in the filling process.

Tanker 17-2's direct fill rate was the worst of the four tankers with a 342 GPM rate using a 3-inch line filling back through the rear dump. A test using the pump-to-tank fill line from the front mount pump was even slower at 236 GPM. Again, the use of threaded connections caused considerable delay in the filling process. There was some confusion over how to fill Tanker 17-2. The driver thought that the tanker could not be refilled through the rear dump, this was proven incorrect. Once again, this shows that more training is needed, because "what you see is what most likely will occur at the fire scene."

In general, the four tankers could all improve their refill capabilities. In the field of rural water supply, the general rule is that the smaller tankers are often faster to dump and fill, and in an extended shuttle operation, the small tankers will outwork the larger tankers. In Montgomery County, just the opposite is true. The two smallest tankers, absent any modifications to improve efficiency, will slow down the operation.

It is difficult to draw conclusions about what is the optimum size tanker. Nationwide, there is a wide variety of tankers and tanker operations. The key to tanker performance is the ability to off-load and refill equally fast. If a small tanker (1800 gallons or less) can dump and refill its tank each within a 90-second time limit, then that tanker's performance will most likely be maximized. Large tankers (greater than 1800-gallons) will provide optimum performance when they can dump and refill at a rate equal to, or greater than, 1000 GPM. Therefore, it is tanker design, not necessarily tanker size that is critical to optimum performance.

Properly designed large tankers should outwork smaller tankers or combination engine-tankers. Future tankers should be purchased with capacities of at least 2500 gallons, designed to dump and fill at a rate equal to or greater than 1,000 GPM. This will require all gravity dumps to be at least 10", an increase in tanker venting requirements, and the elimination of threaded connections on fill piping. We also suggest the addition of adequate lighting around all dump chutes for use by apparatus operators when positioning for dumping at night. End users have suggested that the Apparatus and Facilities Subcommittee reevaluate the need for large capacity pumps on tankers and the addition of a pre-connected master stream device to make them self sufficient.

ISO Continuous Flow Test

The purpose of the continuous flow test is to evaluate the tanker in a "real life" scenario where travel time must also be figured into the water delivery equation. The test uses a dump site and fill site that cause the tanker to complete a round trip similar to a shuttle operation. Time starts when the tanker begins off-loading water, and ends, when the tanker returns to the dump site full. The contributing GPM is then calculated based upon the total time needed to complete the cycle. Of all the tests conducted, the continuous flow test provides realistic data on the capabilities of the tankers. The continuous flow test was conducted at PEPCO's Dickerson power plant facility using a measured course. Each tanker was tested using a 1.6-mile round-trip and a 3.2 mile round-trip. From there, a linear equation can be developed to establish possible flow rates based upon round-trip travel mileage.

Test results showed that Tankers 14 and 17-1 provide the highest flow rate, 317 GPM and 386 GPM respectively for the 1.6-mile round-trip (248 GPM and 289 GPM at 3.2-miles). Tankers 9 and 17-2 were significantly lower with Tanker 9 providing 183 GPM at 1.6-miles and 128 at 3.2-miles. Tanker 17-2 provided 165 GPM at 1.6 miles and 113 GPM at 3.2 miles.

Extrapolation of test data provides the following delivery rates:

	1.6 miles	**3.2 miles**	**4.8 miles**	**6.4 miles**	**8.0 miles**
Tanker 9	183 GPM	128 GPM	73 GPM	18 GPM	0 GPM
Tanker 14	<u>317 GPM</u>	<u>248 GPM</u>	179 GPM	110 GPM	41 GPM
Tanker 17-1	<u>386 GPM</u>	<u>289 GPM</u>	192 GPM	95 GPM	0 GPM
Tanker 17-2	165 GPM	113 GPM	61 GPM	9 GPM	0 GPM

The data shows that it is difficult to maintain even a 250 GPM continuous flow using one of Montgomery County's big tankers if the round trip from the fill site to the fire scene and back to the fill site exceeds 3.2 miles. Therefore, it is critical that more than one tanker be dispatched on the initial assignment if water supply is to be more than a support function.

