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Reference Guide to the Drop Effectiveness of Skimmer and Rotary Wing Airtankers

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The Great Lakes Forestry Centre, Sault Ste. Marie, Ontario

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Reference Guide to the Drop Effectiveness of Skimmer and Rotary Wing Airtankers.

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FOREWORD

Ontario has played a significant role in the use of aircraft to support wildland fire suppression and specifically in the innovation of "waterbombing" fires (Ontario Ministry of Natural Resources, Aviation and Fire Management Branch (OPAS) - Canada's Aviation Hall of Fame 2021). The first recorded use of an aircraft for wildland fire detection and supporting fire suppression in Ontario was in 1921 (Foster 1962).

In 1944, Carl Crossley an Ontario Air Service pilot experimented with the idea of bombing a fire with water. Early attempts to do so included using a 45-gallon steel drum in the cockpit of a KR-34 and modified floats in a Norseman. In 1945, a small wildland fire near Elk Lake Ontario was the first documented waterbombing of a fire in Canada (West 1974).

Waterbombing evolved from these early trials to dropping "waterbombs" of 4-gallon water bags in 1949 (Foster 1962) and then to the sophisticated purpose-built aircraft of today. While lots has changed over the decades, what hasn't changed for fire management agencies are:

- Increasing demands for airtanker support for aerial fire suppression (e.g., larger fires, higher intensities, more urbanization in the wildland and limits to other suppression resources).
- Limited numbers and specific types of airtankers.
- Rising costs to procure, contract, maintain, support and operate airtankers.
- The need to accurately measure the drop effectiveness of airtankers.
- The need to measure how emerging surfactants like gels, polymers, and foams may increase the overall effectiveness and efficiencies of airtanker operations.
- The need to objectively assess emerging aerial suppression technologies.
- The need to ensure environmental concerns are addressed (e.g., greenhouse gas emissions, spread of invasive species).

We hope this guide will be helpful to those who make real-world, complex decisions to protect public safety and encourage meaningful dialog with commercial air operations, the aviation manufacturing industry and research community.

We also want to highlight the need to continue to improve our understanding and use of one of the most effective suppression tools at our disposal. A priority for the fire management community is to address the question of airtanker effectiveness to better plan and use these scarce and costly resources. We feel that work is important and will have impact across the aerial firefighting community and inform future studies.

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SECTION 1: PURPOSE

This guide is intended to provide a systematic and objective method for the relative comparison of the drop effectiveness of both fixed- and rotary-wing airtankers commonly used in the North American boreal regions for various intensities of wildland fire.

The guide also provides resources to support the estimation and interpretation of fire intensity and corresponding suitability of airtankers.

SECTION 2: INTRODUCTION

The effectiveness of airtankers is fundamental to successful control and containment of fires for building control lines and facilitating ground crew suppression activities. Understanding the effectiveness of each airtanker in various situations helps inform the decision-maker when dispatching resources. There are many reasons this is important to fire management staff, such as:

- Airtankers come in a wide range of sizes, capabilities, and operating costs.
- Fires requiring suppression are found in a wide range of sizes and exhibit a wide range of behaviour, and consequently have different suppression needs. We are often faced with limited resources, so it is imperative to assign the right airtankers to the right fires.
- Fire management agencies see regular personnel turnover and a rise in national and international personnel exchange which leads to increased situations where people may be unfamiliar with host agency's airtankers.
- Good evidence indicates that future workloads for fire management will increase dramatically, and it will become more critical to make the most out of our suppression tools and our strategic investments (Wotton and Stocks 2006, Wotton et al. 2017).

This guide presents new information and summarizes known information in innovative ways that directly apply to the needs of aerial fire operations personnel. We recognize the value of knowledge exchange and importance of collaboration, and this guide has evolved through iterative engagement with the North American aerial fire operations community.

In this guide, airtanker drop effectiveness is approached through modelling the application and absorption of water both in the combustion zone and in the fuels ahead of the combustion zone. In doing so it relies on fuel moisture elements of the Canadian Forest Fire Weather Index (FWI) System (Van Wagner 1987), fuels and fire behaviour information from the Canadian Forest Fire Behaviour Prediction (FBP) System (Forestry Canada Fire Danger Group (FCFDG) 1992), and other observed physical characteristics of combustion zones and the heating of fuels. The effect of the forest canopy at reducing water penetration to the forest floor is taken into account in certain tables of this guide (both the effect of a typical boreal conifer and a sparse canopy is presented to allow the user to see a range of impacts of forest canopy on drop effectiveness).

The impact of airtankers during direct attack on a flame front is often described by the change in fire characteristics (e.g., torching to smouldering) which translates to a fire intensity for specific fuel types. The cooling of fuels in the combustion zone and the resulting change in fireline intensity as well as the absorption of water by unburned fuels, along with their subsequent drying and reheating can be thought of as a simple energy balance.

In this guide, these elements are modelled as a physics-based energy balance model which can be thought of as an 'energy bookkeeping system'. This model has two general areas:

- In the first area, the fire behaviour and general fuel type (open and closed canopy) are used to estimate the energy in and above the combustion zone which allows us to estimate the amount of water required to reduce the combustion zone to a non-flaming ('smouldering') state.
- In the second area, we model the unburned fuels next to the fire perimeter that has been affected by the water from the drop. We calculate how much water is necessary to increase the moisture content of the unburned fuels such that the fuels will not support fire spread at close to the original intensity for at least an hour. In this we consider the fuel drying rate that might be observed in the more exposed and turbulent environment along a fire perimeter. This specific assumption about fire behaviour needing to remain reduced for one hour is also aimed at providing a single point of comparison between airtankers and very wide range fire behaviour and drop scenarios.

When these impacts of water are combined with information about the drop footprints of different airtankers (i.e., the amount of water they can deliver within regions within the drop contours under different scenarios), the effectiveness of airtanker drops on a fireline can be systematically assessed and compared across different airtanker types. When that information is then combined with airtanker characteristics such as the time between drops (a function of the cruise and scooping speed, distance from water, and number of airtankers), the relative effectiveness of different airtankers types can be further assessed and objectively compared. The design and assumptions made in developing this energy balance model are specific to this goal of providing an objective and repeatable baseline for this relative comparison of different airtanker types.

SECTION 3: ACCURACY OF THE GUIDE

No model or set of models could fully account for all the factors that influence airtanker effectiveness. Decision-makers must be aware of the assumptions and consequent limitations that underlie and influence the information presented in this guide. Models by their very definition, are simplifications of more complex systems. When used within their stated purpose, models provide an objective and consistent starting point from which users can adjust using their own experience and their knowledge of both the system in general and the current fire specifically.

This guide only considers individual drop effectiveness for water and not the many tactical approaches commonly in use (e.g., different drop configurations, the use of enhancers). Nor does it explore other criteria that would be considered for determining overall suitability of aircraft (e.g., cost of operation; parts availability; crewing requirements; safety record; operational integration).

As such, this guide makes no assertion as to the cost-benefit of different airtanker types.

Even within these limitations, it is not appropriate for us to assess and present an overall relative comparison of airtankers, e.g., that airtanker X has twice the performance of airtanker Y. That is because airtanker suitability and relative performance varies with specific real-world scenarios.

SECTION 4: ASSUMPTIONS AND LIMITATIONS

The key assumptions and simplifications that we use in the results presented in this guide are outlined below:

4.1 DROP FOOTPRINT DETERMINATION:

- The water content (i.e., depth) and drop dimensions for each aircraft are characterized by the observations collected during the Dryden airtanker drop experiments (carried out from 2017 to 2019)[1]. These are a combination of on-ground water cup measurement and infrared (IR) mapping techniques.
- Environmental factors that affect the drop footprint (wind speed and direction, relative humidity, etc.) are assumed constant, and are effectively the average conditions under which the drop tests occurred.
- The speed and drop height of the aircraft that affects the drop footprint are constant and as presented in Table A2-1. We used standard operating practices based on discussions with pilots and Air Attack Officers.

[1] Johnston et al. to be published

- All drops are "salvo" type; other configurations (e.g., multiple doors, staggering or timed) are not addressed.
- The difference between closed canopy and open canopy tables is due to the interception of water by the canopy. This intercepted water is considered not to reach the forest floor or the combustion zone and therefore does not contribute to reducing energy in the combustion zone; we do not consider how this intercepted water stored in the canopy might slow combustion in the crowns, since the focus is reducing the surface fire to a non-flaming state. In this guide, the canopy interception estimates for the full canopy cover forest were taken from drop observations in a mature jack pine stand outside of Dryden (coincident with the open drops at the Dryden airfield). Drop depth contours for each airtanker for the closed canopy situation were developed from the final set of open drop contours and the 'throughfall' observations from drops in the pine site.
- The use of water enhancers is not addressed.

4.2 Energetics model:

- We assume that airtanker drops do not fully extinguish a combustion zone, and some reheating from the surroundings will occur. The rate of reheating of the combustion zone (and consequent fire intensity and spread) is controlled by both the water absorbed by the fuel layer ahead of the advancing fire and the amount of cooling experienced in the combustion zone itself.
- The fuel moisture and fire behaviour changes estimated to occur from drops use the FWI System (Van Wagner 1987) and FBP System (Forestry Canada Fire Danger Group (FCFDG) 1992); therefore, all the assumptions and limitations of the FWI System and the FBP System also apply (e.g., the fuel complex is assumed to be contiguous, uniform, and homogeneous, wind is assumed to blow at a constant rate and direction, terrain is assumed to be flat).
- Drops are assumed not to hold if the active flame front depth is greater than the half width of an effective drop contour).
- Fires are assumed to breach a drop if the half width of the drop (which drops on the unburned fuel) is less than the flame length (which based on intensity).

4.3 Airtanker drop effectiveness:

- The varying depth of water dropped from a single airtanker drop is represented by a nested set of discrete contours that decrease in size as water depth delivered increases (this is analogous to hypsometric lines for topography).

- The length and width of the drop is taken from the contour associated with the effective drop depth is considered the 'effective length' and 'effective width' of the drop footprint. While there is still some water delivered from the drop outside this 'effective drop contour', the model ignores any effect of this water.

The depth of water required to reduce a combustion zone to a non-flaming state ('smouldering') and hold for 1 hour is used to determine the associated contour (called the effective contour) level used from the drop footprints.

- In practice, when tagging on drops to build a line, there may be head-to-tail overlap; this overlap is not explicitly addressed in this model. The model line building tables assume a perfect tagging of "effective drop contour length" there is no overlap of the effective portion of the drop.
- The accuracy of drop location on an active fireline is not addressed, it is assumed all drops are on target.
- At higher effective drop depths (i.e., >1 mm) water delivery was observed to be noncontiguous over the estimated drop contour. The concept of stacking drops is used to fill in the drop contour to a uniform minimum depth. Multiple stacked drops are assumed to be perfectly aligned with previous drops and to create a uniform coverage for a specific contour.
- The drop contour estimates for the sparse canopy sites are an average of the open and closed canopy sites.
- In calculations where we consider the full perimeter of a fire, we assume that fire is an ellipse. When a defined shape is explicitly needed for these calculations, we assume the wind speed is approximately 15 km/h, which, based on the shape models in the FBP System, is consistent with an ellipse with a 2 to 1 length-to-breadth ratio in closed forest canopy forest or 4 to 1 length-to-breadth ratio in open fuels. See Appendix A1, section A1.1.

4.4 AIRTANKER OPERATIONAL CONSTRAINTS AND TACTICS:

- We recognize that, in restricting scenarios to only salvo drops, the different door and drop configurations possible with some airtankers are not represented (e.g., staggered timing of door opening). Thus, there are many tactical uses of airtankers for specific scenarios which are beyond what is presented in this guide.
- It is assumed that airtankers are dropping a full load. In actual flight operations a full load is not always possible in some situations for several factors (e.g., managing fuel weight). We do not consider how often or by how much the water drop patterns of a full drop may be reduced due to mission configuration. This is an important consideration in comparing relative performance that is outside the scope of this guide.

- Specific structural modifications by some operators to airtankers are not addressed. For example, some agencies utilize CL-215/415 aircraft that have postproduction modified bomb doors aimed to diminish friction of the water exiting the aircraft and condense the water drop and reduce drift for a more concise and effective drop pattern. For those CL-215/415 aircraft with non-modified internal bomb door systems (such as those used in the drop tests outlined in Appendix A2) the interior doors are uncovered.
- Not all airtankers can pick up from the same water sources (e.g., a CL-215 and CL-415 require larger waterbodies, whereas a rotary wing can pick up from a very small water source). In a real-world situation this will mean some airtankers on the same fire may operate from different water sources.
- Where we refer to 'holdable' line we assume that the aircraft have at least one hour (60 minutes) of operational airtanking time available.
- In direct attack (water applied on a burning perimeter), airtanker drops typically span both burning and unburned fuels. Through interviews with Air Attack Officers, we developed a simple relationship where the percentage of overlap between burning and unburned fuels is based on the intensity class. While the goal of any drop may be different depending on the operational situation, this simple rule captured the general approach as described in interviews.
    - When a fire's behaviour is at intensity class 3 or greater, 50% of the drop width is targeted at the combustion zone and 50% is targeted to fall on unburned fuel beside the active fireline.
    - When a fire's behaviour is at intensity class 2 or lower, 100% of the drop is targeted on the combustion zone.
- The energetics model (Appendix A5) assumes that a drop can be delivered at the assumed height above a fire of any intensity. In the real-world there are conceptual limits or operational constraints to where an aircraft can fly near or over an active fire (e.g., visibility, turbulence, and heat). Discussions with pilots have identified that this is more of a concern with intermediate fixed-wing and rotary-wing aircraft than heavy fixed-wing aircraft due to several factors such as, aircraft maneuverability (e.g., dropping on a bank), instrumentation, and construction. From these discussions we have developed some simple FBP System-based rules to highlight the situations that would limit the ability for an aircraft to drop directly onto the combustion zone in the higher intensities, so as to not overstate capabilities.
    - In terms of the general outputs of the FBP System, we use the crown fraction burn (i.e., CFB, an estimate of the percentage of a uniform segment of perimeter that may be torching or crowning) as an indicator of intensity and the amount of updraft and turbulence over different

forest fuel types. This simple criterion is used to place an added operational safety limit on our model results. (Table 4.1)

- In open fuels since there is no crowning, we use intensity as an indicator of updraft and operational comfort/safety. For both grasslands and slash, we use 10,000 kW/m; we expect drop effectiveness to be limited by other factors well below these intensity levels.
- We recognize that these may not be actual limits of the aircraft and there are a number of other factors to consider (e.g., cross wind limits). However, this rule ensures that the output of the model is not unrealistic to what is reported by pilots and Air Attack Officers as operational limits.
- In the charts this simple model is used to flag situations where drops are no longer effective. E.g., "Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone)." Of course, real-world operating capabilities are more complex to determine.

Table 4.1. *Operating capability limiting model criteria.*

Airtanker type	Crown fraction burn model limit	Open fuel type intensity limit (kW/m)
Heavy fixed wing airtankers (CL-415, 215)	0.95	10,000
Intermediate fixed wing airtankers (AT-802F Fire Boss, DHC-6 Twin Otter)	0.33	10,000
Rotary wing belly tankers (B212)	0.15	10,000

SECTION 5: USE OF THE GUIDE

This guide can be used in several ways. As a general knowledge/training reference, each section can be used to inform the user about different elements concerning airtanker effectiveness.

This guide is not intended to be used for direct in-aircraft tactical planning. Tactical use of airtankers is complex and coordinated by experts in real-time.

Use case example 1:

To benchmark an unfamiliar airtanker to a familiar one (e.g., an Air Attack Officer or Air Operations Branch Director dispatched out of their jurisdiction to an agency that uses different airtankers):

- Identify an airtanker you are familiar with in the guide.
- Compare the results of that airtanker with your knowledge of it to gauge how the model illustrates the typical effectiveness compared to your experience; and
- Identify the airtanker you are not familiar with and compare to the one you are more experienced with using the airtanker comparison charts presented here.
  a) How does the size of drops differ between the two?
  b) How does the amount of water delivered per drop or per hour differ?
  c) How does the effective drop size differ for the range of intensities you might see?
- Use these relative differences between the two airtankers and your operational knowledge and experience with the familiar airtanker to form initial operational expectations of the unfamiliar airtanker (e.g., an unfamiliar airtanker offers twice the performance of a familiar one in a particular situation).

