Airtanker Drop Guides

Ground Pattern Performance of the National Guard Black Hawk Helicopter With the 660-Gallon SEI Industries Bambi Helibucket

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The Wildland Fire Chemical Systems (WFCS) Program tests a variety of fixed- and rotary-wing airtankers to determine the parameters for optimal ground-pattern coverage over a wide range of fuel and fire conditions. The National Guard Sikorsky S-70 (military version is the UH-60) Black Hawk helicopter with the 660-gallon SEI Industries Bambi helibucket (referred to as the National Guard Black Hawk with 660-gallon Bambi helibucket) is one of a family of helicopters designed for fire suppression with a helibucket. It is qualified as a Type 1 helicopter (figure 1).

The helibucket is constructed of a heavy, coated fabric mounted to a collapsible frame. The dump valve (20 inches in diameter) is electrically actuated from the helicopter using 28 volts dc aircraft power. The bucket's maximum volume is 660 gallons with a maximum fill height of 53 inches. The volume of a given drop can be controlled by the rate at which the helibucket is lifted from the water (faster lift produces more volume) or by adjusting a cinch strap inside the helibucket.

The Missoula Technology and Development Center tested the National Guard Black Hawk with 660-gallon Bambi helibucket with a series of drops over an array of plastic bowls much like Cool Whip containers. The quantity of material in each bowl was measured and the data were used to determine the drop pattern.

Tests included airspeeds from 40 to 88 knots (46 to 101 miles per hour) and drop heights from 73 to 170 feet from the bottom of the tank to the ground. The drops were made with three

Figure 1—The National Guard Black Hawk with 660-gallon Bambi helibucket.

different materials: water, foam, and gum-thickened retardant.

Flow rate, drop height, and airspeed all affect the drop pattern. Because this type of helicopter is normally used over a narrow range of heights and speeds and because this system produces a single flow rate, information about an average drop is presented. Figures 2, 3, and 4 show the effect of drop height while

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Gum-thickened retardant at an airspeed of 57 knots,
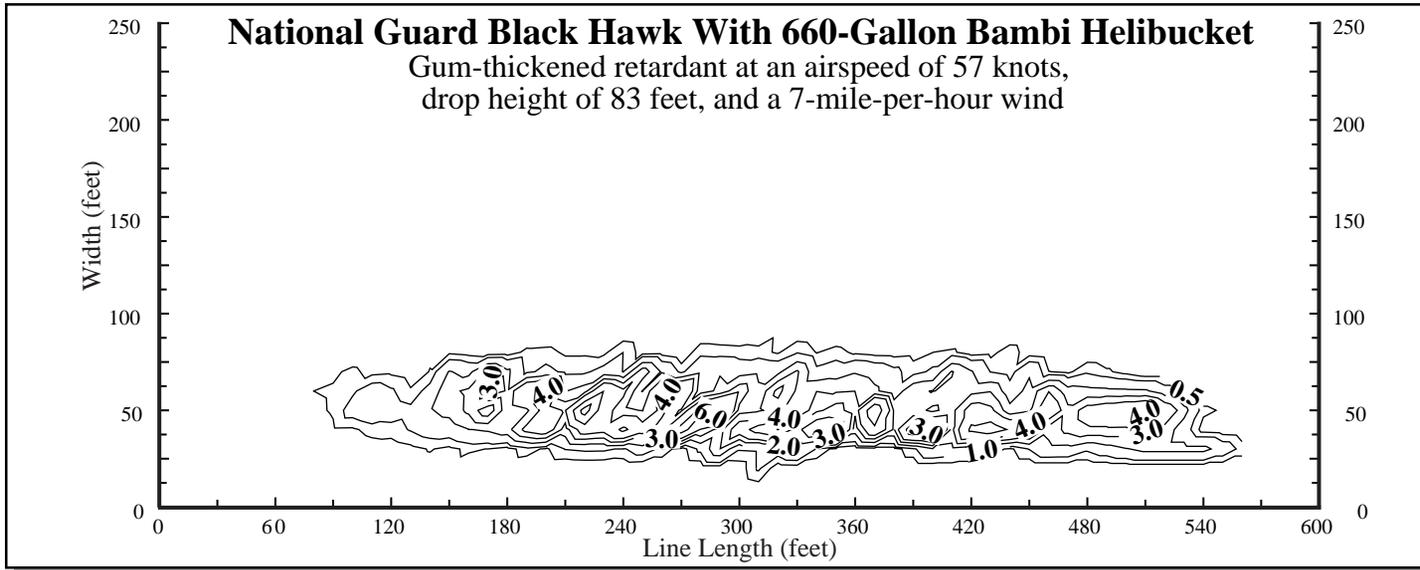drop height of 83 feet, and a 7-mile-per-hour wind