The battery of test results show that half of Montgomery County's tanker fleet is inadequate in providing a 250 GPM fire flow for any extended length of time. The two large tankers performed reasonably well in most aspects of the tests, however, refill operations prove to be the weak link in the operation. The two small tankers possess the potential to be good contributors to an extended shuttle operation, but they are set up to fail by not providing the equipment or the processes by which to dump and refill equally as fast. The tests also indicated a clear need for training on the fundamentals of rural water supply operations; the information taught in the Pumps Course at the Public Services Training Academy (PSTA) is insufficient for understanding the demands of shuttle operations.

Supply Line Hose

In all areas of Montgomery County where municipal water is available, fire suppression water is provided by pumpers laying one or more supply line(s) to or from nearby fire hydrants. The amount of water available is dependent upon the number of lines laid, the appliances available to adapt to various hose combinations, and most importantly, the diameter of the hose lines.

No standard complement of supply line is required by any policy within MCFRS. Most pumpers in Montgomery County are equipped with 3-inch supply lines. Each Local Fire Rescue Department determines the hose compliment to be utilized on their apparatus. The WSWG has determined that a typical supply line configuration consists of two 800-foot beds of 3-inch hose, connected in the middle to permit a single long lay, or dual unconnected supply lines for larger flows. Some departments carry less than 800 feet and some carry up to 1,000 feet in each bed.

A single 3-inch supply line will accommodate fire flows in the 400 GPM range. Placing a pumper at the hydrant to boost the pressure and flow in the line can increase this flow. However, rated pump capacity will never be achieved since the final quantity of water available is limited to the amount that can be forced through one or two 3-inch lines. When higher required fire flows are necessary, dual lines are deployed to enable fire flows nearing 1000 GPM.

Existing procedures have served the system well except when units try to lay long lines creating excessive friction losses, or when flows greater than 800-

1000 GPM are expected. This problem is not limited to rural areas of the county. Montgomery County units rarely achieve the full potential of their pumping ability on the fire ground. Montgomery County utilizes material developed and published by the Maryland Fire Rescue Institute, (MFRI), University of Maryland, as the foundation for pump operator training. MFRI recommends that supply lines be limited to 600 feet in length when utilizing 3 inch supply line. Lays longer than 600 feet require pumpers placed at 600 feet intervals to relay water at net pump pressures that will assure adequate GPM flows. Units in Montgomery County frequently ignore this fundamental recommendation, and, therefore, fail to maximize the efficient use of available water, regardless of the water source[5].

The WSWG recommends that Montgomery County pumpers carry a standard hose complement that is designed to maximize the capability of the apparatus. Even though the risks throughout the county are diverse, the resources necessary for fire suppression units to deliver water rapidly and efficiently should be the same. This does not imply that one size fits all. It does imply that to be efficient, all units should work with similar, if not the same, hose complements, and that our procedures for implementing a water supply should be standardized to the point where we can uniformly train and share resources when required.

The WSWG recommends that the MCFRS move to a standard supply line complement on engines in both rural and urban areas of the county. We recognize that it may be necessary to carry different quantities of hose based upon local needs. The emphasis being that the MCFRS invest in the future by eliminating different hose diameters, appliances, couplings and such so that a well-honed, efficient water delivery system can be rapidly initiated and expanded anywhere in the county with any combination of available units.

Friction Loss in Fire Hose

It is well known that friction loss is the enemy of the fire department when moving water. Actual friction loss in fire department hoses is determined by a variety of factors that include materials used in the construction of the hose, manufacturing techniques, age, condition, and care of the hose, liners, and couplings. However, for the purpose of this report, we will limit our discussion to two primary factors. They are:

- The diameter of the hose, and
- The length of the hose lay

[5] Many pump operators and command officers believe that required fire flows can be delivered when excessively long lays are established. This is simply not true and the practice should be discontinued. Reasonable limits for length of hose lays must be established based upon the hose diameter being utilized, and the amount of water desired.