The guide may also be used to infer the productivity for a particular airtanker in building and holding line of a certain fire type and intensity, given the model framework.

Use case example 2:

Determine the relative suitability for an airtanker given the fuel type, length, and intensity of the fire perimeter.

- Identify the airtanker type available to you.
- Select the corresponding fire conditions (e.g., intensity or degree of crown involvement).
- Determine a realistic time between drops, considering the distance to water and number of airtankers you have.

- Identify the length of line possible to hold and decide if that is representative of your own assessment and needs.
- Use this information to inform the suitability of an airtanker for a certain mission profile, or to consider when determining preparedness levels (e.g., importing more or different types of airtankers).

See Section 10 'Applied use of the Guide' for more examples.

5.1 UNITS USED:

There are conventions in aviation and fire management that we tried to maintain to aid in the operational use of this guide. As such, there is a mix of different units of measurements throughout the guide. For example, it is conventional in aviation to describe drop height as the height above the ground level (AGL) measured in feet instead of the metric units used in Canada.

We have provided conversions to metric on charts where appropriate. The following are units and abbreviations used in this guide.

- h – hour
- KIAS – knots (kn) indicated air speed (1 kn = 1.15 mph or 1.852 km/h)
- NM - nautical miles (1 NM = 1.852 km)
- km - kilometres (1 km = 0.540 NM)
- m - metre (1 m = 3.28 feet)
- mm – millimetres (1 mm = 0.04 inches)
- L - litre (1 L = 0.26 US gallons)
- AGL - height above ground level in feet (1 ft AGL = 0.304 metres)
- ha – hectares (1 ha = 2.47 acres)

SECTION 6: AIRTANKER DESCRIPTIVE DETAILS

The following section provides a general description of airtanker attributes. The speeds are approximations and do not consider specific conditions (e.g., weights, maneuvering limits, flap settings, time needed to achieve the speed or environmental factors).

Aircraft specifications reported here are based on subject matter expert interviews describing typical operating conditions and expectations, for this reason these may deviate from manufacturer specifications (e.g., maximum cruise speed vs elicited cruise speeds shown here).

Note: the speeds and heights on the following tables are not what are used in the drop effectiveness models but are here for general reference only. However, the model specifications are detailed in Table 7-1.

In all cases the pilot in command of an aircraft identifies the safe operating conditions for the aircraft.

Aircraft represented in this book are:

- CL-415
- CL-215 (and CL-215T)
- AT-802F Fire Boss
- DHC-6 Twin Otter
    - equipped with a Wipaire 13000 Series Floats with MNRF bombing conversion
- Bell 212 (B212)
    - equipped with a Simplex model 304 fire attack system

6.1 CL-415

Drop description	Skim, 4 variable doors
Tank capacity (L)	6,137
Cruise speed empty (KIAS)	165
Cruise speed full (KIAS)	150
Drop speed typical range (KIAS)	105-115
Drop height typical range (AGL ft)	100-150

6.2 CL-215 AND CL-215T

Drop description	CL-215 Skim, 2 variable doors	CL-215T Skim, 2 variable doors
Tank capacity (L)	5,400	5,400
Cruise speed empty (KIAS)	140	165
Cruise speed full (KIAS)	130	150
Drop speed typical range (KIAS)	105 – 110	105 – 110
Drop height typical range (AGL ft)	100 – 200*	100 – 200*

*May have higher drop heights to lower the chance of downing trees making for hazardous working conditions.

6.3 AT-802F Fire Boss

Drop description	Float skim, 2 variable door tank centre
Tank capacity (L)	3,000
Cruise speed empty (KIAS)	140
Cruise speed full (KIAS)	130
Drop speed typical range (KIAS)	105 – 115
Drop height typical range (AGL ft)	60 – 100

6.4 DHC-6 Twin Otter

(Equipped with a Wipaire 13000 Series Floats with MNRF bombing conversion)

Drop description	Float skim, 2 variable door per float
Tank capacity (L)	2,091
Cruise speed empty (KIAS)	135
Cruise speed full (KIAS)	140*
Drop speed typical range (KIAS)	95 – 105
Drop height typical range (AGL ft)	100 – 150

When carrying water, a Twin Otter observes a maneuvering speed of 140 KIAS.

6.5 Bell 212

(Equipped with a Simplex model 304 fire attack system)

Drop description	Snorkel pick up, 3 variable door bellytank
Tank capacity (L)	1,400
Cruise speed empty (KIAS)	100
Cruise speed full (KIAS)	100
Drop speed typical range (KIAS)	20 – 30 (may hover)
Drop height typical range (AGL ft)	30 – 40* (105)

*Height above canopy or target is often used vs. AGL (e.g., 40' above canopy is around 105' AGL in a jack pine stand with a 65' canopy).

SECTION 7: AIRTANKER DROP COMPARISONS

7.1 DROP FOOTPRINT DIMENSIONS

The dimensions and characteristics of drop footprints for a given airtanker depend on many factors, such as drop height, drop speed, wind speed, and wind direction; though even with the same set of environmental factors, there will be some random variation from drop to drop. Drop dimensions used in this guide are averaged from actual drops from field tests conducted during 2017 – 2019 in Ontario (see Appendix A2 for more details on how the footprints are derived). These data provided a way of averaging dimensions for a series of different levels of water depth (e.g., 0.75 to 1.0 mm) for each airtanker. In applying this water drop information we construct an idealized drop footprint using a nested set of ellipses, each representing different depths (Figure 7-1a, for more detail on how the open drops were derived see Appendix A2, section A2.1).

When introducing the effect of canopy (Figure 7-1b) we wanted to achieve consistency with the open observations on the airfield. For each airtanker type, the average drop dimensions for each water depth in the open and in the canopy were compared and the effective drop interception capacity of the pine canopy was estimated (informed by drop tests in a C-3 canopy with an estimated 90% crown closure, see Appendix A2, section A2.2).

Figure 7-1 presents a comparison between the averaged drop footprints in the open [a] and the canopy [b] and shows an example of an individual actual drop [c]. Figure 7-1 [a] and [b] show the effect of canopy interception by illustrating the reduction of drop size (on the ground). The examples of actual drop patterns (Figure 7-1c) show lack of uniformity in the depth of water across the drop area; this is particularly the case for the higher water depths observed (i.e., >1 mm) and is reflected in the drop effectiveness modelling through the need to stack drops.

We also created a set of estimated drop patterns for a sparse canopy fuel type, which represented a scenario where the full canopy stand was considerably thinner than typical. To create this set of sparse canopy drop patterns for each airtanker, drop dimensions for each water depth were estimated as the average between the open and full canopy dimensions.

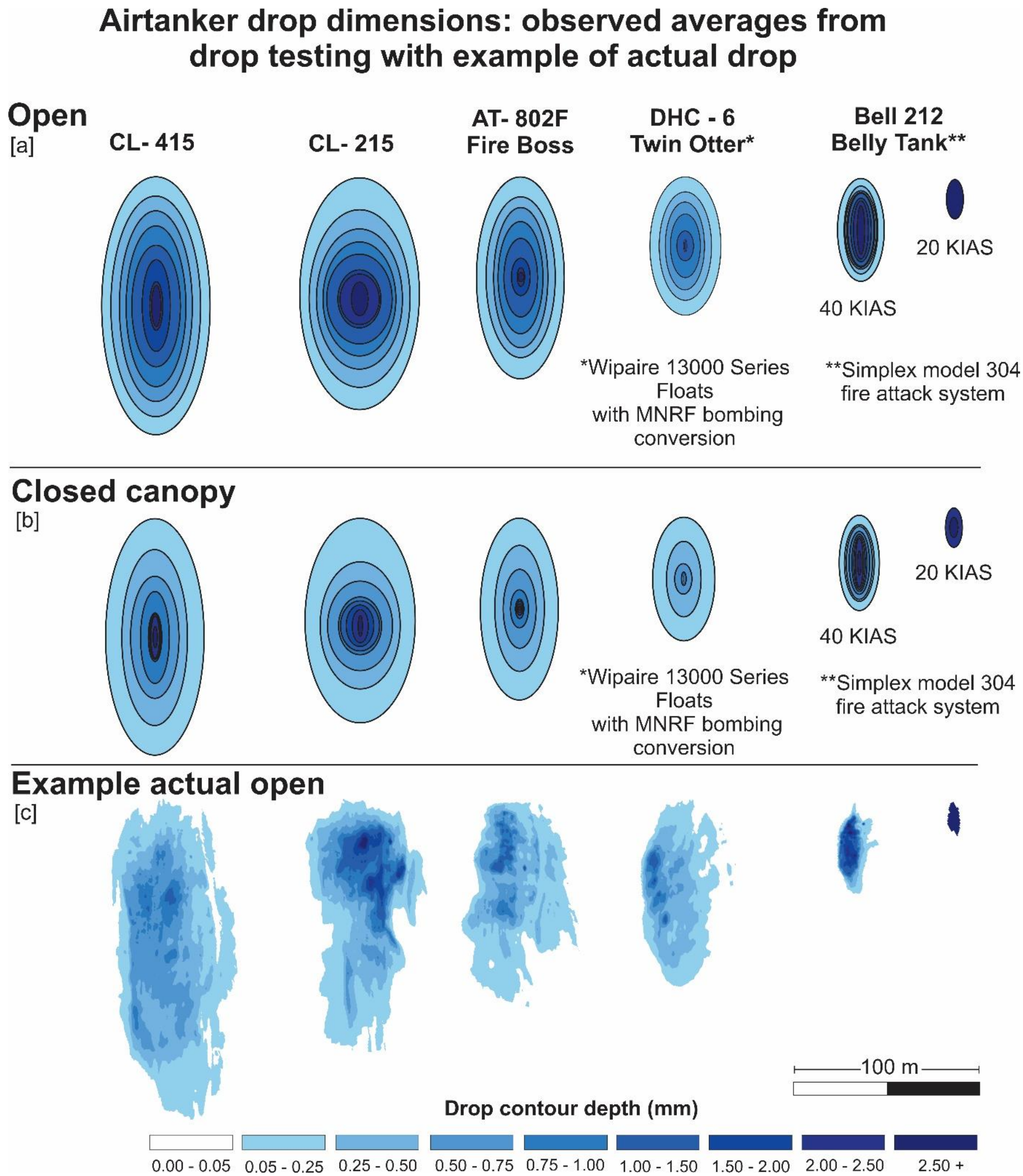


Figure 7-1. *Conceptual airtanker extents for each water coverage level observed from the Dryden airtanker drop observation campaign, reproduced to scale for comparison. [a] shows the medians of observed lengths and widths for drop contours observed with IR in the open field site. [b] shows the canopy estimates derived from the contours measured in the open and within-stand measurement of water amount, and [c] shows an example of an individual drop as characterized by the IR water depth measurement method. Both [a] and [b] are used in the energetics model.*

7.2 DELIVERY RATE CHARTS

The number of drops possible per hour for a single airtanker is recognized here as being a function of:

1. Pick up phase (line up, decelerate, fill, accelerate to cruise).
2. Travel to the fire at full water capacity.
3. Drop (line up, decelerate, drop, accelerate to cruise).
4. Travel to the water source empty.

When considering line length building capacity, we use a simplified model of these phases which use a blended speed that considers both cruise speed when empty, full and during the drop, and with an added flight time increment per cycle to account for the impact of various deceleration times and fill time (Table 7-1). These blended speeds are within the operational ranges provided in Section 6 Airtanker descriptive details. The time increment per cycle was estimated from previous observations of airtanker drop and pick up times.

Table 7-1. *Blended speed and time increment used to calculate time between drops based on distance between fire and water.*

Airtanker	Blended speed (KIAS)	Additional time increment (min)
CL-415	158	3.0
CL-215	135	4.0
CL-215T	158	3.0
AT-802F Fire Boss	135	3.2
DHC-6 Twin Otter	138	2.9
B212 - BT Fast	100	1.8
B212 - BT Slow	100	1.8

To test the suitability of our simple representation of the number of drops possible per hour as a function of distance between fire and pickup water source, we examined air attack mission information from Ontario for CL-415 single airtanker missions between 2007 – 2021. Observations of the number of drops per hour as a function of distance to the pickup water source appear in the Figure 7-2 our model (based on information in Table 7-1) for the number of drops per hour achievable by a CL-415 air tanker (the black line). The data show the same decreasing trend. Given the wide variability in air attack tactics our model performs reasonably well, although the air attack data suggest that our model underestimated the number of drops observed per hour, which errs the model on the side of caution (i.e., does not over represent the drops per hour). Since we did not have similar observational data for the other airtankers types, we did not fit a model to our observed data for the CL-415, but retained the approach of using the coefficients shown in Table 7-1; this decision was made to allow consistency between our airtanker comparisons.

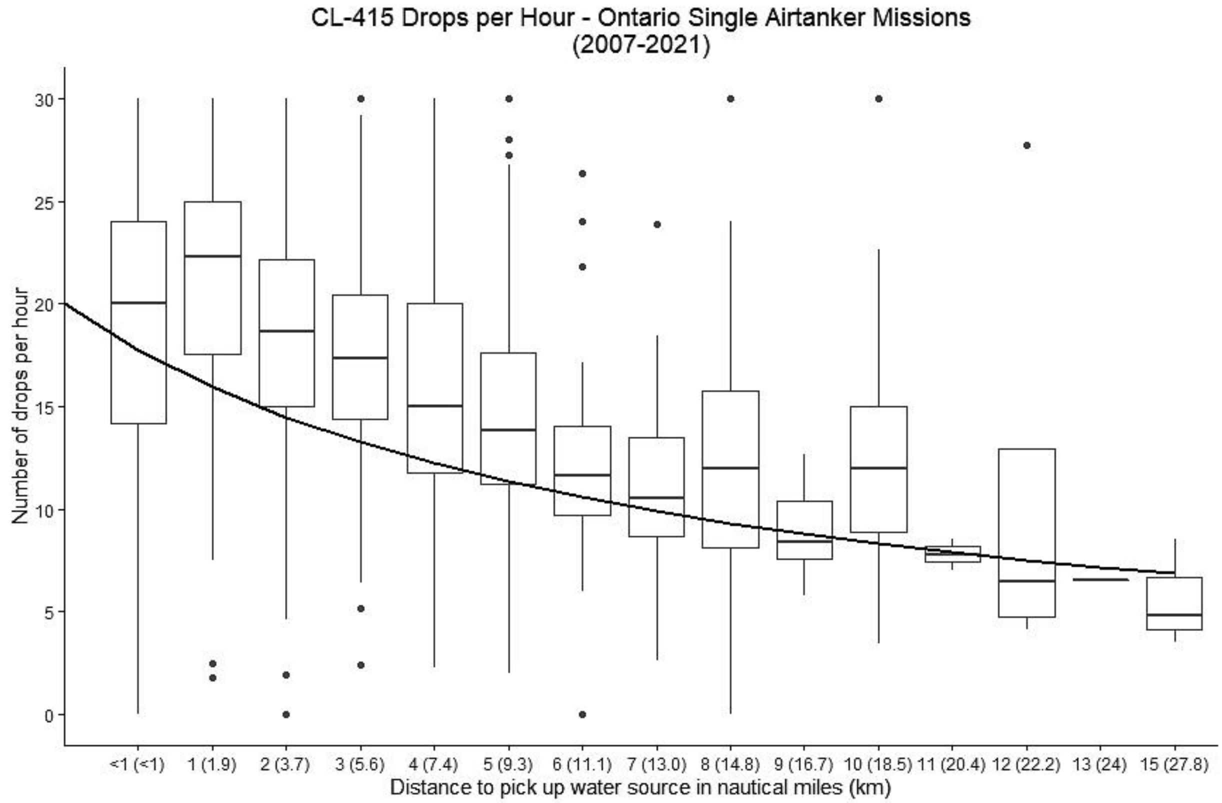


Figure 7-2. *Boxplots illustrating the relationship between the number of drops per hour and distance from pickup lake for a CL-415 airtanker using Air Attack Officer observations from 2007-2021.The middle line in each box represents the median (where 50% of the data lie above and below) of the number of drops per hour for each distance to a pick up water source. The lower and upper edges of the boxes represent the 25th and 75th quartiles of the data respectively. The black line represents the modeled output using the data from Table 7-1. The horizontal axis is in nautical miles (distance in kilometres is in brackets).*

7.3 NUMBER OF DROPS POSSIBLE FOR SINGLE AIRTANKER (1 HOUR) BY DISTANCE

Table 7-2 allows the comparison across different airtanker types of the number of drops possible in an hour with a single airtanker as a function of the distance from the pickup lake. The number of drops possible in an hour is a function of the blended cruise speed, (presented in the previous section, Table 7-1) and distance between pickup water source and fire.