Figure 2—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using gum-thickened retardant at an airspeed of 57 knots (66 miles per hour) and a drop height of 83 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Gum-thickened retardant at an airspeed of 56 knots,
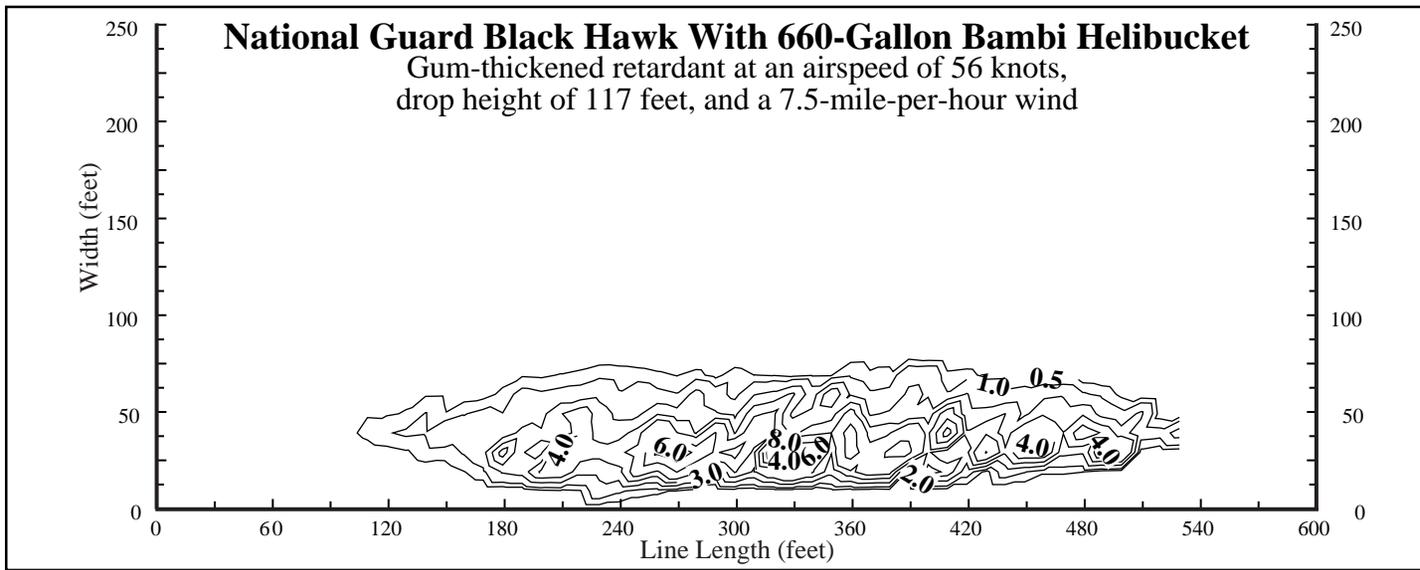drop height of 117 feet, and a 7.5-mile-per-hour wind

Figure 3—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using gum-thickened retardant at an airspeed of 56 knots (64 miles per hour) and a drop height of 117 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Gum-thickened retardant at an airspeed of 59 knots,
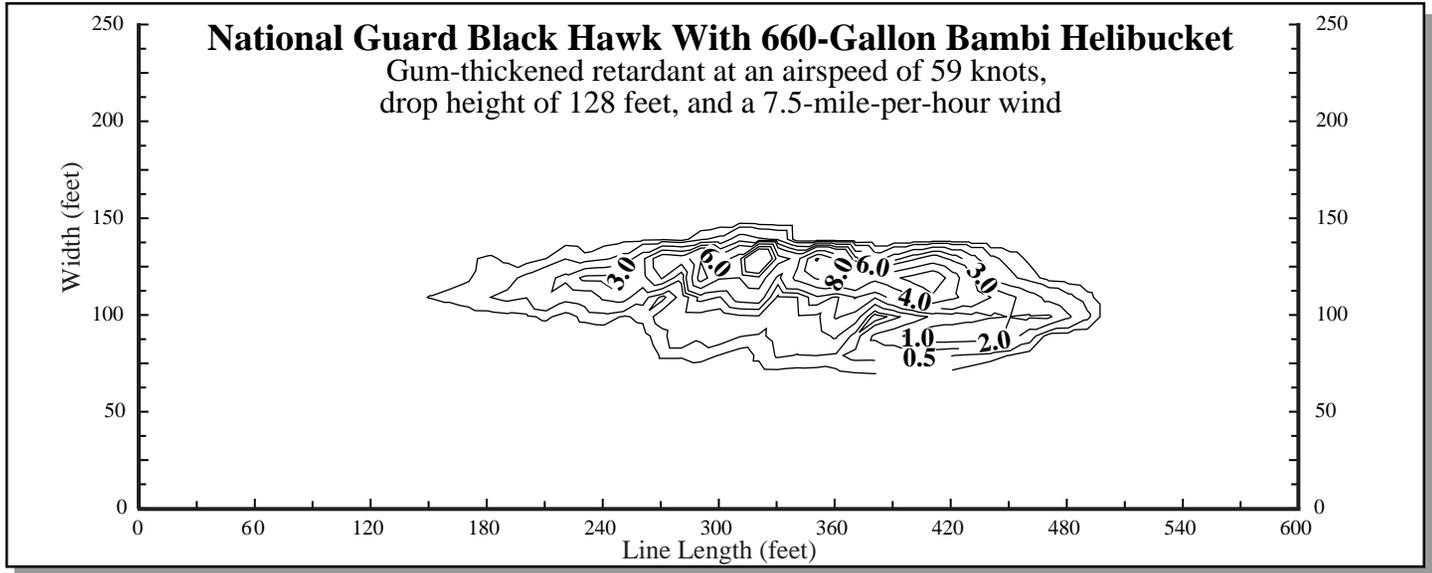drop height of 128 feet, and a 7.5-mile-per-hour wind