Pump operators are taught that the relationship between hose diameter and friction loss is exponential. Therefore, a small increase in hose diameter results in a large increase in available GPM flow and a considerable decrease in net PSI required to deliver the flow. This is a win-win combination that cannot be ignored. Simply stated, larger diameter hose will enable fire department units to move larger volumes of water over greater distances at lower pressures.

The NFPA 18th edition of the Fire Protection Handbook lists the following relative hose carrying capacities of different diameter hoses at normal operating pressures:

1-3 inch – supply line 350 GPM
1-4 inch – supply line 750 GPM
1-5 inch – supply line 1300 GPM

The following flows are achievable **at 150 PSI net pump pressure with 1,000 feet between pumps**[6]. These numbers are more applicable to our operations in Montgomery County since the MCFRS deploys a pumper at the hydrant. They are:

1-3 inch – supply line 400 GPM
1-4 inch -supply line 800 GPM
1-5 inch - supply line 1,600 GPM

In other words, these are the flows that can reasonably be achieved when the length between pumps is limited to **1,000 feet** and the net pump pressure is restricted to approximately **150 PSI.** The MCFRS sometimes fails to account for these two critically important benchmarks. Frequently, units attempt to lay a single line that is too long for the required flow. The planned intent to violate this rule is evidenced by pumpers that continue to carry supply line hose in dual beds that are connected. Clearly, the expectation is to lay a single line longer than 800-1000 feet, with no break in the middle for a relay pumper. In other instances, apathy and laziness prevent unit officers from deploying dual lines when higher flows will potentially be needed. By the time the need for additional flow is recognized, laying additional lines is impractical. The steps necessary to expand the water supply at this point are so labor intensive and time consuming, the fire gains too much headway to be properly managed.

Many times the water capacity of a hydrant system is blamed by fire service personnel for a shortage of water on the fire ground. In reality, most of these problems can be alleviated by a proper hose evolution above the ground. Because the intake gauge on a pumper reads "0 PSI" doesn't necessarily mean that there is no more water available from the hydrant. Typically, the water is

[6] It is critically important to understand that these flows can vary considerably between hose manufacturers. It is not uncommon to experience actual flow tests that differ by plus or minus 20%.

"trapped" in the underground main because of an unrealistic hose evolution above the ground. Large diameter hose lays can help the fire department utilize this unused water. However, there are disadvantages to operating with large diameter hose.

Large Diameter Hose

The National Fire Protection Association considers any hose with an inside diameter larger than 3 ½ inch to be large diameter hose, (LDH). Four and five inch hose are the most common sizes utilized by municipal fire departments, even though current technology permits construction of hose up to 12 inch in diameter. Six-inch diameter LDH is gaining popularity in many industrial applications[7]. Many fire departments, including most of those in Montgomery County have strongly resisted the transition to large diameter hose.

As a general rule the flow doubles between 3-inch and 4-inch hose; and doubles again between 4-inch and 5-inch hose. This is a powerful comparison that cannot be discounted. From the efficiency perspective, a single 4-inch hose line will accomplish what two 3-inch hose lines will. If the service is willing to adapt to the difficulties and limitations of 5-inch or larger hose, this increase in efficiency is even more dramatic. Replacing dual 3-inch supply lines with a single 4-inch supply line can result in savings that can be utilized elsewhere.

The success of initial attempts to utilize large diameter hose in Montgomery County is still debated. The WSWG is describing those experiences in this report for completeness. We would recommend that any future evaluation of LDH and its working components are conducted from a fresh starting point for a number of reasons.

Improvements in the design, manufacture, and implementation of LDH systems have improved many fold in recent years. Early attempts to utilize LDH in Montgomery County dates to the 1970's. Rejection of the concept now based upon the problems encountered then would simply not be a clear and fair evaluation.