- Alone the number of drops possible per hour does not indicate "effectiveness". One must also consider the amount of water delivered within that time span, see Section 7.4.

Table 7-2: *The number of drops possible in an hour by a single airtanker. The green bars illustrate the numerical values for a visual relative assessment.*

Number of Drops possible in an hour

Distance from Water Source	CL-415	CL-215	CL-215T	AT-802F Fire Boss	DHC-6 Twin Otter	Bell 212 Belly Tank Fast	Bell 212 Belly Tank Slow
0 NM [0 Km]	20	15	20	19	21	33	33
1 NM [2 Km]	18	13	18	16	18	25	25
2 NM [4 Km]	16	12	16	15	16	20	20
3 NM [6 Km]	14	11	14	13	14	17	17
4 NM [7 Km]	13	10	13	12	13	14	14
5 NM [9 Km]	12	10	12	11	12	12	12
6 NM [11 Km]	11	9	11	10	11	11	11
7 NM [13 Km]	11	8	11	10	10	10	10
8 NM [15 Km]	10	8	10	9	9	9	9
9 NM [17 Km]	9	7	9	8	9	8	8
10 NM [19 Km]	9	7	9	8	8	8	8
15 NM [28 Km]	7	6	7	6	6	6	6
20 NM [37 Km]	6	5	6	5	5	4	4

7.4 VOLUME OF WATER DELIVERY POSSIBLE FOR SINGLE AIRTANKER (1 HOUR) BY DISTANCE

Table 7-3 builds upon Table 7-2 and shows the volume of water delivered in an hour is a function of the number of drops possible per hour (Section 7.3), the tank size and a general loss factor that accounts for drift or other losses prior to the water reaching the combustion zone. These charts assume a full load pickup (note, a full load is not always possible in some situations as airtankers need to reduce the pick up load based on fuel weight on board).

- Important: this table does not include a canopy effect (i.e., all water assumed to reach the surface).

Alone, volume of water delivered per hour does not indicate "effectiveness". One must also consider at a minimum the intensity of the fire and the area of the drop with the requisite amount of water to hold the fire, see Section 8.

Table 7-3. *The total volume of water that can be delivered in an hour by a single airtanker. The blue bars illustrate the numerical values for a visual relative assessment.*

Volume of water delivered per hour (L/hr)

Distance from Water Source	CL-415	CL-215	CL-215T	AT-802F Fire Boss	DHC-6 Twin Otter	Bell 212 Belly Tank Fast	Bell 212 Belly Tank Slow
0 NM [0 Km]	98,000	65,000	86,000	45,000	33,000	37,000	37,000
1 NM [2 Km]	87,000	58,000	77,000	40,000	29,000	28,000	28,000
2 NM [4 Km]	78,000	53,000	69,000	35,000	26,000	22,000	22,000
3 NM [6 Km]	71,000	49,000	63,000	32,000	23,000	19,000	19,000
4 NM [7 Km]	65,000	45,000	57,000	29,000	21,000	16,000	16,000
5 NM [9 Km]	60,000	42,000	53,000	27,000	19,000	14,000	14,000
6 NM [11 Km]	56,000	39,000	49,000	25,000	18,000	12,000	12,000
7 NM [13 Km]	52,000	36,000	46,000	23,000	16,000	11,000	11,000
8 NM [15 Km]	49,000	34,000	43,000	21,000	15,000	10,000	10,000
9 NM [17 Km]	46,000	32,000	40,000	20,000	14,000	9,000	9,000
10 NM [19 Km]	43,000	31,000	38,000	19,000	13,000	9,000	9,000
15 NM [28 Km]	34,000	24,000	30,000	15,000	10,000	6,000	6,000
20 NM [37 Km]	28,000	20,000	24,000	12,000	8,000	5,000	5,000

SECTION 8: "EFFECTIVE" DROP FOOTPRINT

In this guide we define "effectiveness" as the degree to which an airtanker drop will reduce fire intensity on a burning perimeter. The countless situationally specific scenarios that arise cannot be documented in the pages of this guide. We have chosen to provide a concrete comparison point for drop scenarios, by assessing the ability of the differing depths of water in a drop to eliminate flaming combustion from some target segment.

Greater intensity requires a greater water depth to decrease energy in the combustion zone. In our drop pattern shape model (Figure 7-1 [a] and [b]), zones of greater water depth are nested inside the elliptical drop pattern. An "effective drop" is the portion of the drop footprint which will lower the intensity of a segment of a fire to a temporary smouldering state (i.e., the absence of flaming). We refer to the dimensions of an 'effective drop' as the 'effective drop length' and the 'effective drop width'.

Throughout this guide in text and in the drop footprint tables and figures we refer to water volume delivered to a fire (or the unburned fuels beside a fire) as water depth (in mm). We are simply equating a water volume delivered across a small area with the depth of that water spread out uniformly across that area. This approach is used because water depth is easier to visualize than water volume: we use this equivalence when we talk about rainfall amount. Here 1 mm of water depth uniformly spread across one square metre is equivalent to 1 kg/m^2 of water or 1 L/m^2 of water, using the standard definition of water density.

The conditions for what constitute an "effective" drop in this guide comprise three elements.

1. **Lowered intensity:** The water volume (referred to as depth of water) within an effective drop extent must reduce the intensity of a fire to a flameless (smouldering) state.
2. **Duration:** There should be at least <u>1 hour</u> before the fire begins spreading again at the original rate at the drop location.
3. **Breaching:** The active fire will <u>not</u> breach the drop if either:
    a. The full active flame front depth at the location of the drop is covered fully by the half-width of the effective portion of the drop.
    b. The half-width of the effective drop is more than the flame length at the drop location (this is a conservative modification of Byram's criteria for fireline breaching).

The part of a drop contour that meets the above conditions is considered to be "**holding**" a segment of line. If the parameters in 1-3 above are changed, it will affect the model outputs, for example, if the duration were 0.5 h instead of 1 h. Representing this new situation would require an entirely new set of tables; to keep the dimensionality of this guide from growing too large we have chosen to present results using only the definition of an 'effective drop' listed above.

As described in Section 7 (and shown in detail in Appendix A2), drops in the model are arranged into a nested set of ellipses representing increasing water depths delivered to the ground (Figure 7-1 [a] and [b]). The elliptical contour that represents the lowest amount of water that will reduce the fire intensity down to a flameless state defines the outer extent of the 'effective drop' (Figure 8-1).

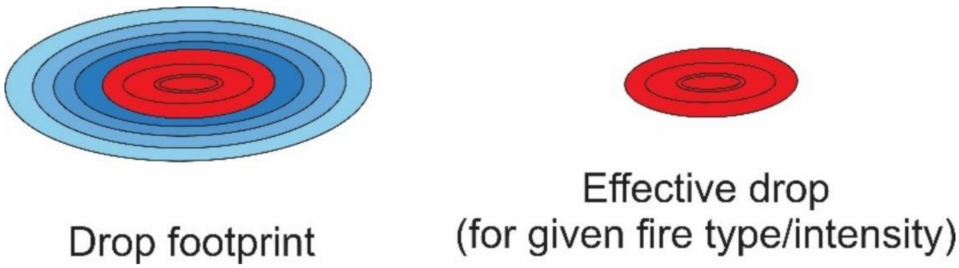


Figure 8-1. *An example of a drop footprint and the effective portion of the drop which will lower the intensity to a flameless state (smouldering).*

The lower water depths, outside the 'effective drop' footprint, are assumed to not influence the fire intensity in a significant way outside the effective drop (i.e., overlapping multiple drops with a lower, less effective, volume of water will not have an additive affect on reducing intensity; see dashed lines on Figure 8-2).

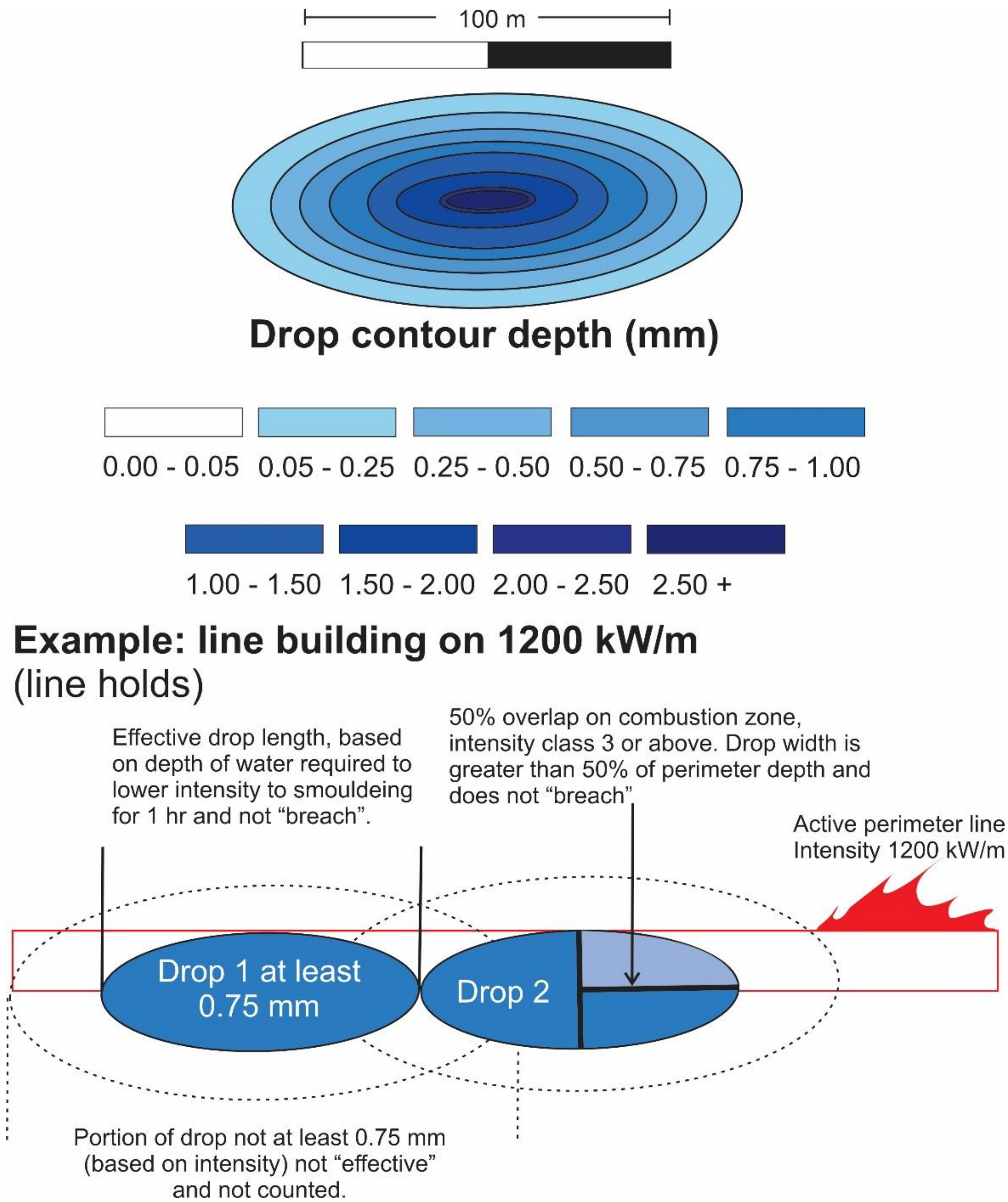


Figure 8-2. *Example of how line building model works.*

The spatially detailed observations from the IR monitoring during the drop experiment (e.g., Figure 7-1c, and described in Appendix A2) suggest that modelling the water distribution throughout a drop as a set of nested ellipses is a reasonable approximation for the larger areas of the footprint where water volumes are low (i.e., <1 mm depth). The airtankers we studied seemed to produce relatively uniform distributions at these lower thresholds of water depth. However, further interpretation indicated that the areas receiving larger water depths were noncontiguous and spread non-uniformly throughout what we defined to be the drop contour area. Our method of estimating contour dimensions assesses the length and width of the region which encloses all these discrete areas at or above the contour depth; therefore, the contours for these higher water depth regions include both areas at or above a specific threshold depth, and areas where water depth is below the specific threshold depth of the contour. For example, within the region we define as enclosed by the 1.5 mm contour, there are areas of the water drop that are above 1.5 mm in depth and areas where water depth is below 1.5 mm. Table 8-1 shows estimates of the fraction of the area within the reported drop dimensions that received a water depth greater than the lower end of the contour range. For example, Table 8.1 shows that for the CL-415, the CL-215 and the AT-802F, only one third (0.33) of the area within the 1.5 mm contour actually contained water depths at or greater than 1.5 mm. In the calculations within the energetics model, we assume that to be effective at these higher levels where water depth distribution becomes highly variable, multiple drops must be 'stacked' on one another to achieve a minimum uniform coverage depth across the entire contour. Using the previous example, to achieve a uniform coverage of at least 1.5 mm depth across the full drop contour, the defined the 1.5 mm depth we must stack 3 drops, since only one third (0.33) of the area is above the 1.5 mm depth for any individual drop (i.e., 1/0.33 ≈ 3 drops).

Table 8-1. *Fractional coverage of water depth at or above the defined drop contour depths within the defined contour area for different airtankers.*

Depth contour ranges (mm)	CL-415	CL-215T	AT 802F Fire Boss	DHC-6 Twin Otter	Bell 212 Belly Tank Fast	Bell 212 Belly Tank Slow
0.05 - 0.25	1.00	1.00	1.00	1.00	1.00	1.00
0.25 - 0.50	1.00	1.00	1.00	1.00	1.00	1.00
0.50 - 0.75	1.00	1.00	1.00	0.50	1.00	1.00
0.75 - 1.00	1.00	0.50	0.50	0.33	1.00	1.00
1.00 - 1.50	0.50	0.50	0.50	0.33	1.00	1.00
1.50 - 2.00	0.33	0.33	0.33	0.25	0.50	1.00
2.00 – 2.50	0.33	0.25	0.33	0.25	0.33	1.00
>2.50	0.25	0.20	0.14	0.20	0.17	1.00

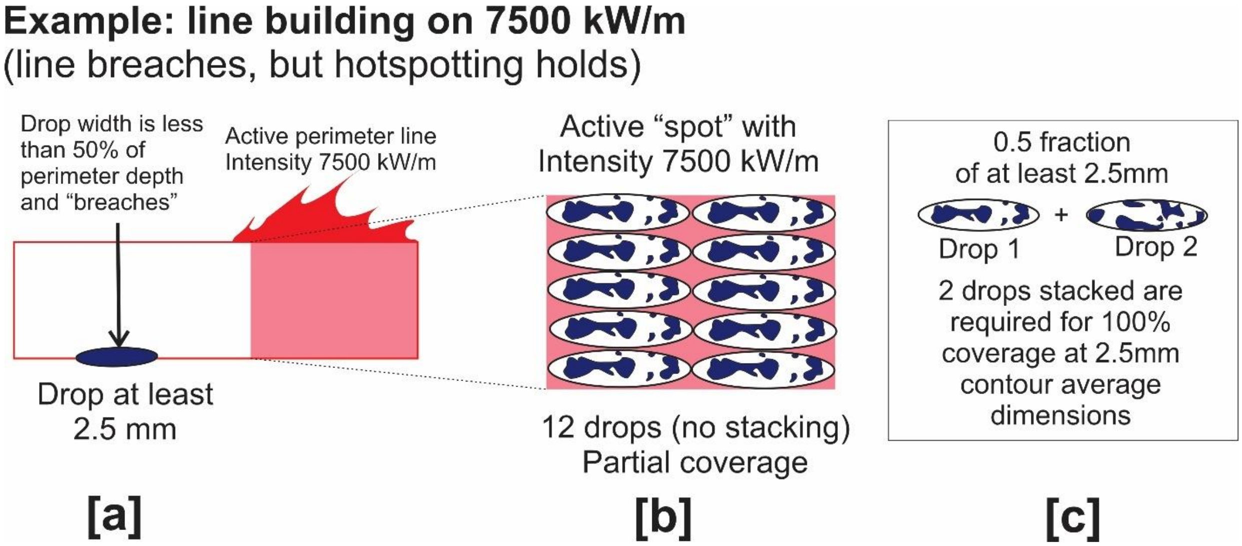


Figure 8-3. *Example of hotspotting and stacking of drops. In the case where a drop is breached **[a]**, we assume the "effective" portion of drops are perfectly delivered and estimate the area it is possible to hotspot and hold (e.g., the rectangle here is 0.1 ha). This is no longer line building - but hotspotting. However, in the deeper depth contours we know the water is not evenly distributed across the whole ellipse. I.e., there are pockets of deeper depth in our averaged ellipse **[b]**. We use the fractional coverage of the drop contour to determine how may drops need to "stack" on top to cover the whole area of the depth contour **[c].** In this example half the drop has at least 2.5 mm. So, it would take 2 drops (assuming perfect alignment) to make a drop with evenly distributed depth across the whole ellipse. In this example, it takes 24 drops to hold a 0.1 ha hotspot.*

8.1 COMPARISON OF EFFECTIVE DROP DIMENSIONS BETWEEN DIFFERENT AIRTANKER TYPES FOR VARYING FIRE INTENSITIES

This section provides examples for comparing effective drop sizes for different airtanker types across a range of fire types and fire intensities. These charts show the impact of the definition of an 'effective drop' as defined in the previous section.