Figure 4—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using gum-thickened retardant at an airspeed of 59 knots (68 miles per hour) and a drop height of 128 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

maintaining airspeeds between 57 to 59 knots (65 to 68 miles per hour) with drop heights ranging from 83 to 128 feet while using gum-thickened retardant. Figures 5, 6, and 7 show the effect of increasing airspeed from 42 to 81 knots (48 to 93 miles per hour) while maintaining the drop height between 138 and 149 feet.

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Water at an airspeed of 42 knots,
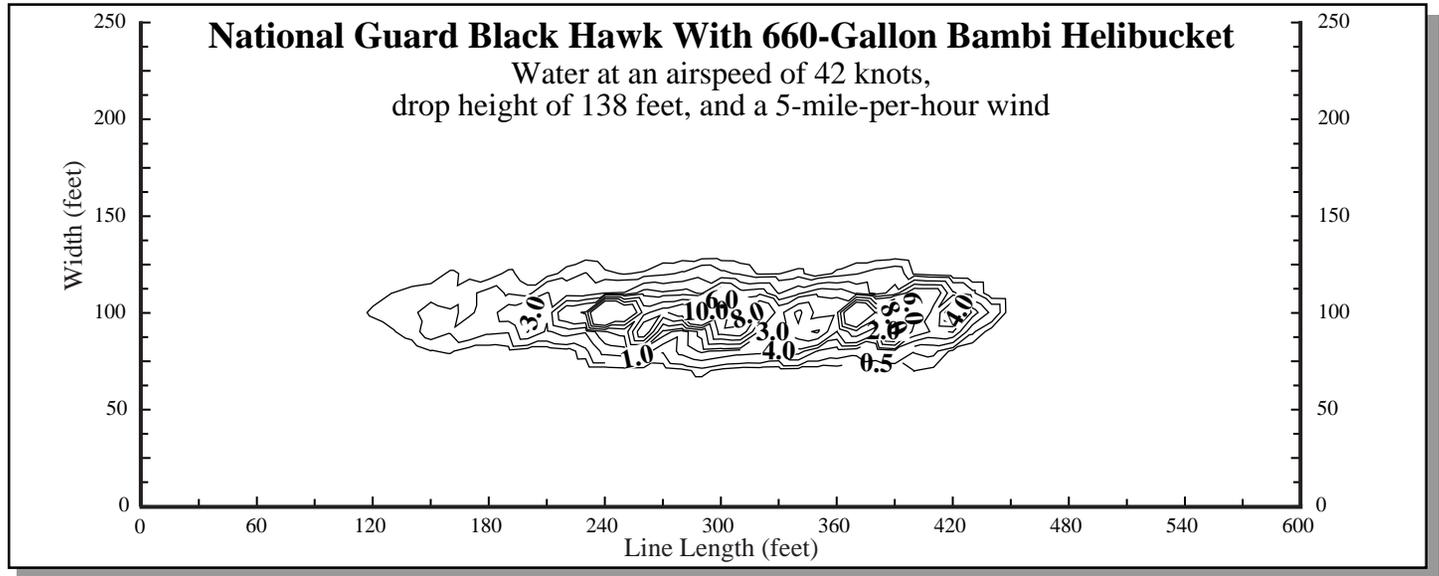drop height of 138 feet, and a 5-mile-per-hour wind