The Kensington Fire Department operated a converted reserve pumper running as Water Supply 21 that was specially equipped with 2,000 feet of 5" hose and a variety of appliances designed to accommodate a hydrant problem in Old Town Kensington. This unit was also available and sometimes utilized to expand water supplies for other departments who requested Kensington's assistance. Most often WS-21 was requested by other departments on multiple

[7] Hose larger than 5 inches in diameter is normally considered to be too difficult to handle without apparatus specifically designed to deploy the hose. In addition, safety becomes a key variable when moving water through large diameter hose at pressures necessary for fire department use.

alarm fires. The benefits of the LDH were rarely utilized early in an incident where the full potential of the LDH could be realized. Because the unit was a specialty piece of apparatus, other departments had a limited familiarity with the unit, or the proper utilization of the equipment. This unit is no longer in service.

The Gaithersburg-Washington Grove Fire Department carried 1,000 feet of 5-inch supply line in the 2nd bed of E-81 to be used primarily as a means to supply the elevated master stream on Tower 8, and as a large flow supply line in limited areas where hydrants were not readily available. Problems encountered with dressing out the hydrant when laying dual lines, and lack of compatibility with neighboring units eventually led to the hose being moved to the reserve pumper at FS-8, and then to a military 4x4 for rural operations. The hose was finally taken out of service due to age and condition. Most employees recognized the benefits of the hose but were frustrated with adapting to the special appliances and handling characteristics necessary to set-up. As the work force became more transient, training became difficult to manage, and these problems were exasperated. The LDH was taken out of service in 1996.

Currently, 4-inch large diameter hose is in use at Fire Stations 2 (Takoma Park), 4 (Sandy Spring), 9 (Hyattstown), 11 (Glen Echo), and 40 (Sandy Spring).

Takoma Park FS-2 has utilized 4-inch hose in an urban environment since the early 1980's with good success. FS-2 pumpers operate with 1,600 feet of 4-inch supply line arranged in a single bed with storz connections[8]. Since FS-2 operates near several political jurisdictional boundaries, they carry several appliances that permit neighboring companies to adapt back and forth between conventional threaded coupling 3-inch lines and the enhanced storz couplings. In addition to the 1600 feet of 4-inch supply line, several short lengths of 4-inch hose are carried to improve operational efficiency around the pumper. For easy access to fire department connections, FS-2 units also carry 400 feet of 3-inch hose for a variety of other uses.

Sandy Spring FS-4 and FS-40 currently operate with dual 1,000 foot beds of 4-inch supply line on their pumpers. After an attempt to utilize 5-inch hose, the department chose to sell that hose and switch over to 4-inch. In a meeting with Sandy Spring personnel, they strongly recommend that two beds of LDH be available for use. Justification for this recommendation is based upon the ability for each pumper to be self-sufficient. Laying two lines from the same unit assures that each pumper can supply their rated pump capacity from separate water supply points. This argument is not without merit and should be fairly considered in future evaluations of LDH systems. However, nearly every other application of 4 inch hose evaluated by the WSWG more closely reflects the Takoma Park model.

[8] A Storz connection is a quarter turn coupling that does not have conventional threads. This is significant in that the ends of the hose are "sexless". The time required to make and break connections is reduced considerably. In addition, the need to adapt back and forth between male and female ends is eliminated.

Hyattstown FS-9 carries 1,000 feet of 4-inch hose on Tanker 9 for rural use. The leadership at FS-9 have struggled to agree on the optimum utilization of the LDH and have moved the hose from E-91 to Tanker-9 and back on several occasions. The WSWG believes that predominantly rural areas can benefit significantly from the proper use of LDH. The MCFRS, however, must first overcome the outdated notion that there is not sufficient water available to fill the hose.

The Glen Echo Fire Department currently carries 800 feet of 5-inch supply line on E-112 along with 800 feet of 3-inch line that is used as the primary supply line. No published SOP is available for its use. Few command officers are aware that this hose is available. Recently this unit and the LDH was utilized on a large mansion fire in a rural portion of Fairfax County, VA. Comments from end users reveal compatibility problems with other units, and lack of specific training on LDH capabilities and limitations.