These tables allow direct comparison of the difference in the effective drop size from airtankers; in Table 8-2 we show an example for fire behaviour in a full canopy C-2 fuel type. Drop size in this table is shown as the drop's length-to-width in ratio (i.e., Length:Width, in metres).

- See Appendix A7 for complete set of charts for C-3 and C-2 full and sparse canopy, O-1a (100%) open, S-1 open.

Chart use: across the top row, select column that describes the observed or expected fire behaviour (as described by fire type (smouldering to crown), rate of spread (ROS) and Intensity class). Go down the column to see the required depth of water to reduce that fire behaviour to smouldering for a period of time. Then, move downward in that column to reference the effective drop size (for that fire behaviour) for each aircraft. For example, the "Torching (low)" column lets a user compare the size of an effective drop for each of the airtanker types for a fire that has just begun to exhibit intermittent crowning.

Table 8-2. *Effective drop comparison across airtankers for Fuel Type C-2, Full Canopy Drop. Cells are coloured by the fire type.*

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

	Fire behaviour							
Fire Type	**Smould.**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	**14 (0.9)**
Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	**12,000 (IC6)**
Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	**>4mm**
Airtanker								
CL-415	130:50 (1)	90:40 (1)	90:40 (1)	90:40 (1)	70:30 (1)	Br	Br	Br
CL-215	110:60 (1)	70:40 (1)	70:40 (1)	70:40 (1)	50:30 (2)	30:20 (2)	Br	Br
CL-215T	110:60 (1)	70:40 (1)	70:40 (1)	70:40 (1)	50:30 (2)	30:20 (2)	Br	Br
AT-802F Fire Boss	100:40 (1)	70:30 (1)	70:30 (1)	70:30 (1)	40:20 (2)	NA	NA	NA
DHC-6 Twin Otter	70:30 (1)	40:20 (1)	40:20 (1)	40:20 (2)	20:9 (3)	NA	NA	NA
Bell 212 Belly Tank Fast	50:20 (1)	40:20 (1)	40:20 (1)	40:20 (1)	40:10 (1)	NA	NA	NA
Bell 212 Belly Tank Slow	20:10 (1)	20:9 (1)	20:9 (1)	20:9 (1)	20:9 (1)	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

8.2 COMPARISON OF THE NUMBER OF DROPS NEEDED BY DIFFERENT AIRTANKERS TO HOLD 100M OF UNIFORM FIRE PERIMETER

As fire intensity increases the amount of water needed to reduce an actively spreading fireline to a flameless state (smouldering) increases and the length of the effective drop becomes smaller. The example presented here in Table 8-3 illustrate the minimum number of drops needed to hold 100 m of a linear fire perimeter in a C-2 fuel type (assuming the canopy is fully closed). The scenarios presented allow for easy comparison of the different airtankers across a range of fire behaviour. In these scenarios we assume that fire intensity is uniform across the 100 m of fire perimeter and that the fire perimeter is a straight line. The same criteria for an 'effective drop' described earlier are used here.

- See Appendix A8 for complete set of charts for C-3 and C-2 full and sparse canopy, O-1a (100%) open, S-1 open.

Chart use: across the top row, select column that describes the observed or expected fire behaviour (as described by fire type (smouldering to crown), rate of spread (ROS) and Intensity class). Go down the column to see the required depth of water to reduce that fire behaviour to smouldering for a period of time. Then, move downward in that column to reference the number of drops needed to hold 100 m of fire perimeter for each aircraft. For example, the "Torching (low)" column lets a user compare the number of drops needed from each of the airtanker types for a fire that has just begun to exhibit intermittent crowning.

Table 8-3. *Number of drops needed to build and hold 100m of active fireline for Fuel Type C-2, Full Canopy Drop. Cells are coloured by the fire type.*

		Minimum number of drops needed to build 100m of line							
		Fire behaviour along a fireline segment							
Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		1	1	1	1	2	Br	Br	Br
CL-215		1	1	1	1	2	7	Br	Br
CL-215T		1	1	1	1	2	7	Br	Br
AT-802F Fire Boss		1	1	1	1	2	NA	NA	NA
DHC-6 Twin Otter		2	2	2	2	12	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	2	2	3	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	5	5	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone).

8.3 Comparison of the number of drops needed by different airtankers to hold a 1 hectare 'hotspot'

The examples presented here show the number of drops needed to completely cover and hold an actively spreading area that is 1 ha in size; Table 8-4 shows a specific example for the C-2 fuel type assuming a full overstory canopy. These tables differ from the line building charts in the previous section in that area being suppressed is assumed to be a relatively compact area in terms of its length and width; that is, it is not a long thin fireline. The scenarios presented allow easy comparison of the different airtankers across a range of fire behaviour; however, because of the assumptions made, the results should be considered idealized minimums designed to show the relative differences across the airtanker types.

This simple application of the drop effectiveness model makes several assumptions. Fire intensity is assumed to be uniform across the 1 ha 'hotspot' area. The effective area of the drops is assumed to fit together perfectly in the 'hotspot' area being suppressed; that is, there is no overlap in the effective drop area for multiple drops.

- See Appendix A9 for complete set of charts for C-3 and C-2 full and sparse canopy, O-1a (100%) open, S-1 open.

Chart use: across the top row, select column that describes the observed or expected fire behaviour (as described by fire type (smouldering to crown), rate of spread (ROS) and Intensity class). Go down the column to see the required depth of water to reduce that fire behaviour to smouldering for a period of time. Then, move downward in that column to reference the number of drops needed to suppress a 1 ha area for each aircraft. For example, the "Torching (low)" column lets a user compare the number of drops needed to cover 1 ha fire for each of the airtanker types for a fire that has just begun to exhibit intermittent crowning.

Table 8-4. *Minimum number of drops needed to cover a 1 ha fire area in Fuel Type C-2, with the Full Canopy Drop scenario. Cells are coloured by the fire type.*

Airtanker	Minimum number of drops needed to effectively cover a 1 ha area — Fire behaviour of area								
	Fire Type	**Smould.**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
	ROS m/min (CFB)	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
	Intensity kW/m (Class)	**<10 (ICI)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	**>4mm**
CL-415		2	3	3	3	6	53	96	###
CL-215		2	3	3	3	6	18	65	###
CL-215T		2	3	3	3	6	18	65	###
AT-802F Fire Boss		3	6	6	6	14	NA	NA	NA
DHC-6 Twin Otter		5	13	13	13	67	NA	NA	NA
Bell 212 Belly Tank Fast		9	15	15	15	18	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) = indicates this intensity level requires an unreasonable number of drops (>100).

NA = Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone).

8.4 TOTAL NUMBER OF DROPS NEEDED FOR THREE FIRE SIZE SCENARIOS

It is well-known that fire intensity varies around the perimeter of a fire; when a fire is being driven by the wind, the intensity at the back of the fire will be much lower than the intensity at the head of a fire. The FBP System uses an elliptical model to estimate the growth of a spreading fire in any direction relative to the wind. This is most typically presented as the spread rates at the head, flank and back of the fire; however, spread rate and fireline intensity can be calculated at any point around an ellipse.

The following examples illustrate potential scenarios of suppressing (i.e., brining to a smouldering state) a relatively small (<10 ha) elliptical fire and incorporate the impact of the variation of intensity around the perimeter; that is, the effective drop lengths (and therefore line building rate) will be much longer at the back of a fire compared with the head.

For further information on elliptical fire behaviour and its implications, see:

- Appendix A1, A1.1 for description of elliptical fire growth; and
- Appendix A1, A1.5 for estimating length of perimeter at different intensities based on head fire intensity.

In the example below the number of drops needed for three scenarios of fire size in C-2 (1 ha, 5 ha and 10 ha) are shown and airtanker drop requirements listed for a range of whether expected or observed head fire behaviour is presented. Each scenario includes a breakdown of the percentage of the total length of fireline at different intensity classes (IC1 – IC6) between head fire and backfire. Airtanker requirements are summarized as the number of drops required to change that length of perimeter to a flameless (smouldering) state. To allow the inclusion of the most dimensions, each table is specific to only a single airtanker type.

- See Appendix A10 for complete set of charts for each aircraft in C-3 and C-2 full and sparse canopy, O-1a (100%) open, S-1 open.

There are several additional assumptions worth noting that are made in creating these summary tables.

- The assessment of the number of drops needed is done at an instant in time when the fire is at the listed size. Clearly an actively spreading fire would grow if there were delays in the delivery of the required number of drops onto the fire perimeter. This fire growth is not considered (i.e., we do not consider the perimeter growth rate), despite the spread rates being used in the energy balance model to determine the size of the effective drop needed.
- In the closed canopy, this assessment assumes the length to breadth ratio of the ellipse is 2:1. In the open canopy, this assessment assumes the length to breadth ratio of the ellipse is 4:1.
- All of the FBP System's assumptions about the elliptical nature of fire spread apply. The ellipse is, even in the FBP System, an idealized approximation of a

growing fire. In addition, here the fire is assumed to be spreading at its equilibrium spread rate (i.e., not accelerating, even in the 1 ha fire example).

- The sizes examined span what we think are a potentially useful range. The sizes however are independent of the fire behaviour scenarios. That is, an IC5 fire that is only 1 ha in size may seem rather improbable from a fire behaviour perspective since it would be growing at a very fast rate, but we allow it for consistency in the table.
- The number of effective drops is calculated for each intensity class segment of the perimeter separately, regardless of where the drop length exceeds the amount of fireline at that intensity. Therefore, the overall number of drops may overestimate the number of drops needed, particularly on the 1 ha fire.

Chart use: The leftmost box describes one of three fire size scenarios **[a]**. The top row describes the head fire behaviour observed or expected under the scenario being considered **[b]**. Fire intensity around an elliptical perimeter drops from a maximum at the head fire to a minimum at the back. Moving down the column (red outline), the row data within each fire size grouping **[a]** corresponds to the percentage of that fire perimeter that is at each intensity class (blue outline) and gives an estimate of the minimum number of drops required for a specific airtanker to hold that portion of line (i.e., that portion of the fire perimeter at each specific intensity class). At the bottom of each fire size scenario grouping, the "total" row is the total number of drops needed for this scenario **[c]**, for this aircraft (assuming all drops occur at the same time – no reheating or fire growth). Also identified is the percentage of the total perimeter possible to hold given the head fire intensity. In this example, a 1 ha fire with a 400m perimeter is burning in C-2 with a full canopy. A CL-415 can hold 100% of a high intensity surface fire with a head fire intensity class of 3, with 5 drops. The highlighted column shows 52% of the perimeter is at intensity class 2 (the rear and flanks) and can be held with 2 drops. It also shows that 48% of the perimeter is at intensity class three (this is mostly head fire) and needs 3 drops to hold. When the head fire intensity is very high, there are situations where not all portions of the fire can be held, for example when a drop breaches. In another scenario of more intense fire, the total percentage of perimeter is not possible to hold **[d]** (e.g., only 55% is held).

[b]

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha)	IC1							
1	IC2	4 (100%)	3 (66%)	2 (52%)	2 (43%)	1 (24%)		
Perimeter (m)	IC3		2 (34%)	3 (48%)	3 (57%)	2 (38%)	2 (36%)	2 (25%)
400	IC4					8 (39%)	4 (18%)	4 (15%)
[a]	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**4 (100%)**	**5 (100%)**	**5 (100%)**	**5 (100%)**	**11 (100%)**	*6 (55%)*	*6 (41%)*

[c] [d]

Figure 8-4. Example of use for tables of total number of drops needed for three fire size scenarios.

Table 8-5. *Number of drops needed to build line around three small fires in the C-2 fuel type (full canopy) using a CL-415 airtanker.* Cells are coloured by the fire type.

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
	IC1							
Area (ha)	IC2	4 (100%)	3 (66%)	2 (52%)	2 (43%)	1 (24%)		
1	IC3		2 (34%)	3 (48%)	4 (57%)	3 (38%)	3 (36%)	**2 (25%)**
Perimeter (m)	IC4					12 (39%)	6 (18%)	**6 (15%)**
400	IC5						Br (45%)	**Br (32%)**
	IC6							NA (27%)
	Total*	**4 (100%)**	**5 (100%)**	**5 (100%)**	**6 (100%)**	**16 (100%)**	*9 (55%)*	***8 (41%)***
	IC1							
Area (ha)	IC2	10 (100%)	6 (66%)	5 (52%)	4 (43%)	3 (24%)		
5	IC3		5 (34%)	7 (48%)	8 (57%)	5 (38%)	5 (36%)	4 (25%)
Perimeter (m)	IC4					13 (39%)	7 (18%)	5 (15%)
900	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**10 (100%)**	**11 (100%)**	**12 (100%)**	**12 (100%)**	**21 (100%)**	*12 (55%)*	*9 (41%)*
	IC1							
Area (ha)	IC2	13 (100%)	9 (66%)	7 (52%)	6 (43%)	3 (24%)		
10	IC3		7 (34%)	9 (48%)	11 (57%)	7 (38%)	7 (36%)	5 (25%)
Perimeter (m)	IC4					18 (39%)	9 (18%)	7 (15%)
1,200	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**13 (100%)**	**16 (100%)**	**16 (100%)**	**17 (100%)**	**28 (100%)**	*16 (55%)*	*12 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

SECTION 9: AIRTANKER DROP EFFECTIVENESS CHARTS FOR DIRECT ATTACK

The preceding sections build from water delivery to determining the effectiveness of a single drop, being dropped around a perimeter with the intent of providing easy and direct comparisons between airtanker type's performance. In this section, the information presented in the tables allow a user to assess each airtanker's performance in direct attack line building and hotspotting in a given fuel type. These charts can be used to either identify what conditions an airtanker is suitable for or determine if the mission specifics are notionally compatible for an available airtanker type; these assessments are of course subject to the constraints and assumptions that have been made (and are described earlier).

- **Line Building:** is when there is a more defined active perimeter which requires tagging drops together in sequence.
- **Hotspotting:** is the delivery of water directly on a small fire (or small target area within a larger fire) resulting in a quick knockdown of the intensity.

These tables, by necessity, simplify the very complex and situationally dynamic process of fire suppression with air attack. The core output is the length of line that is theoretically possible to "hold" (i.e., to keep from spreading for at least one hour before water is reapplied) for a given fire type (intensity) and given time between drops. In a situation where line-building drops are breached, but hotspotting is possible, the total area that can be made to "hold" is indicated. For more detail on real-world air attack tactics see Appendix A3.