Figure 5—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using water at an airspeed of 42 knots (48 miles per hour) and a drop height of 138 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Water at an airspeed of 50 knots,
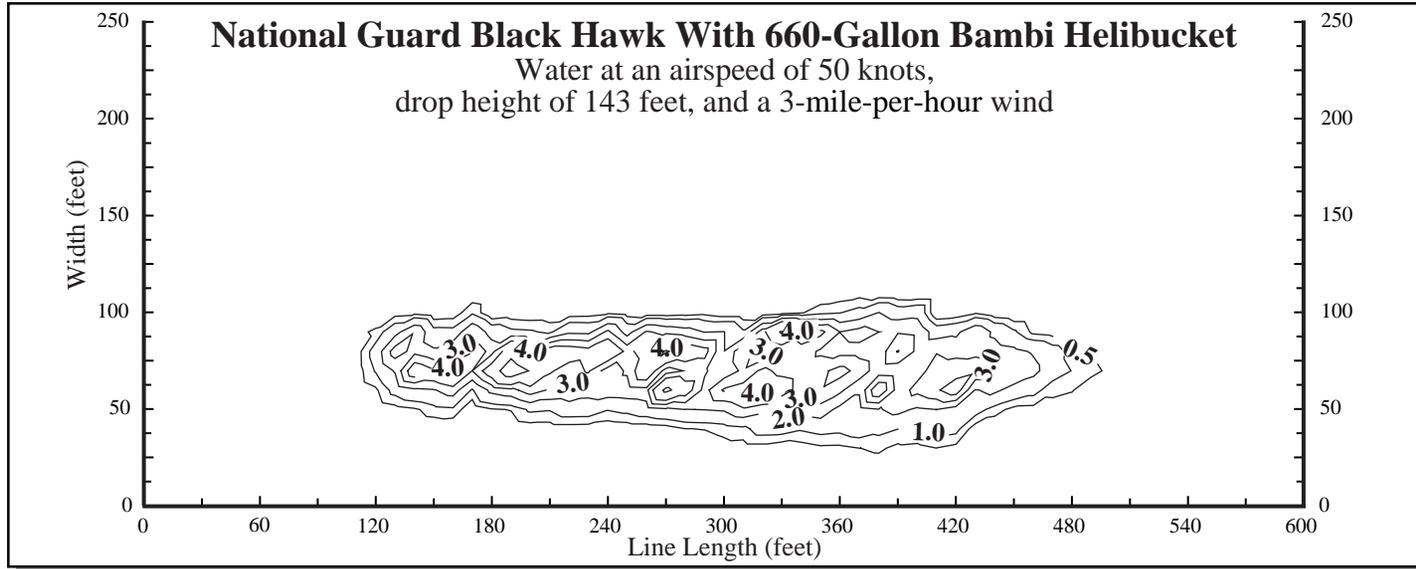### drop height of 143 feet, and a 3-mile-per-hour wind

Figure 6—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using water at an airspeed of 50 knots (58 miles per hour) and a drop height of 143 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

National Guard Black Hawk With 660-Gallon Bambi Helibucket
Water at an airspeed of 81 knots,
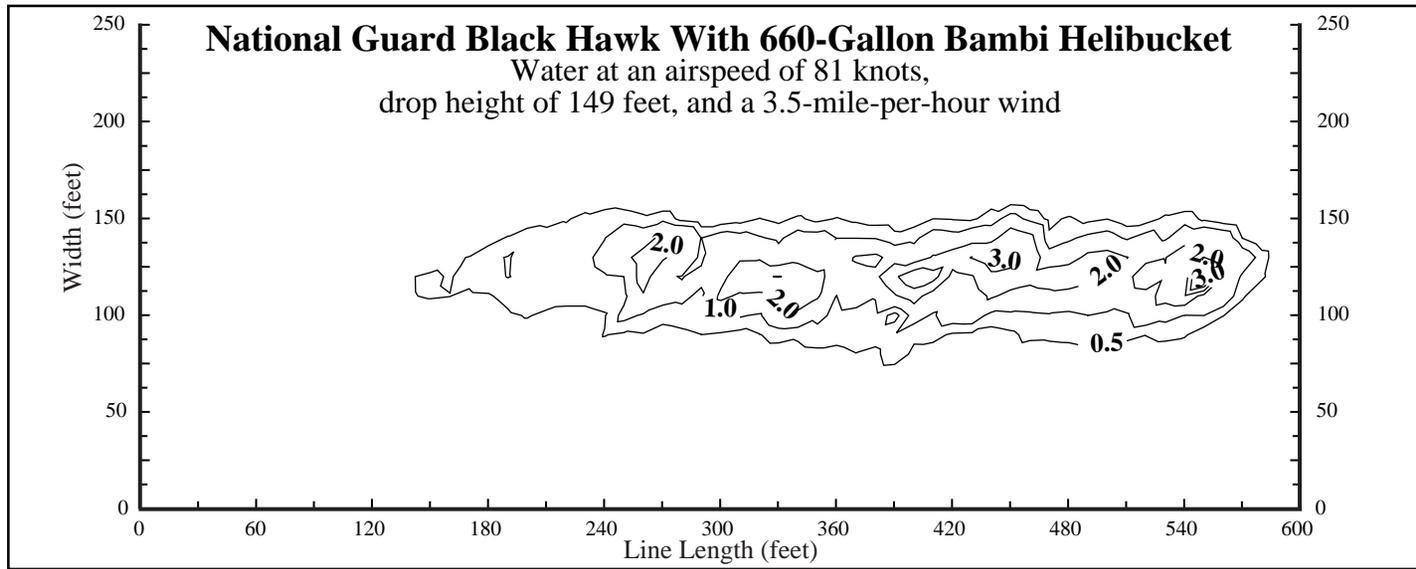### drop height of 149 feet, and a 3.5-mile-per-hour wind

Figure 7—Drop pattern characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket using water at an airspeed of 81 knots (93 miles per hour) and a drop height of 149 feet. The contour lines are at coverage levels of 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet.