The primary disadvantage of large diameter hose lies in the ability to handle the hose in a variety of applications. Personnel complain that it is more difficult to repack, weighs too much, and is difficult, and sometimes impossible, to move once filled with water. Others argue that apparatus cannot cross the line once charged without special hose ramps. Still others believe that it is impossible to load the lines flat without trapping air in the line. These arguments are outdated in that new techniques, special appliances, and reels have been developed to mitigate these concerns. Most of our personnel who have operated with LDH have done so in an environment where the apparatus and equipment was non-standard. Training on the correct application and use of the hose was limited. Therefore, many departments utilizing LDH have not had the opportunity to use it to its full potential.

Safety arguments have been raised in the past regarding the integrity of couplings and the tendency for LDH to kink and twist at the end of the supply-line. These problems have been eliminated with locking safety lugs and swivel connections on the pumpers. New lightweight couplings have helped, as well. Many end users are not familiar with these changes and regard LDH as an unacceptable component in the fire-fighting arsenal. In reality, the opposite is true. Using the locking, swivel type, Storz connections, LDH improves both safety and efficiency.

Many departments across the country choose 5-inch over 4-inch for high capacity above ground water delivery. The WSWG believes that 5-inch supply line would not meet the expectations of the service, particularly in urban areas where establishing a water supply from a hydrant is more common. Buy-in from the end users would be difficult, as experienced in the Sandy Spring, Gaithersburg, and Kensington trials of the past. This is not to say that a few specialty pumpers designed specifically for 5-inch or 6-inch LDH could not successfully be utilized, particularly in rural areas. However, the common request from all parties interviewed in this effort has been to standardize applications for increased efficiency and standard training. The WSWG strongly supports both of these requests and submits that 4-inch supply line is the way to accomplish these goals. It is the closest thing to a one size fits all solution presently available. ***The WSWG recommends that the MCFRS initiate a goal to switch over to 4-inch large diameter hose as the standard supply line.*** The MCFRS should expect a training liability if this recommendation is adopted. The majority of our workforce both volunteer and career has limited experience with the components of a large diameter hose system. Nonetheless, this should be easily achieved with a quarterly in service training schedule that is expanded to accommodate the volunteer employees, as well.

In local departments where a hose replacement program is in place that meets recommended standards, hose is tested annually. Hose is replaced if it fails a static pressure test, or automatically at the end of ten years service. All fire fighting hose should be on a ten-year replacement cycle to meet the hose testing standard. Hose testing speaks directly to the reliability of our fire fighting operations. A burst section of hose on the fire ground can have catastrophic results. At this writing, the Division of Fire and Rescue Services is preparing a standard hose testing package that is fully NFPA compliant. Screw down type gate valves have been purchased for distribution to the five districts for use where local resources are not provided. ***The WSWG recommends that all fire fighting hose be tested annually in compliance with NFPA-1962, The Standard for the care, Use and Service Testing of Fire Hose, Including Couplings and Nozzles.***

Appliances

Appliances that adapt to and from the variety of water sources are necessary to assure efficiency on the fire ground. As proven in the tanker evaluation tests, time wasted making and breaking connections can have an adverse impact on overall efficiency.

This is particularly true in Montgomery County where the components are non-standardized. Standardization of critical components in the past decade is slowly eroding by permitting Local Fire Rescue Departments to purchase apparatus, hose, and appliances that do not meet county specifications prepared by the Apparatus Specifications Committee. These changes create difficult training and certification problems for a transient workforce.

The WSWG recommends that all LFRD apparatus specifications prepared for purchase be reviewed by the apparatus specifications committee to assure that essential components are standardized.

By far, the most time consuming process in establishing a water supply is the making and breaking of threaded hose connections. The fire service has overcome this problem with attack hose by pre-connecting lines around the apparatus to perform a variety of functions. However, when laying supply lines, this process slows the operation down considerably.

Large diameter hose is shipped with sexless quarter turn couplings. Although these couplings are available from a number of manufacturers, they have become known by the trade name of one manufacturer, Storz. More recently, these couplings have been equipped with locking safety lugs and swivels that enhance safety, and prevent the line from twisting shut when charged.

The WSWG recommends that all future supply line be purchased with quarter turn couplings, and equipped with locking safety lugs. In addition, we recommend connections on both ends of the hose lay be equipped with swivels to prevent the charged line from accidentally unlocking.