Reminder: this guide is not intended to be used for use in an airtanker for direct tactical planning

We selected the maximum distance between pick up lake and fire in these charts using the Ontario historic air attack records for all fixed wing airtankers (Figure 9-1). In examining the distance to pickup lake for all missions, the data show that across Ontario the median fire to water source distance was ~3 nautical miles (or ~5 km). The historical distribution of fire to lake distance is shown in the following figure for reference. Less than one percent of missions had a lake to fire distance of > 15 nautical miles (28 km). It should be noted that different geographic regions will have a different distance to water distribution pending the availability of suitable waterbodies.

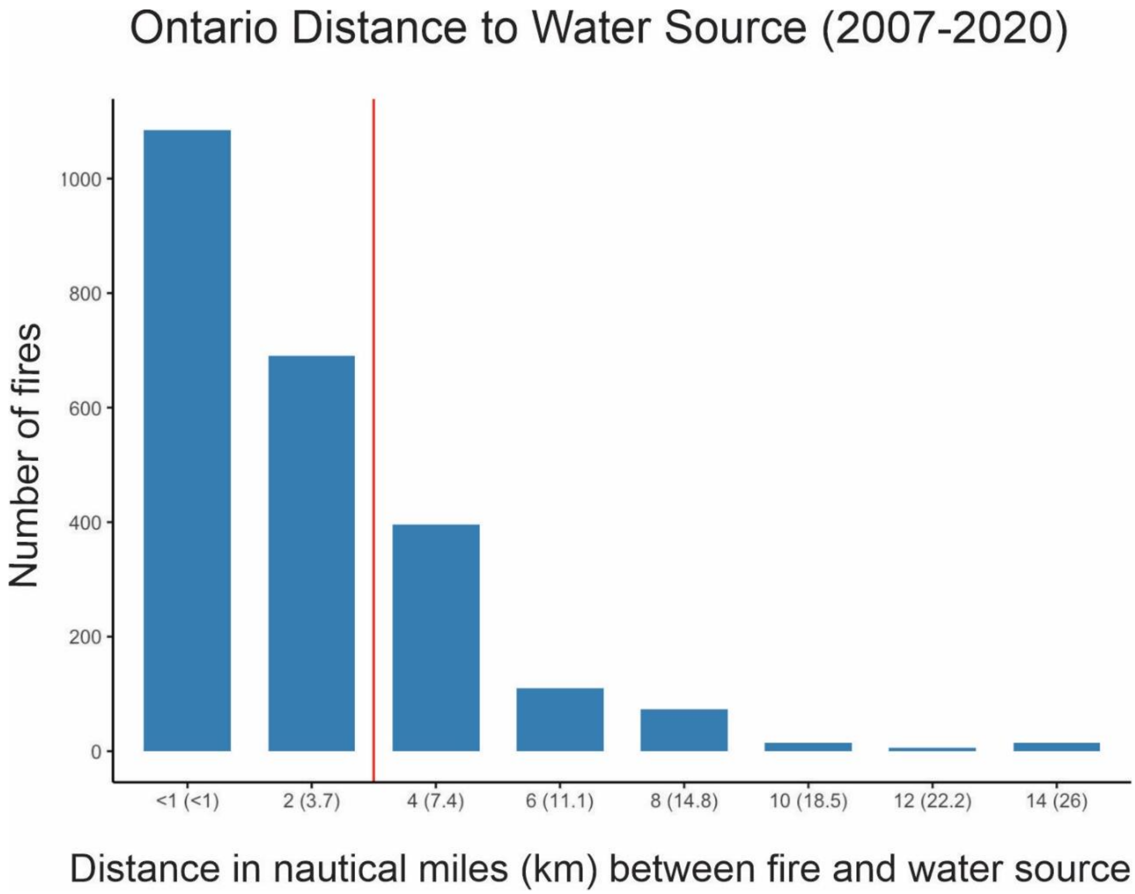


Figure 9-1. *Frequency distribution of tanking distance in Ontario from (where the red line represents the median fire to water source distance; 2.7 NM, 5 km. Less than one percent of drops had a water source to fire distance of > 15 nautical miles (28 km). This figure only represents fires that received air attack from fixed wing aircraft.*

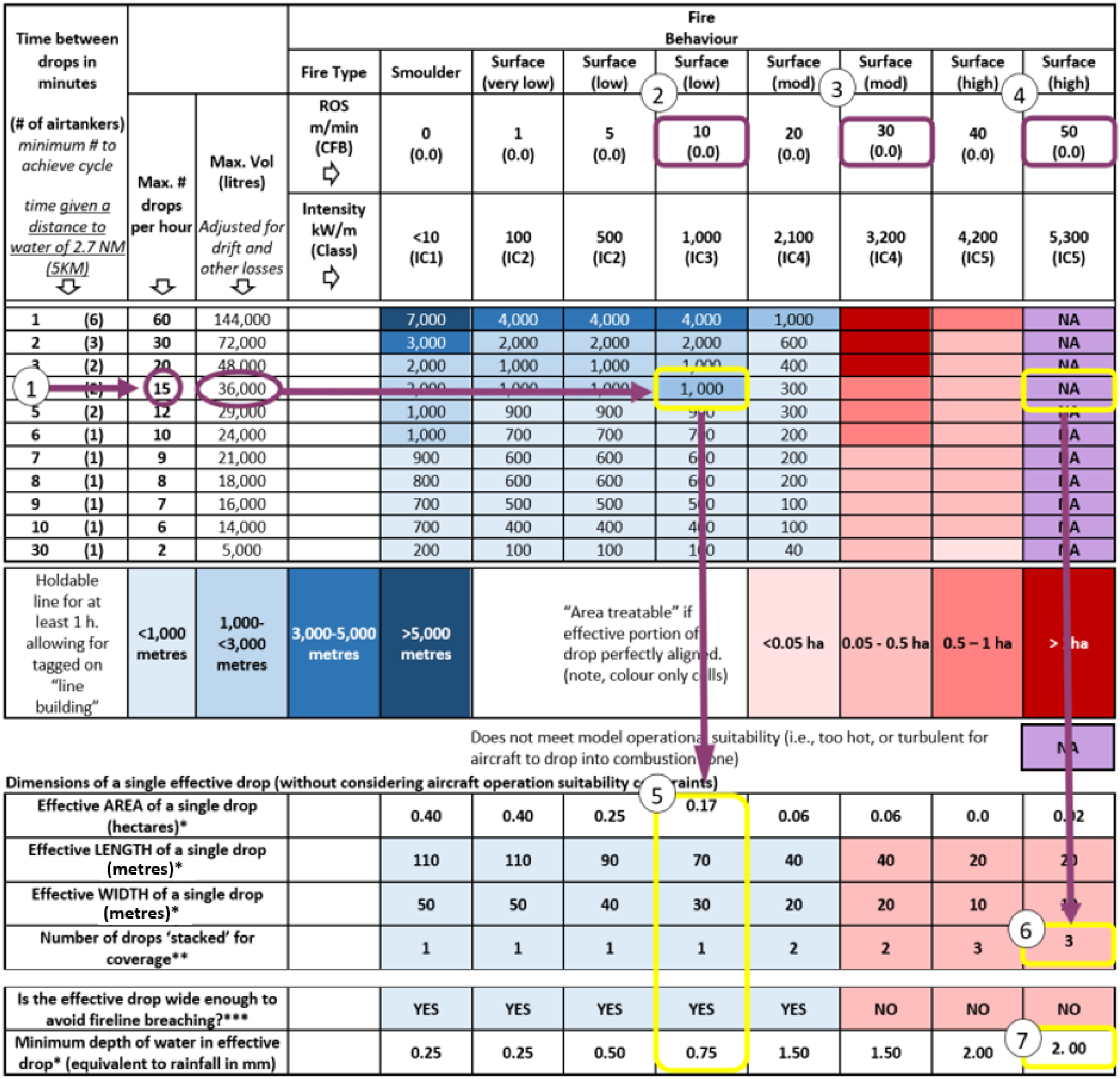
9.1 HOW TO USE THE EFFECTIVENESS CHARTS

Figure 9-2 shows an annotated version of the line building chart, for the situation where there is a need for **4** minutes between drops (see 1). The number in brackets beside the time between drops gives the number of airtankers of this type needed where the distance to water is 2.7 NM or 5 km (2 in this example). With 4 minutes between drops there can be a maximum of 15 drops over an hour which, for this airtanker, will result in 36,000 litres of water delivered to the fireline.

Once the number of drops possible in an hour is determined, one can assess the amount of holdable line which can be built over that hour. The columns in the main part of this table are designed to present a range of potential fire behaviour; these column headers provide both qualitative and quantitative descriptions of fire behaviour based on values calculated using FBP System and assumed conditions. In the example in Figure 9-2 a fire in O-1a fuel (grass) is spreading as a surface fire (see 2) with 10 m/min rate of spread and fire intensity of 1000 kW/m, or intensity class 3 (IC3). Given where (1) and (2) meet, the blue shading indicates that the drops are estimated to be "effective" at building line, and that the airtanker chosen can build and hold 1000 m of perimeter over an hour of continuous activity. If there were an increase in fire behaviour to 30 m/min (see 3), the table suggests it is no longer possible to build holdable line, however the red shading indicates that it may be still possible to effectively treat hotspot areas. In this case, the lighter shade of red indicates the area that could be effectively treatable. If, fire behaviour is even more intense (see 4), neither line building nor is hotspotting will be effective. In this case, the NA (highlighted by purple shading) indicates that the fire behaviour is beyond operational suitability of the airtanker (which we defined earlier in Table 4-1).

Aside from the line building and hotspotting in the upper portion of the charts, you can also follow the appropriate column down to the lower section which provides a number of reference points for a single drop for the given intensity. In the column labelled as (5) in Figure 9-1 we can see that a single "effective" drop can treat an area of 0.17 ha and that dimensions of this effective drop are approximately 70 m by 30 m. The chart also indicates (in the row that indicates 'stacking') that, for that specific fuel type at the intensity chosen, only 1 drop is needed for the drop to be effective over the area indicated. In some cases, to achieve enough consistent water coverage over the defined drop area, more than one drop at the same location may be needed; this can be seen in Figure 9-2 where the table indicates for the high fire behaviour scenario (labelled as (6)) that 3 stacked drops are needed. This need for 'stacking' and its estimation from the spatially detailed experimental drop coverage data are described in section 8 and shown in Figure 8-3.

The classification of a drop being able to hold a spreading fire is determined by an assessment of whether the spreading fire will simply breach the effective drop width. This indicator is based on flame length, the depth of the fire front and the half-width of a drop; it is shown in the second last row of the table as a "YES/NO" indicator of breaching. The last row of the column shows the water depth from the drop the energetics model estimates as being necessary for the selected fire behaviour. In the column labeled by (5) in Figure 9-2 this final value suggests the drop water depth is 0.75 mm, in the higher intensity scenario (labelled as (7)) with depth is 2.0 mm. These water depths while expressed as water depths (like rainfall) are the equivalent of volume delivered (in L) per square metre; they are conceptually the equivalent of coverage level used as a descriptor of airtanker water coverage in other documentation.



Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)*	Max. # drops per hour	Max. Vol (litres) *Adjusted for drift and other losses*	Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
			ROS m/min (CFB)	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
			Intensity kW/m (Class)	<10 (IC1)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
1 (6)	60	144,000		7,000	4,000	4,000	4,000	1,000			NA
2 (3)	30	72,000		3,000	2,000	2,000	2,000	600			NA
3 (2)	20	48,000		2,000	1,000	1,000	1,000	400			NA
4 (2)	15	36,000		2,000	1,000	1,000	1,000	300			NA
5 (2)	12	29,000		1,000	900	900	9[illegible]0	300			NA
6 (1)	10	24,000		1,000	700	700	7[illegible]0	200			NA
7 (1)	9	21,000		900	600	600	6[illegible]0	200			NA
8 (1)	8	18,000		800	600	600	6[illegible]0	200			NA
9 (1)	7	16,000		700	500	500	5[illegible]0	100			NA
10 (1)	6	14,000		700	400	400	4[illegible]0	100			NA
30 (1)	2	5,000		200	100	100	1[illegible]0	40			NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	>[illegible] ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
Effective AREA of a single drop (hectares)*		0.40	0.40	0.25	0.17	0.06	0.06	0.0	0.[illegible]2
Effective LENGTH of a single drop (metres)*		110	110	90	70	40	40	20	2[illegible]
Effective WIDTH of a single drop (metres)*		50	50	40	30	20	20	10	[illegible]
Number of drops 'stacked' for coverage**		1	1	1	1	2	2	3	3
Is the effective drop wide enough to avoid fireline breaching?***		YES	YES	YES	YES	YES	NO	NO	NO
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		0.25	0.25	0.50	0.75	1.50	1.50	2.00	2. 00

Figure 9-2. *Demonstration of how to read the line building charts.*

9.2 CL-415 LINE BUILDING AND HOTSPOTTING CHART (C-2, FULL CANOPY)

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes **(# of airtankers)** *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (6)	60	295,000		8,000	3,000	3,000	3,000	3,000			
2 (3)	30	147,000		4,000	2,000	2,000	2,000	2,000			
3 (2)	20	98,000		3,000	1,000	1,000	1,000	1,000			
4 (2)	15	74,000		2,000	800	800	800	800			
5 (2)	12	59,000		2,000	700	700	700	600			
6 (1)	10	49,000		1,000	600	600	600	500			
7 (1)	9	42,000		1,000	500	500	500	400			
8 (1)	8	37,000		900	400	400	400	400			
9 (1)	7	33,000		800	400	400	400	300			
10 (1)	6	29,000		800	300	300	300	300			
30 (1)	2	10,000		300	100	100	100	100			

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.52	0.26	0.26	0.26	0.13	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	90	90	90	70	30	20	0
Effective WIDTH of a single drop (metres)*		50	40	40	40	30	7	5	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

- See Appendix A11 for complete set of charts for each airtanker in C-3 and C-2 full and sparse canopy, O-1a (100%) open, S-1 open.

SECTION 10: APPLIED USE OF THE GUIDE

We have laid the guide out in a way that builds in complexity, from comparing the number of drops airtankers can potentially do in a mission, to line building effectiveness. There are also several supporting sections, such as Appendix A4 Bellytank Use Considerations. As stated above, there are several ways to use this guide. One way is to use the following set of steps and worksheet as a framework.

To help determine the amount of fireline able to hold for a specific airtanker and scenario, Figure 10-1 illustrates the inputs and outputs. In this guide there are several sections that one can reference to aid in determining different factors that are required. For example, if guidance is needed to estimate the size of a fire, **Step 1** will provide charts that allow estimation of the perimeter length based on area. If perimeter length (Step 1) is already known, you (the user) can proceed to **Step 2** and estimate head fire intensity given several observable fire characteristics. With both Step 1 and 2 completed, the next step **(Step 3)** is to determine what proportion of the fire perimeter is effectively suppressible given how intensity varies from head fire to back fire. Now that the potential targets are identified (i.e., different lengths of perimeter by fireline intensity classes) it is time to account for the different airtanker types. For a given scenario, where an airtanker type is known, (**Step 4**) requires an estimate of the possible cycle time, then considering the effective drop size for the intensity of the target section of line, the quantity of line that is possible to hold can be calculated (**Step 5**). Finally **Step 6** determines if the airtanker mission is suitable for the fire scenario. If unsuitable, you can look at what a change in cycle time would do (i.e., add more aircraft to the circuit) or using a different type of airtanker.

This process may also be logically laid out in a worksheet (Table 10-1); however, it must be noted this worksheet is not to be considered as explicitly predictive as is the case for similar style work sheets in the "Red Book" (Taylor and Alexander, 2018). This worksheet is intended to assist users in considering one way to use the various data contained in this guide.