The proper amount of fire-retarding materials to be applied (expressed as coverage level in gallons per 100 square feet) differs depending on the fuel model. Table 1 shows the coverage needed for specific fuel models using both the National Fire Danger Rating System (NFDRS) and Fire Behavior Fuel Model descriptions.

The results of drop tests allow managers to estimate the length of line a specific helicopter with a particular bucket produces at various coverage levels. Table 2 or figures 8 and 9 can be used to determine the drop height and airspeed of a water drop required to obtain the longest line at each coverage level. Table 3 or figures 10 and 11 can be used to determine the drop height and airspeed of a foam drop required to obtain the longest line at each coverage level. Table 4 or figures 12 and 13 can be used to determine the drop height and airspeed of a gum-thickened retardant drop required to obtain the longest line at each coverage level.

Table 1—The retardant coverage needed for specific fuel types.

| Fuel Model | | Coverage Level (gal/100 ft²) | Description |
National Fire Danger Rating System (NFDRS)	Fire Behavior		
A, L, S	1	1	Annual and perennial western grasses, tundra
C	2		Conifer with grass
H, R	8	2	Shortneedle closed conifer; summer hardwood
E, P, U	9		Longneedle conifer; fall hardwood
T	2		Sagebrush with grass
N	3		Sawgrass
F	5	3	Intermediate brush (green)
K	11		Light slash
G	10	4	Shortneedle conifer (heavy dead litter)
O	4		Southern rough
F, Q	6	6	Intermediate brush (cured), Alaska black spruce
B, O	4		California mixed chaparral, high pocosin
J	12	Greater than 6	Medium slash
I	13		Heavy slash

Table 2—Water tests producing the longest line at various coverage levels.

Coverage Level (gal/100 ft²)	Line Length (feet)	Drop Height (feet)	Airspeed (knots)
0.5	528	111	84
1	502	111	84
2	385	111	84
3	350	92	60
4	285	102	46
6	216	78	40
8	202	78	40
10	176	78	40

Effect of Airspeed on the Length of Line at Various Coverage Levels
National Guard Black Hawk with 660-gallon Bambi helibucket using water

Figure 9—Use this graph to estimate the airspeed needed to provide the longest line of water at various coverage levels.

Effect of Drop Height on the Length of Line at Various Coverage Levels
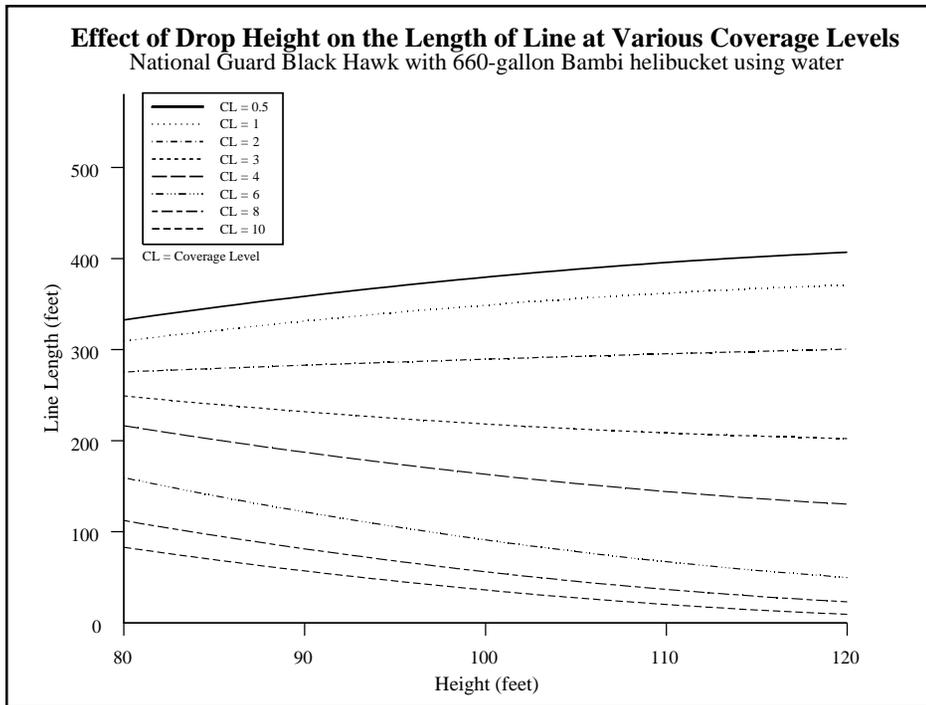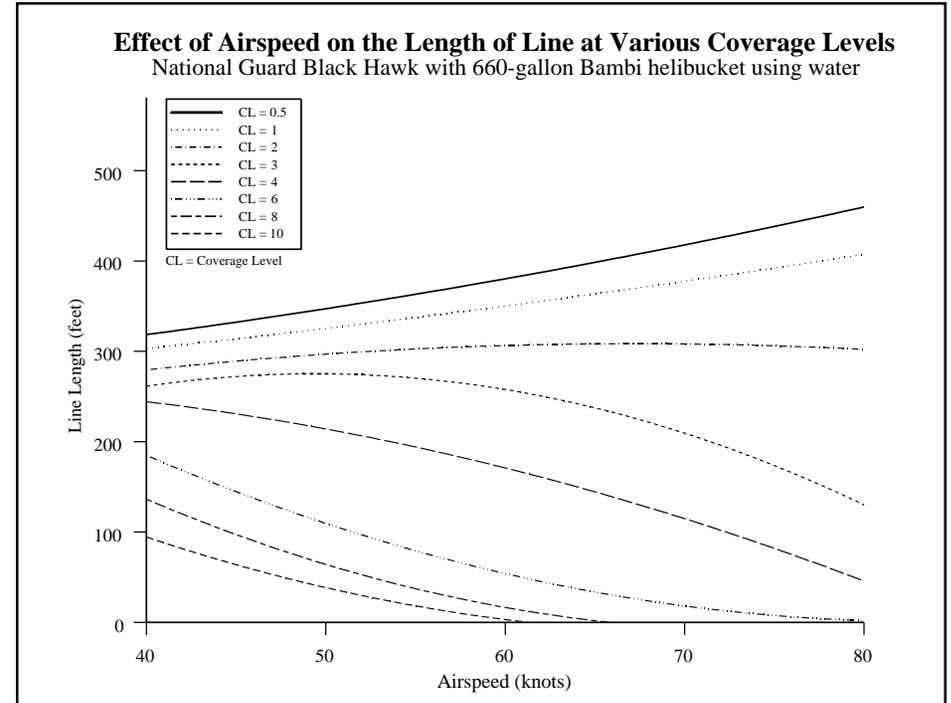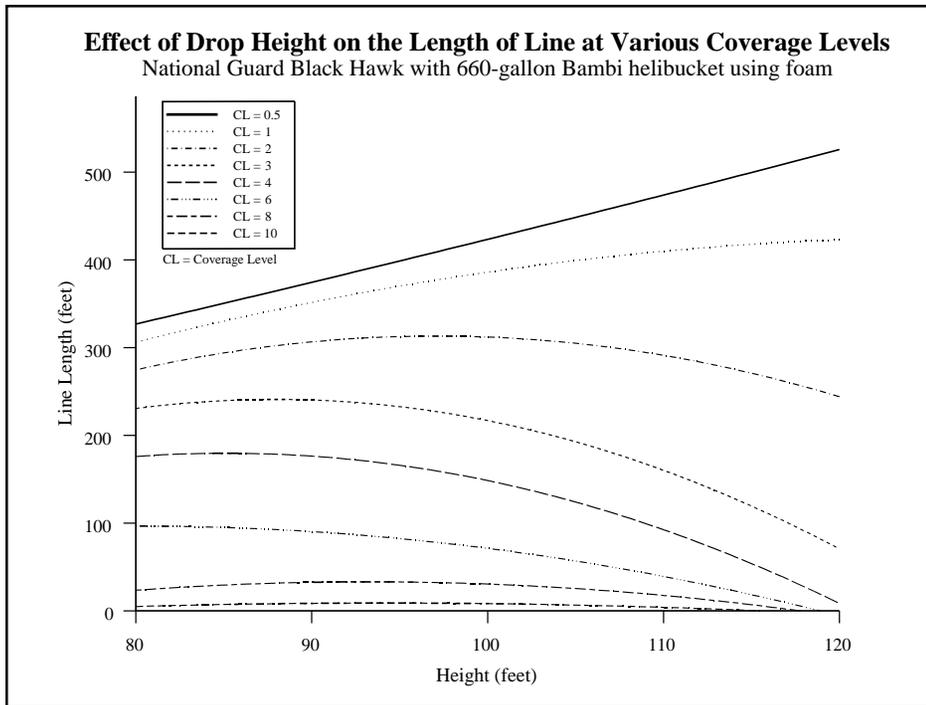National Guard Black Hawk with 660-gallon Bambi helibucket using water

Figure 8—Use this graph to estimate the drop height needed to provide the longest line of water at various coverage levels.

Table 3—Foam tests producing the longest line at various coverage levels.

Coverage Level (gal/100 ft²)	Line Length (feet)	Drop Height (feet)	Airspeed (knots)
0.5	533	118	80
1	447	107	82
2	333	92	61
3	295	92	61
4	231	92	61
6	176	92	41
8	105	92	41
10	32	92	41

Effect of Airspeed on the Length of Line at Various Coverage Levels
National Guard Black Hawk with 660-gallon Bambi helibucket using foam

Figure 11—Use this graph to estimate the airspeed needed to provide the longest line of foam at various coverage levels.