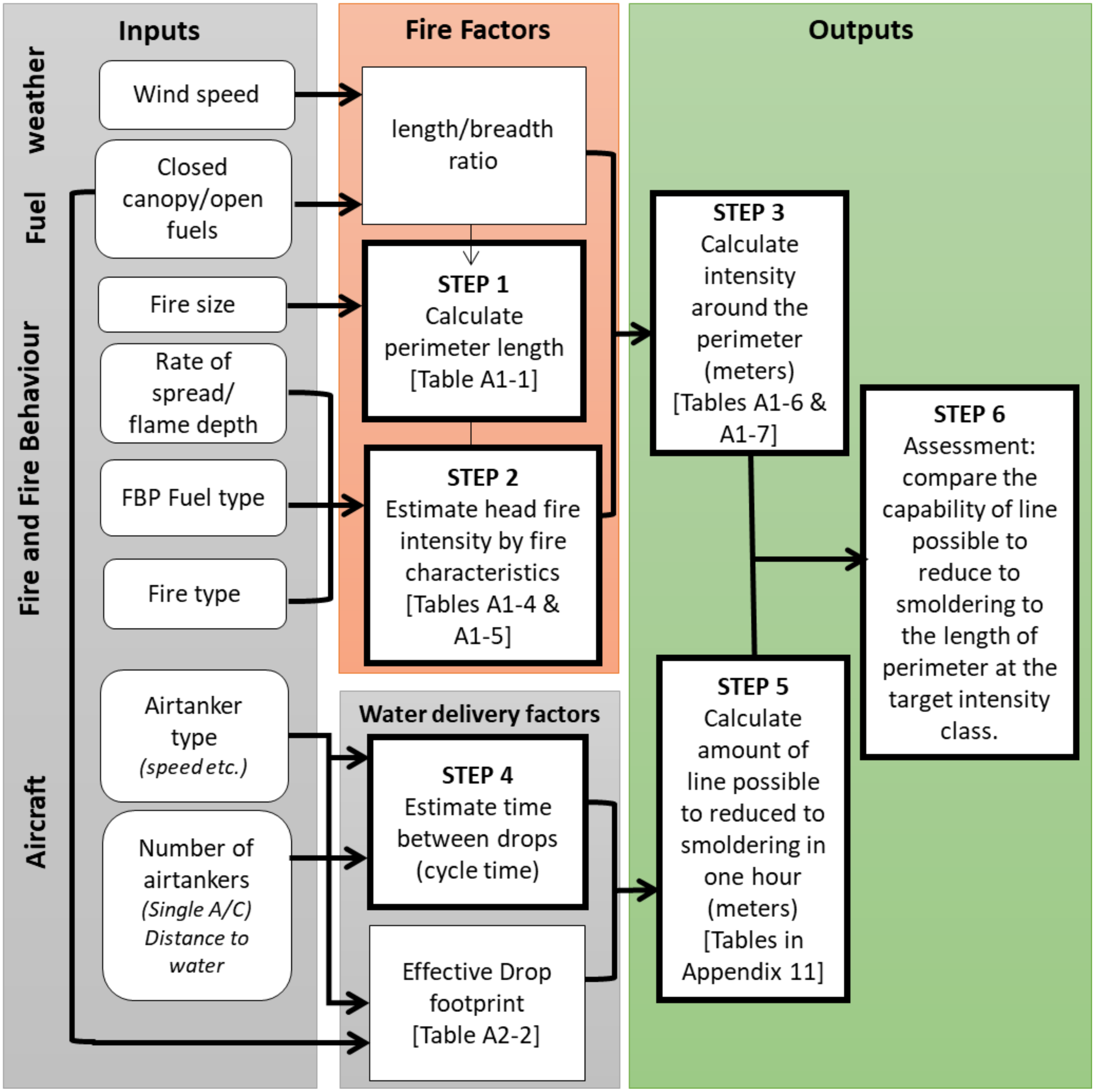


Figure 10-1. *illustrating the interactions between inputs and outputs to determine line holding for a specific airtanker and scenario.*

Table 10-1. *Printable worksheet for direct attack – Line building.*

Step	Task		Fuel type	Closed canopy forest (2:1)	Open fuels (4:1)
	Estimate FBP benchmark fuel type		Fuel type	**Closed canopy forest (2:1)**	**Open fuels (4:1)**
Step 1	**Calculate total perimeter length**		*Estimate fire area, record it below*	*Select the most representative fuel description. Record corresponding "perimeter length" to fire area. Follow the column down under the appropriate length – breadth ratio.*	
	Table A1-1		Area (ha)	Total perimeter length **(PL)** (m)	Total perimeter length **(PL)** (m)
Step 2	**Estimate head fire intensity class (HFI)**		ROS (m/min)	HFI and Intensity Class (IC class) (kW/m)	HFI and Intensity Class (IC class) (kW/m)
	Table A1-4			IC Range Low ☐ High ☐	IC Range Low ☐ High ☐
Step 3a	**Calculate intensity class (IC) around the perimeter**		Using the same length to breadth ratio above; using the HFI class and range (low or high) enter the % of total perimeter length for each intensity class. Enter as a decimal (e.g., 65% = 0.65)		
	Table A1-6 (for 2:1) Table A1-7 (4:1)		IC 1	(%)	(%)
			IC 2	(%)	(%)
			IC 3	(%)	(%)
			IC 4	(%)	(%)
			IC 5	(%)	(%)
			IC 6	(%)	(%)

Step	Task		IC1	IC2	IC3	IC4	IC5	IC6
Step 3b	**Calculate length of perimeter for different IC**		IC1	IC2	IC3	IC4	IC5	IC6
	3b *(PL step 1) x (% step 3a) = Length of perimeter at IC (m)*		(m)	(m)	(m)	(m)	(m)	(m)
Step 4 & 5	**Select aircraft & estimate cycle time**		Aircraft type:			Cycle time:		
	4a: Amount of line possible to reduce to smoldering (1 h) Appendix A11		(m)	(m)	(m)	(m)	(m)	(m)
Step 6	**Assess suitability of aircraft**	Amount of total perimeter at IC (4a – 3b)	(m)	(m)	(m)	(m)	(m)	(m)
	Results	**If Step 6 is a negative number (line is being reduced), positive number (line is growing still).** Note, each IC segment is assessed independently. E.g., it may require more than the 1-hour from the tables in Appendix A11 to hold all segments. Starting with the higher IC you can roughly estimate the surplus of line for lower IC.						

SECTION 11: GLOSSARY OF TERMS

- **Air Attack:** Wildland fire suppression operation involving the use of aircraft to deliver suppressants or retardants to a wildland fire.
- **Air Attack Officer:** The person responsible for directing, coordinating, and supervising a wildland fire suppression operation involving the use of aircraft to deliver retardants or suppressants on a wildland fire.
- **Airtanker:** an aircraft (rotary or fixed wing) that carries and drops water (possibly with water enhancers) and/or retardant for aerial firefighting operations. There are many kinds of airtankers, and classifications vary among agencies, e.g., skimmer, siphon, bucket, land-based; Single Engine Air Tankers (SEATs); definitions of light, intermediate, heavy/large, very large based on the drop litres and/or physical size of the airtanker (synonymous with waterbomber, scooper).
- **Barrier building:** An area ahead of the fire is pre-treated for the purpose of creating a barrier that will either halt or steer a fire.
- **Cycle time** (or time between drops)**:** The time between drops on a given portion of the fire.
- **Drop footprint** (or footprint)**:** The pattern on the ground of the airtanker's dropped load. can be characterized by position, orientation, size, shape, and the distribution of the depth of water or retardant within its boundary.
- **Effectiveness:** The degree to which an airtanker will change fire intensity on a burning perimeter or hotspot to an acceptable level, in this case smouldering.
- **Effective drop:** A portion of the drop footprint considered to be effective to lower the intensity to an acceptable level, i.e., excludes parts receiving very little water and/or spotty coverage. We refer to the dimensions of an effective drop as the effective drop length and drop width relative to the intensity.
- **Hotspotting:** The delivery of water directly on a small fire (or small target area within a larger fire) resulting in a quick knockdown of the intensity. Typically used on initial attack.
- **Initial attack (IA):** quick initial action (generally on small fires) to reduce the rate of spread and intensity to facilitate ground crew follow-up.
- **Lapped on:** The tactic where drops are overlapped laterally, with a previous load. The standard overlap is one-third.

- **Line building:** The delivery of water directly on a burning segment of fireline perimeter, reducing the fire intensity in that portion of the fireline to a level easier control by ground crews.
- **Operating suitability or capabilities:** In the real-world there are operational constraints to where an aircraft can fly near or over an active fire (e.g., visibility, turbulence, and heat). This term describes some simple FBP System-based rules to highlight the situations that would limit the ability for an aircraft to drop directly onto the combustion zone based on crown fraction burned and fire intensity.
- **Reduce to smouldering:** The tactic where fire intensity will be reduced to levels where, while combustion may still be occurring within the fuel bed, the fire is not actively spreading. The combustion rate within the drop zone will eventually return to the levels where the fire begins actively spreading again, if further drops do not occur over the perimeter.
- **Rolled up:** The tactic where drops are connected from the head (front) of the drop to a previous drop or reference feature.
- **Salvo:** A single discharge of the full capacity of the tank(s) of the airtanker.
- **Support mission:** Missions generally taken after initial attack phase and/or on an unstaffed section of a larger fire. Actions include cooling off hotspots, holding a section of line, protecting values, or knocking down spot fires.
- **Sustained Attack:** is where bombing action lasts more than two hours. This is more likely with an aggressive or contentious fire under IA.
- **Tagged on:** The tactic where drops are connected from the tail (rear) of the drop to a previous drop or reference feature.

SECTION 12: ACKNOWLEDGEMENTS

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SECTION 13: REFERENCES

Albini, F.A. 1981. A model for the wind-blown flame from a line fire. Combustion and Flame, 43, 155-174. doi: 10.1016/0010-2180(81)90014-6

Albini, F.A.; Stocks, B.J. 1986. Predicted and observed rates of spread of crown fires in immature jack pine. Combustion Science and Technology, 48(1-2), 65-76. doi: 10.1080/00102208608923884

Alexander, M.E. 1982. Calculating and interpreting forest fire intensities. Canadian Journal of Botany, 60(4), 349-357. doi: 10.1139/b82-048

Alexander, M.E.; de Groot, W.J. 1988. Fire behaviour in jack pine stands as related to the Canadian Forest Fire Weather Index (FWI) System. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta.

Anderson, H. E. (1969). Heat transfer and fire spread. Res. Pap. INT-RP-69. Ogden, Utah: US Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 20 p., 69.

Aviation Forest Fire and Emergency Services (AFFES). 2015. AV110 Air Attack Officer Course. Ontario Ministry of Natural Resources and Forestry. Internal Document.

Butler, B.W.; Cohen, J.; Latham, D.J.; Schuette, R.D.; Sopko, P.; Shannon, K.S.; Jimenez, D.; Bradshaw, L.S. 2004a. Measurements of radiant emissive power and temperatures in crown fires. Canadian Journal of Forest Research, 34(8), 1577-1587. doi: 10.1139/x04-060

Butler, B.W.; Finney, M.A.; Andrews, P.L.; Albini, F.A. 2004b. A radiation-driven model for crown fire spread. Canadian Journal of Forest Research, 34(8), 1588-1599. doi:10.1139/x04-074

Byram, G.M. 1959. Combustion of forest fuels. pp. 61-89 in K. P. Davis (Ed.), Forest Fire Control and Use. McGraw-Hill Book Company, Inc. G. M.

Forestry Canada Fire Danger Group (FCFDR). 1992. Development and structure of the Canadian Forest Fire Behaviour Prediction System. Information Report ST-X-3. Forestry Canada, Headquarters, Fire Danger Group and Science and Sustainable Development Directorate, Ottawa. 64 p.

Foster, W. T. 1962. Aircraft in forest fire control in Ontario. The Forestry Chronicle, 38(1), 38-48. doi:10.5558/tfc38038-1

Hirsch, K. G. 1996. Canadian Forest Fire Behaviour Prediction (FBP) System: user's guide. Special Report 7. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. 122 p.

Hirsch, K.; Martell, D.L. 1996. A review of initial attack fire crew productivity and effectiveness. International Journal of Wildland Fire, 6(4), 199-215. doi:10.1071/WF9960199

Kidnie, S.; Wotton, B.M. 2015. Characterization of the fuel and fire environment in southern Ontario's tallgrass prairie. International Journal of Wildland Fire, 24(8), 1118-1128. doi:10.1071/WF14214

Loane, I. T.; Gould, J. S. 1986. Aerial suppression of bushfires: cost-benefit study for Victoria. National Bushfire Research Unit, CSIRO Division of Forest Research.

Nelson, R.M.; Butler, B.W.; Weise, D.R. 2011. Entrainment regimes and flame characteristics of wildland fires. International Journal of Wildland Fire, 21(2), 127-140. doi: 10.1071/WF10034

Ontario Ministry of Natural Resources, Aviation and Fire Management Branch (OPAS)—Canada's Aviation Hall of Fame. (2021, February 15). https://cahf.ca/ontario-ministry-of-natural-resources-aviation-and-fire-management-branch-opas/

Prichard, S.J.; Ottmar, R.D.; Anderson, G.K. 2007. CONSUME user's guide and scientific documentation. Available online: http://www.fs.fed. us/pnw/fera/research/smoke/consume/consume30_users_guide.pdf (accessed on 04 08 2022).

Reinhardt, E.D.; Keane, R.E.; Brown, J.K. 1997. First order fire effects model: FOFEM. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah, GTR-INT-344. doi.:10.2737/INT-GTR-344

Taylor, S.W.; Alexander, M.E. 2018. A field guide to the Canadian Forest Fire Behavior Prediction (FBP) System. Third edition. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC.

Taylor, S.W; Wotton, B.M. Alexander, M.E., Dalrymple, G.N. 2004. Variation in wind and crown fire behaviour in a northern jack pine – black spruce forest. Canadian Journal of Forest Research, 34(8),1561-1576. doi:10.1139/x04-116

Thomasson, J. 2012. Improving the visual assessment method of measuring cup amounts in airtanker drop tests. FP Innovations, Wildfire Operations Research. Hinton, Alberta.

Van Wagner CE (1977). A method of computing fine fuel moisture content throughout the diurnal cycle. Information Report PS-X-69. Canadian Forest Service, Petawawa, Ontario. 15 p.

Van Wagner, C.E. 1987. Development and Structure of the Canadian Forest Fire Weather Index System; Forestry Technical Report 35. Canadian Forestry Service, Headquarters, Ottawa, ON. 35 p.

Van Wagner, C.E. 1989. Prediction of crown fire behaviour in conifer stands. pp. 207-212 in D. C. MacIver.; H. Auld.; R. Whitewood (Eds.), Proceedings of the 10th Conference on Fire and Forest Meteorology. April 17-21, 1989, Ottawa, ON, Canada.

West, B. 1974. The Firebirds: How Bush Flying Won Its Wings. Ministry of Natural Resources.

Wotton B.M. 2009. A grass moisture model for the Canadian Forest Fire Danger Rating System. In Proceedings Eighth Fire and Forest Meteorology Symposium. Kalispell, MT, Oct 13-15, 2009.