Effect of Drop Height on the Length of Line at Various Coverage Levels
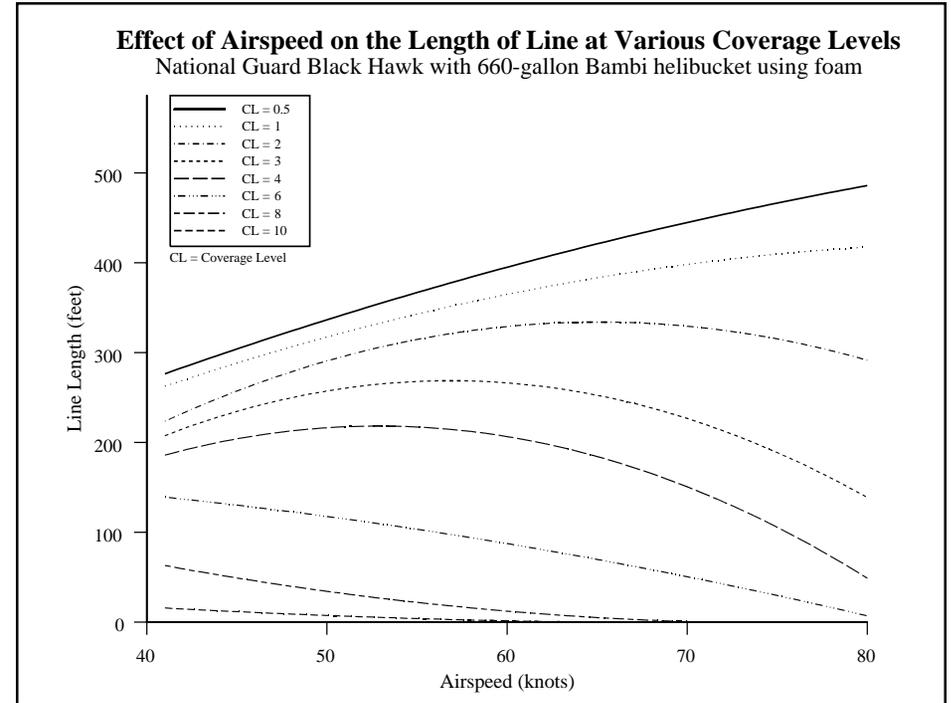National Guard Black Hawk with 660-gallon Bambi helibucket using foam
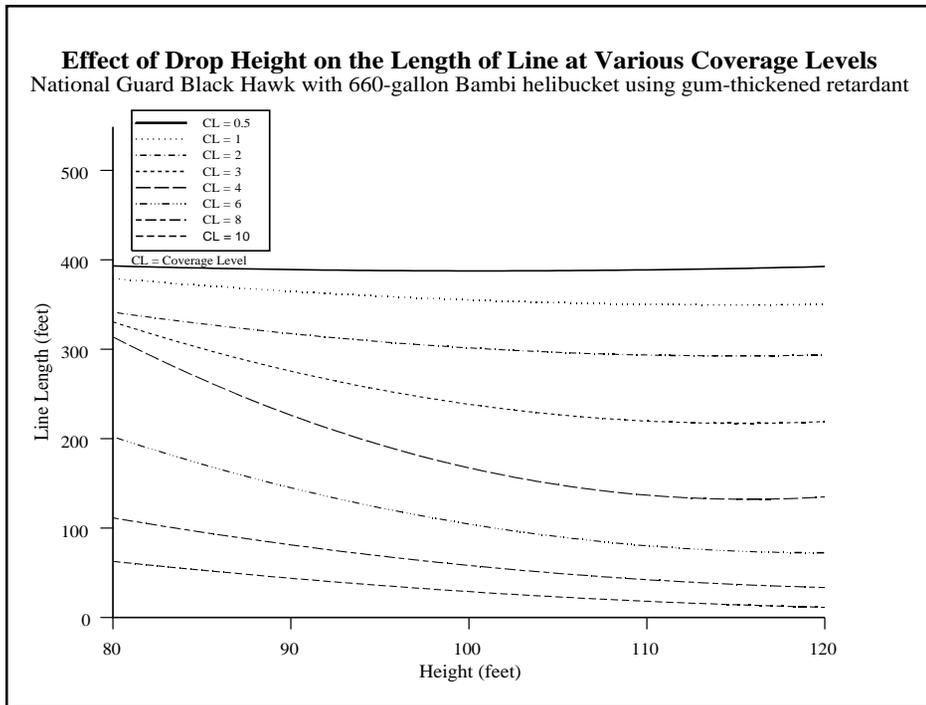
Figure 10—Use this graph to estimate the drop height needed to provide the longest line of foam at various coverage levels.

Table 4—Gum-thickened retardant tests producing the longest line at various coverage levels.

Coverage Level (gal/100 ft²)	Line Length (feet)	Drop Height (feet)	Airspeed (knots)
0.5	487	131	79
1	462	83	57
2	399	83	57
3	363	83	57
4	313	83	57
6	231	86	48
8	189	86	48
10	123	86	48

Effect of Airspeed on the Length of Line at Various Coverage Levels
National Guard Black Hawk with 660-gallon Bambi helibucket using gum-thickened retardant

Figure 13—Use this graph to estimate the airspeed needed to provide the longest line of gum-thickened retardant at various coverage levels.

Effect of Drop Height on the Length of Line at Various Coverage Levels
National Guard Black Hawk with 660-gallon Bambi helibucket using gum-thickened retardant

Figure 12—Use this graph to estimate the drop height needed to provide the longest line of gum-thickened retardant at various coverage levels.
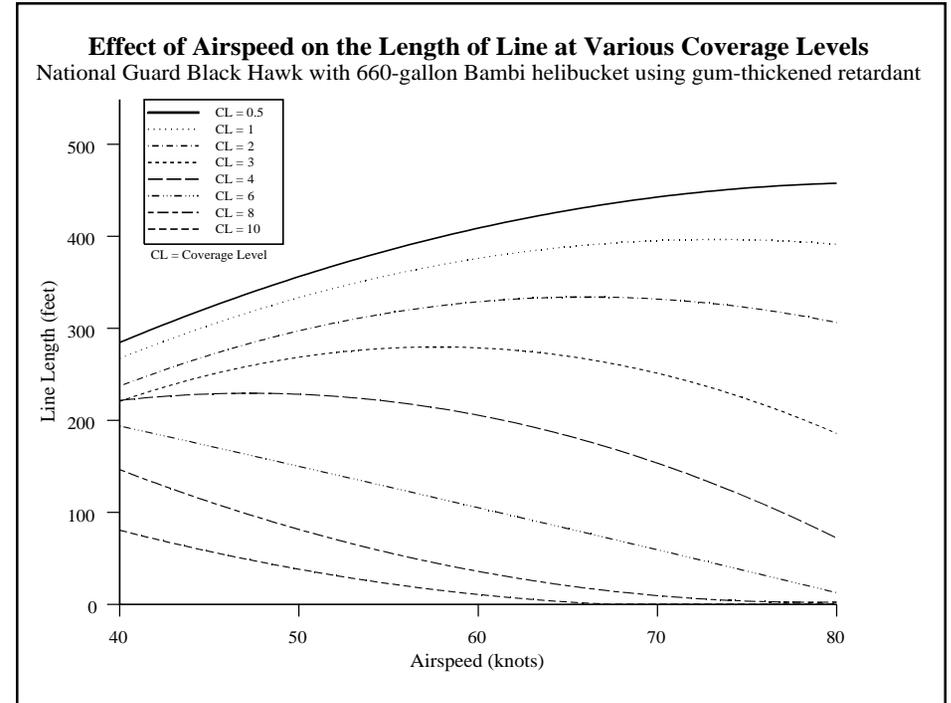
The line-length graphs predict line length (in feet) as a function of drop height (in feet) and airspeed (in knots). The tables are constructed by selecting the drop producing the longest line at each coverage level. Either the graphs or tables may be used to estimate the drop height and airspeed required to produce the longest line for a given coverage level. The tables show an ideal case, while the graphs represent an average.

To select the proper drop height or airspeed, first use table 1 to determine the coverage level required by the NFDRS or Fire Behavior Fuel Model. The coverage levels in table 1 represent the coverage level required for average fire intensity for each fuel model. The required coverage level can be adjusted up or down depending on the actual fire intensity. Once the required coverage level is determined, the drop height and airspeed can be found. Use the table for the material dropped (water, foam, or gum-thickened retardant) to find the drop height and airspeed that produce the longest line for the desired coverage level. The same information can be found in the appropriate drop table.

For example, if a fire is burning in NFDRS Fuel Model H, R (Fire Behavior Model 8), represented by shortneedle closed conifer or summer hardwood, table 1 shows that a coverage level of 2 is required. The table for gum-thickened retardant (table 4) shows that for coverage level 2, a drop height of approximately 83 feet and airspeed of 57 knots (66 miles per hour) produces the longest line (399 feet).

The ground drop characteristics for the National Guard Black Hawk with 660-gallon Bambi helibucket were derived through controlled test drop procedures on flat ground (figure 14). This information is to serve only as a guide in assisting field personnel to determine the proper drop height and airspeed for delivering water, foam, or gum-thickened retardant. Actual coverage may vary depending on terrain, wind, weather, and pilot proficiency.

Figure 14—Drop test of the National Guard Black Hawk with 660-gallon Bambi helibucket using water.

About the Authors...

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Paul Solarz is Program Leader for the Wildland Fire Chemical Systems Group. He received his bachelor's degree from Eastern Oregon State College in 1986. Paul has worked in Aviation and Fire Management since 1973, serving at seven Ranger Districts and in two Forest Supervisor's offices. He has an extensive operational background in fire, fuels, and aviation.