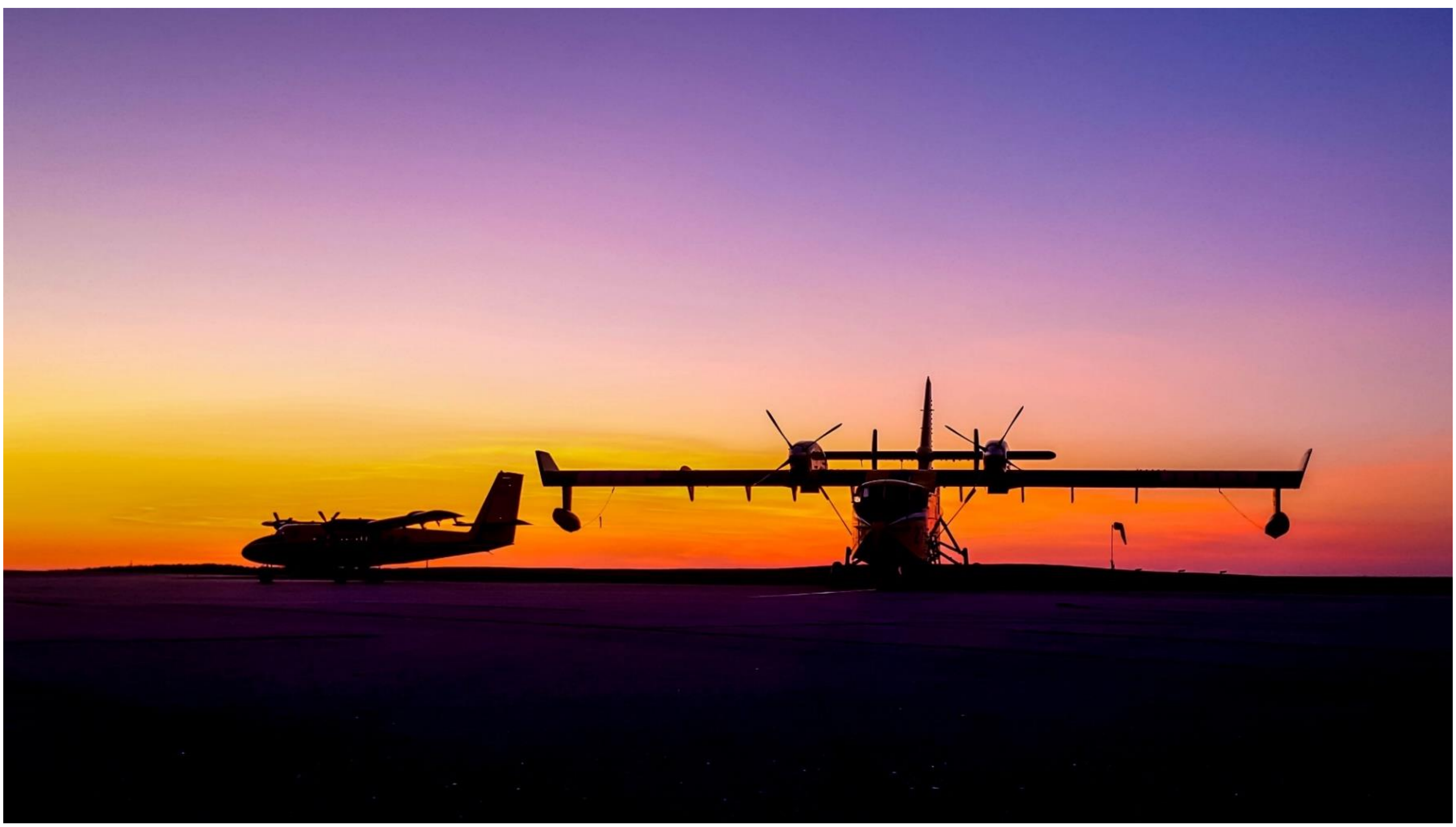
Wotton, B.M.; Flannigan, M.D.; Marshall, G.A. 2017. Potential climate change impacts on fire intensity and key wildfire suppression thresholds in Canada. Environmental Research Letters, 12(9), 095003. doi: 10.1088/1748-9326/aa7e6e

Wotton B.M.; Gould, J.S.; McCaw, W.L.; Cheney, N.P.; Taylor, S.W. 2011. Flame temperature and residence time of fires in dry eucalypt forest. International Journal of Wildland Fire, 22(3), 270-281. doi:10.1071/WF10127.

Wotton, B.M.; Martin, T. L. 1998. Temperature variation in vertical flames from a surface fire. Pages 533-545. In *Proceedings 3rd International Conference on Forest Fire Research and 14th Conference on Fire and Forest Meteorology.* November 16-20, 1998. Luso, Portugal.

Wotton, B.M.; Stocks, B.J. 2006. Fire management in Canada: vulnerability and risk trends. pp 49-55 in K. Hirsch and P. Fuglem (Eds.), Canadian Wildland Fire Strategy: background syntheses, analyses, and perspectives.

Appendices



A1 Appendix: Wildland Fire Factors

The following section primarily deals with information to assist in assessing the conditions of a wildland fire, namely the size, perimeter length, intensity class and fire characteristics.

A1.1 Calculate perimeter length

On an actual fire the size (or area) is estimated on a fire scouting assessment. Using the elliptical model for fire spread allows us to relate the area of the fire and length of perimeter in a simple way.

In the fire growth assumptions in the FBP System, the fire perimeter expands following a simple elliptical shape where the length of the ellipse is the sum of the head fire spread distance and the back fire spread distance and width of the ellipse is twice the flankfire spread distance (Figure A1-1). This elliptical model is often used for short duration fire growth and accounts for some things like small differences in fuels or the random variation of wind around a overall wind flow direction and can be a convienient approximation for the shorter term growth of fires. It is, however, an oversimplification for larger fires where significant landscape features and lasting shifts in overall wind direction complicate fire spread leading to more complex shapes.

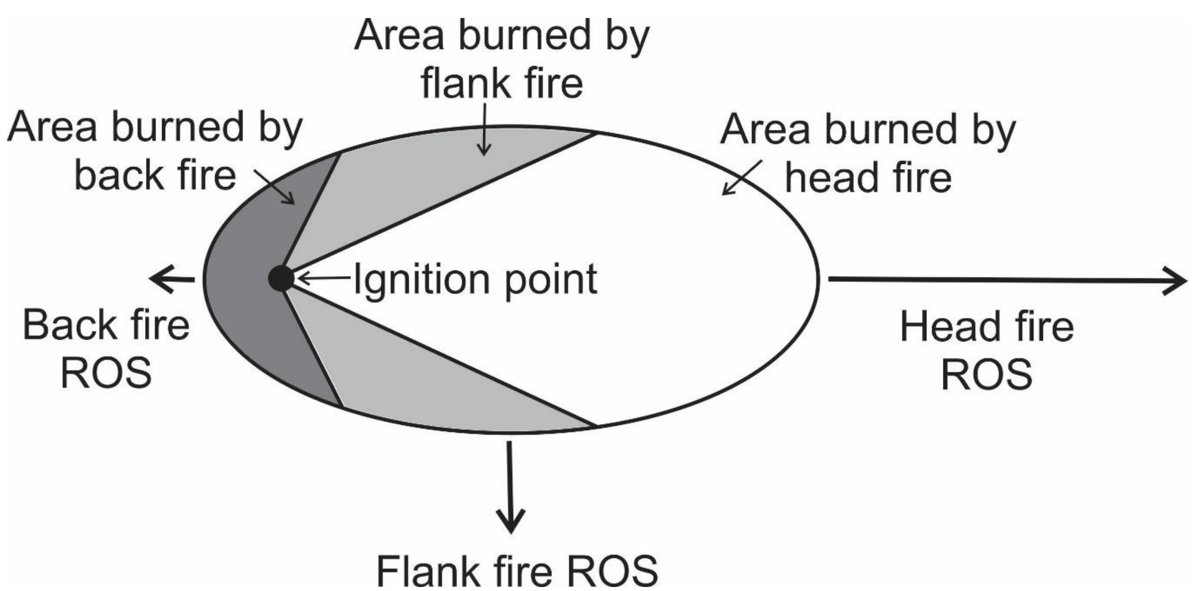


Figure A1-1. *Simple elliptical fire growth model (2:1 length to breadth ratio) with ignition point, area burned and rate of spread (ROS) and direction.*

The following table relates the fire size or area (ha) to the perimeter (and the approximate length and width of an elliptical fire) which can be used to estimate the total length of perimeter. Two different length to breadth ratios are presented, representing a typical fire spreading in closed canopy forest and open canopy fuels respectively.

Using Table A1-1 one can either estimate the perimeter length from the observed area or also estimate the area using observations of the apparent length and width of the fire and then perimeter. This table could also be used as a job aid for estimating fire size on a scouting report.

Table A1-1. *For 15 km/h winds the FBP System length-to-breadth model (Forestry Canada Fire Danger Group (FCFDG) 1992) predicts a 2:1 ellipse in closed canopy fuels and a 4:1 ellipse in open fuels. For a given fire area, this chart provides the approximate perimeter length and the length-to-breath ratio dimensions for 2:1 and 4:1.*

Area (ha)	2:1 Total perimeter Length (m)	2:1 Length (m)	2:1 Width (m)	4:1 Total perimeter Length (m)	4:1 Length (m)	4:1 Width (m)
0.1	120	50	25	150	70	20
0.5	270	110	55	340	160	40
1.0	390	160	80	490	230	60
1.5	480	200	100	600	280	70
2.0	560	230	115	680	320	80
2.5	610	250	125	770	360	90
3.0	680	280	140	830	390	100
4.0	770	320	160	1000	450	110
5.0	870	360	180	1100	500	130
10	1200	500	250	1500	710	180
15	1500	620	310	1900	870	220
20	1700	710	355	2100	1000	250
25	1900	800	400	2400	1100	280
30	2100	870	435	2600	1200	300
35	2300	940	470	2800	1300	330
40	2400	1000	500	3000	1400	350
45	2700	1100	550	3200	1500	380
50	2700	1100	550	3400	1600	400
100	3900	1600	800	4900	2300	580
200	5600	2300	1150	6800	3200	800

A1.2 Fire intensity

Fire intensity is the "rate of energy release, or rate of heat release, per unit time per unit length of fire front" (Byram 1959) and refers to the energy released in the passage of the coherent flaming front. It is the product of the rate of fire spread, the amount of fuel consumed, and the heat of combustion (effectively a constant). Byram's fire intensity (which is also often in more modern use referred to as 'fireline intensity') is expressed in kilowatts per metre (kW/m).

Fire intensity highly influences flame lengths, and therefore influences the width of a control line required to effectively limit access to fuel. Because of its relation to the buoyancy and the upward force of the fire, intensity level also influences the strength of the updraft and the turbulence above a fire. The combusting fuel within a fire has a certain amount of energy stored within it; part of this energy (which is somewhat related to intensity) helps it maintain the combustion process. Water, when applied directly to a fire, can reduce the energy in the combustion zone (since water is an excellent 'sink' of energy) and hence reduce the rate of combustion and the intensity of a fire. This balance between the energy sink that water provides and amount of energy within a fire front allows you to start to think about tactics or how wide a barrier is needed.

A1.2.1 Head fire intensity

Head fire intensity (HFI) is defined (in the FBP System) as the intensity of the fastest moving portion of the fire perimeter; in the absence of slope this is in the downwind direction. On an initial scouting assessment, it is the behaviour at the head of the fire that is often reported.

- For example, a specific fire may be described as “intensity class 5” on an initial scouting report; however, that is likely describing the most active portion of the fire which is the head (e.g., other parts of the fire may be a lower intensity) (see Figure A1-3 below for example).

A1.3 Flame length and flame front depth

These are the physical and observable characteristics of a spreading fire front and are often used to characterize fire intensity (e.g., Albini 1981; Alexander 1982; Butler et al. 2004a).

- **Flame front depth:** the length of the zone within which continuous flaming occurs behind the edge of the fire front.
- **Flame length:** the length of flames measured along their axis at the fire front; the distance between the flame height tip and the midpoint of the flame depth at the ground surface.

A1.3.1 Flame front depth

Flame front depth can be estimated by multiplying the flame front residence time by the spread rate of a fire. Flame front residence time represents the duration of flaming during the main passage of the fire front; disconnected flaming during burnout, the energy from which would not contribute to flame front intensity, is not considered in flame front residence time. In the energetics model which is used to determine the size of drops that effectively ‘cool’ the combustion zone (Appendix A5) flame front depth is considered to define the depth of the active combustion zone which must receive water. Details about flame front depth and flame front residence times assumed for each fuel type are presented in the overall descriptions of the energetics model in Appendix A5.

A1.3.2 Flame length

To estimate flame length for surface fires we use Byram’s (1959) flame length – intensity relationship. To estimate flame length for active crown fires we use a model originally calibrated for pine by Albini and Stocks (1986) and used for mature jack pine by Butler et al (2004b).

Estimating flame length in an intermittent crowning fire is challenging. One might argue there is no defined flame length during this phase of a fire’s development, since along the fireline one will see a mix of the flame front with flame lengths consistent with surface fire and small sections where individual trees are torching, and flames are extending up the entire length of the tree and up well above the crown.

These areas of vertically extended flame length are however interspersed along the flaming front with much lower surface fire flames (see Figure A1-2). For the sake of consistent transition between the two models of surface and crown fire flame lengths we have mathematically defined a flame length function to transition between the surface and crown intensity-based flame length models described in the previous paragraph. We transition between these surface and crown flame length estimates using a modification of the FBP System's crown fraction burned (Van Wagner 1989, FCFDG 1992). Butler et al.'s (2004b) model of crown fire flame length requires a stand height estimate be used, so in Table A1-2 below we assume the height of the jack pine stand is 15 metres; to estimate surface fire intensity for the FBP System calculation we also require a BUI value that we set at a mid-range value of 50.

Figure A1-2. *Conceptual visualization of flame lengths as a fire front passed through a stand as a surface fire spreading with torching of some trees (intermittent crowning).*

A1.4 Barrier breaching

When the flaming fire front crosses or otherwise jumps a barrier, it is called breaching. This can happen because radiation and convection (heat transferred directly from flame contact) heat the fuel on the far side of the barrier while the fire provides a ready source of flaming fire brands for piloted-ignition. This heating and piloted-ignition allows the fire to pass across a fuel-free 'barrier' with little interruption in its overall spread. This short-range process is different than medium- and longer-term spotting, where fire brands land, and start independent new ignitions growing ahead of the fire front.

We do not consider spot fire development in this Guide.

Byram (1959) developed a simple general rule about barrier breaching that suggested that a barrier must be wider than 1.5 times the flame length of the spreading fire to hold (Table A1-2). In our assessment of the potential for a drop to hold an intense fire we use a modification of Byram's breaching rule; we assume the area of wetted fuels must only be wider than the flame length. Our modified flame length rule is used in the drop effectiveness assessment in the energetics model determining the minimum half drop width needed for wetting surface fuel to create an effective barrier that will inhibit spread for a time (see Appendix A5 for more detail). In interpreting these values presented in Table A1-2, it is important to remember that:

1) The process of breaching does not account for medium or longer-range spotting.
2) Flame length and-fireline intensity relationships are quite variable.
3) The general rule is a very coarse simplification of a complex process and Byram did not develop his original rule from intensities expected from actively spreading boreal crown fires.

Table A1-2 shows expected flame lengths for a range of head fire intensities in a standard mature Jack pine stand (C-3) and provides an estimate of expected barrier width needed to prevent breaching. This minimum effective width of a fuel break is the value given by Byram's (1959) original general flame length rule; our modification of that rule for effective drop width classification uses the flame length itself.

Table A1-2. *Flame length and Byram's effective width of a barrier in 15 m tall mature jack pine* (C-3).

Intensity Class	Head Fire Intensity (kW/m)	Fire type	Flame Length (m)	Byram's Effective Barrier Width (m)
2	100	Surface	**1**	>1
2/3	500	Surface	**1**	>2
3	1,000	Surface	**2**	>3
3/4	2,000	Surface	**3**	>4
4	3,000	Surface	**3**	>5
4/5	4,000	Intermittent*	**5**	>7
5	6,000	Intermittent*	**10**	>15
5	8,000	Intermittent*	**14**	>21
5/6	10,000	Intermittent*	**17**	>25
6	**15,000**	**Crown***	**22**	**>32**
6	**25,000**	**Crown***	**27**	**>40**
6	**50,000**	**Crown***	**36**	**>54**

*For the purposes of transitioning between surface and crown fire flame length models, the process assumes BUI=50 and Foliar Moisture content is 100%. Long-distance spotting is ignored.

A1.5 FIRE INTENSITY CLASSIFICATION

The intensity class definitions (classes 1 through 6 in Table A1-3) in Canada can be traced back to Alexander and de Groot (1988) who were describing fire characteristics in mature jack pine (C-3). Hirsch (1996) showed similar intensity class tables linking fire characteristics to intensities for both C-2 and C-3. Hirsch and Martell (1996) provide a comprehensive summary of fire intensity and how it has been linked to fire suppression capability thresholds and the common general rules regarding suppression capabilities (e.g., Air Attack required when above intensity class 3).

Table A1-3. *Canadian fire intensity classes (Taylor and Alexander 2018).*

Intensity Class (kW/m)	Fire Behaviour Descriptions
1 (<10)	Smouldering ground or creeping surface fire Little visible flame Firebrands and active fires tend to self-extinguish except with high DC and/or BUI
2 (10 – 500)	Low vigor surface fire In stands with low crown base height, some foliage of individual trees consumed
3 (500 – 2,000)	Moderately vigorous surface fire with both low and high flames Ladder fuels (lichen and bark flakes) consumed Isolated torching in stands with low crown base height or ladder fuels
4 (2,000 – 4,000)	Highly vigorous surface fire with moderate to high flames Passive crowning (isolated to abundant torching) increasing with amount of ladder fuels with low crown base height
5 (4,000 – 10,000)	Extremely vigorous surface fire or active crown fire with abundant torching and continuous crowning in dense stands Flames extend from the forest floor to above the tree canopy Short to medium range spotting likely
6 (>10,000)	Blow-up or conflagration type fire runs Continuous crowning in forested fuel types Great walls of flame Towering convection columns Medium to long-range spotting Fire whirls

A1.5.1 Determining intensity and class

In Canada, agencies have different general rules about what descriptive characteristics of a fire relate to intensity and, commonly, the surface head fire flame length, flame heights and descriptions of behaviour are associated with expected fire behaviour in mature pine stands (C-3) – see Table A1-2.

To assist in the determination of intensity class using descriptive characteristics that are potentially easier to distinguish from the air by a person than say flame length, the following may be useful:

- **Rate of spread (ROS):** the speed of forward movement of a fire expressed in metres per minute.
- **Flame front depth:** the length of the zone within which continuous flaming occurs behind the edge of the fire front.

The observable characteristics of intensity are not the same in all fuel types; for instance, crowning, and extended flame lengths observed in boreal spruce (C-2) can occur long before any crown involvement in mature pine types (C-3 or C-5). In air attack operations "intensity class" is typically estimated overhead of a fire and given as part of an initial (scouting) report which is used to convey the general behaviour of the fire and inform the kinds of tactics that are appropriate. In this guide we focus more on the characterization of fire type as defined in the FBP System that occurs for each intensity class which is somewhat analogous to the classic fire "rank" system[2].

Flame front depth can be used to estimate fire intensity by assuming that the residence time of flaming is relatively constant for a specific fuel complex that is burning. Flame depth is simply the residence time of flaming multiplied by the spread rate of the fire. In our tables below, and in the airtanker drop energetics model (Appendix A5) we use a residence time of flaming of 25 seconds for grasslands, 30 seconds for pine, 40 seconds for spruce and 2 minutes for slash (Table A5-1).

Table A1-4 indicates the relationships between rate of spread (ROS) and depth of the flame front of a spreading line of fire at a particular intensity. This in turn can be compared to the effective width of the airtanker drop when considering scenarios involving different air tankers. Coverage of the full flaming depth of the fire will influence the reheating of the combustion zone (e.g., if the width of the drop does not cover the full depth of the flame front it will reheat faster). The amount of overlap used in tactics may also be inferred from the charts below.

Table A1-5 simply further demonstrates the different types of fires (surface to crown) that occur under different intensity classes in different fuel types by rate of spread.

[2] https://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-response/about-wildfire/wildfire-rank

Table A1-4. *Relationship of rate of spread (ROS) and flame front depth to head fire intensity (HFI) and intensity class, type of fire and with crown fraction burned (CFB) for C-2 and C-3 fuel types. Also, without CFB for slash (S-1) and grass (O-1a) open fuel types. Cells are coloured by the fire type with beige being surface fire, orange intermittent, and red with white text a crown fire.*

		FUEL type C-2			FUEL type C-3		
Intensity Class	HFI	Head fire ROS (m/min)	Flame front depth (m)	CFB	Head fire ROS (m/min)	Flame front depth (m)	CFB
1-High	10	0.02	0.01	0.0	0.02	0.02	0.0
2-Low	100	0.2	0.1	0.0	0.2	0.2	0.0
2-High	400	0.6	0	0.0	1	0.7	0.0
3-Low	750	1	1	0.0	2	1	0.0
3-High	1,500	2	2	0.3	4	3	0.0
4-Low	2,500	3	2	0.5	6	5	0.0
4-High	4,000	5	4	0.6	9	7	0.1
5-Low	5,000	6	5	0.7	10	7	0.3
5-High	8,000	9	7	0.8	12	9	0.7
6-Low	15,000	17	13	1.0	20	15	1.0
6-High	25,000	28	21	1.0	33	25	1.0

		FUEL type S-1		FUEL type O-1a	
Intensity Class	HFI	Head fire ROS (m/min)	Flame front depth (m)	Head fire ROS (m/min)	Flame front depth (m)
1-High	10	0.0	0.01	0.1	0.03
2-Low	100	0.1	0.1	1	0.3
2-High	400	0.2	0.4	4	1
3-Low	750	0.4	0.8	7	2
3-High	1,500	0.8	2	14	5
4-Low	2,500	1	3	24	8
4-High	4,000	2	4	38	13
5-Low	5,000	3	5	48	16
5-High	8,000	4	9	76	24
6-Low	15,000	8	16	143	48
6-High	25,000	14	27	--	--

Fire Type colour code

Surface fire	Intermittent crowning	Crowning

Table A1-5. *Intensity class - IC, intensity (kW/m) and fire type for a given rate of spread in common Ontario fuel types assuming an average BUI =50 and a live fuel moisture (FMC) of 100%. Cells are coloured by the fire type with beige being surface fire, orange intermittent, and red with white text a crown fire.*

Rate of Spread (m/min)	C-2	C-3	C-5	M-1 (50%)	O-1a (100%)	S-1
0.1	IC2 (61)	IC2 (35)	IC2 (25)	IC2 (43)	IC2 (11)	IC2 (180)
0.5	IC2 (300)	IC2 (170)	IC2 (130)	IC2 (210)	IC2 (53)	IC3 (880)
1	IC3 (610)	IC2 (350)	IC2 (250)	IC2 (430)	IC2 (110)	IC3 (1,800)
2	IC3 (1,300)	IC3 (700)	IC3 (510)	IC3 (860)	IC2 (210)	IC4 (3,500)
3	IC4 (2,000)	IC3 (1,000)	IC3 (760)	IC3 (1,300)	IC2 (320)	IC5 (5,300)
4	IC4 (2,900)	IC3 (1,400)	IC3 (1,000)	IC3 (1,700)	IC2 (420)	IC5 (7,000)
5	IC4 (3,700)	IC3 (1,700)	IC3 (1,300)	IC4 (2,100)	IC3 (530)	IC5 (8,800)
10	IC5 (8,100)	IC4 (3,500)	IC4 (2,500)	IC5 (5,800)	IC3 (1,100)	IC6 (18,000)
15	**IC6 (13,000)**	IC5 (8,400)	IC4 (3,800)	IC5 (9,600)	IC3 (1,600)	IC6 (26,000)
20	**IC6 (17,000)**	IC6 (13,000)	IC5 (5,100)	**IC6 (13,000)**	IC4 (2,100)	IC6 (35,000)
25	**IC6 (21,000)**	**IC6 (17,000)**	IC5 (6,300)	**IC6 (17,000)**	IC4 (2,600)	IC6 (44,000)
30	**IC6 (25,000)**	**IC6 (21,000)**	IC5 (7,600)	**IC6 (20,000)**	IC4 (3,200)	IC6 (53,000)
35	**IC6 (30,000)**	**IC6 (24,000)**	IC5 (8,900)	**IC6 (23,000)**	IC4 (3,700)	IC6 (61,000)
40	**IC6 (34,000)**	**IC6 (28,000)**	IC6* (10,000)	**IC6 (27,000)**	IC5 (4,200)	IC6 (70,000)
50	**IC6 (42,000)**	**IC6 (35,000)**	IC6* (13,000)	**IC6 (33,000)**	IC5 (5,300)	IC6* (88,000)

*Rate of spread (ROS) for this fuel type exceeds maximum non-slope influenced ROS listed in FBP.

Fire Type colour code

Surface fire	Intermittent crowning	Crowning

A1.6 INTENSITY AROUND THE PERIMETER

In the simple elliptical model for fire growth in the FBP System, spread rate varies from a maximum at the head of the fire (with the wind), around the perimeter to a minimum at the back of the fire (against the wind). We can therefore use the FBP System to estimate fireline intensity around the perimeter of a freely burning elliptical fire from the HFI. Figures A1-3 and A1-4 for two different HFI. Since airtanker drop effectiveness depends strongly on fireline intensity, we have also included a set of basic tables (A1-6 and A1-7) that show the breakdown of fire perimeter into the different intensity classes based on the head fire intensity.

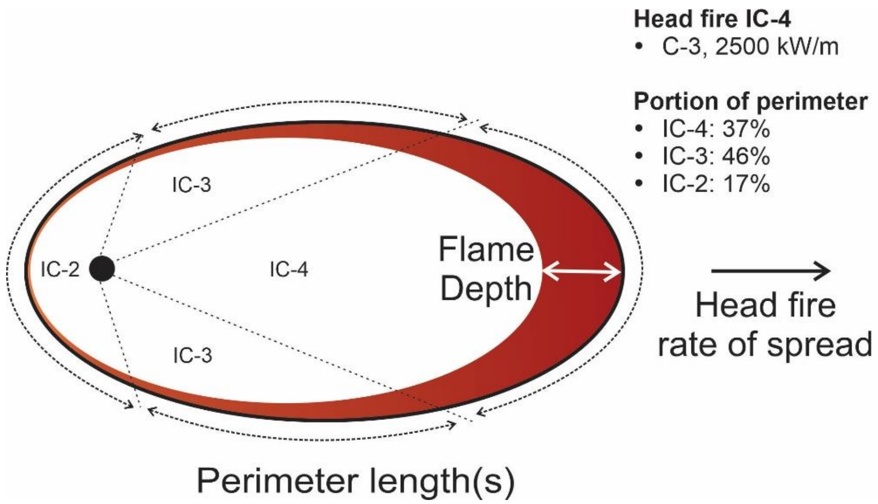


Figure A1-3. *Example of fire perimeter segmented by intensity class with a head fire of IC 4 in mature jack pine (C-3). Flame depth shown uses rate of spread (at the point on the perimeter) and the residence time of flaming.*

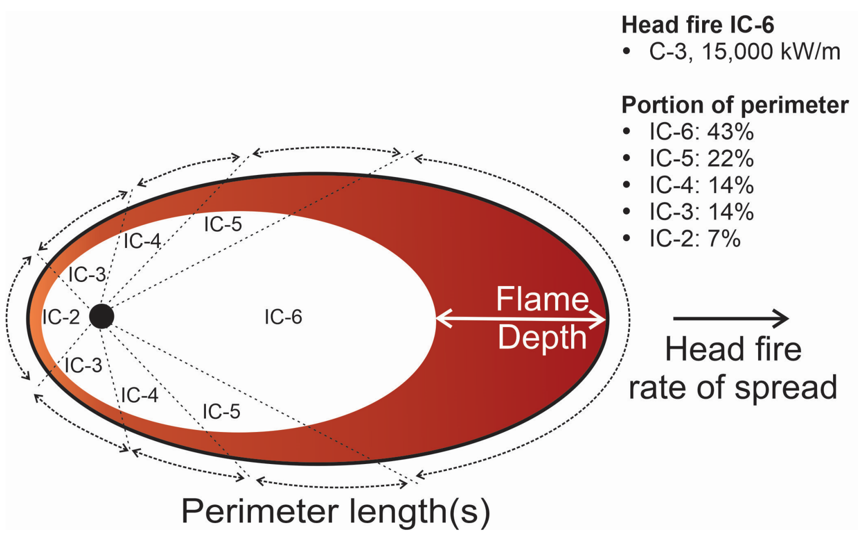


Figure A1-4. *Example of fire perimeter segmented by intensity class with a head fire of IC 6 in mature jack pine (C-3). Flame depth shown uses rate of spread (at the point on the perimeter) and the residence time of flaming.*

Table A1-6. *Breakdown of fire perimeter into the different intensity classes based on the head fire intensity. Estimates made using the FBP System's elliptical model for C-2 (a closed canopy fuel) and assume elliptical length to breadth of 2:1, BUI=50 and FMC-100%. Starting with the HFI in the left column, move along the row for corresponding percent of perimeter at different IC. The colour value in right most column of each row corresponds to the HFI in the left most. Colour of intensity class corresponds to Table A1-3.*

	Proportion of perimeter at Intensity Class (IC)					
Head Fire Intensity Class (HFI)	**1**	**2**	**3**	**4**	**5**	**6**
2-Low	**0%**	**100%**				
2-High	**0%**	**100%**				
3-Low	**0%**	**61%**	**39%**			
3-High	**0%**	**35%**	**65%**			
4-Low	**0%**	**28%**	**44%**	**28%**		
4-High	**0%**	**22%**	**35%**	**44%**		
5-Low	**0%**	**12%**	**35%**	**25%**	**28%**	
5-High	**0%**	**0%**	**35%**	**18%**	**47%**	
6-Low	**0%**	**0%**	**20%**	**16%**	**26%**	**38%**
6-High	**0%**	**0%**	**0%**	**15%**	**25%**	**60%**

Table A1-7. *Breakdown of fire perimeter into the different intensity classes based on the head fire intensity (in red). Estimates made using the FBP System's elliptical model for the O-1a fuel type, a constant elliptical length to breadth of 4:1 and a fuel load of 0.35 kg/m^2. Starting with the HFI in the left column, move along the row for corresponding percent of perimeter at different IC. The colour value in right most column of each row corresponds to the HFI in the left most. Colour of intensity class corresponds to Table A1-3.*

	Proportion of perimeter at Intensity Class (IC)					
Head Fire Intensity Class (HFI)	**1**	**2**	**3**	**4**	**5**	**6**
2-Low	**16%**	**84%**				
2-High	**6%**	**94%**				
3-Low	**1%**	**54%**	**45%**			
3-High	**0%**	**33%**	**67%**			
4-Low	**0%**	**27%**	**41%**	**32%**		
4-High	**0%**	**22%**	**29%**	**49%**		
5-Low	**0%**	**18%**	**21%**	**29%**	**32%**	
5-High	**0%**	**14%**	**19%**	**15%**	**52%**	
6-Low	**0%**	**6%**	**19%**	**11%**	**23%**	**40%**
6-High	**0%**	**0%**	**15%**	**7%**	**16%**	**63%**

A2 Appendix: Sample Footprints

The following section contains drop footprints for different airtankers in open conditions and within a C-3 – Jack pine canopy. These drops were carried out in Dryden, Ontario during 2017-2019.

The water reaching the ground during open airfield drops was estimated by a tower mounted with a mid-wave infrared (MWIR) camera[3]. The 'footprint' of the water dropped from the airtanker was measurable by the instantaneous change in ground surface temperature it caused; this change in ground surface temperature at any specific location within the drop was strongly related to the amount of water received. The water reaching the ground during the canopy drops was measured by a grid of individual cups placed at regular intervals within the designated drop zone. Coverage level and water depth equivalent were estimated during a stand cruise immediately after the drop using the visual assessment method described by Thomasson (2012). See sections on the Open and Canopy drops below for the methods of mapping and digitizing the drops.

Table A2-1. *Specifications used for drop tests.*

	Drop speed	Drop height
Fixed wing airtankers	110 KIAS	150 AGL ft
Rotary wing airtankers	40 KIAS (fast) 20 KIAS (slow)	100 AGL ft

We expect there to be some variability around the actual drop height and speeds used in the field tests (Table A2-1) due to the differences in instrumentation between the aircraft and operational flight factors (e.g., weather, visibility).

A2.1 Drops in the Open: Infrared Water Depth Estimation

The process for estimating water depth within drop footprints with IR is illustrated in Figure A2-1 and was as follows. The airtanker drop occurred in a designated area completely within the field of view of the camera mounted on a tower at the end of the drop zone. Immediately before and during the drop, the tower-mounted (~15 m high) MWIR camera captured a time series of images (at 1 second intervals or faster) of the ground surface temperature. The ground temperature change - water depth calibration comes from MWIR camera observations of control squares just outside the drop area (but within the camera's field of view) where known quantities of water are applied to the surface. In subsequent analysis the MWIR imagery is projected onto a very high-resolution digital surface model and, using the water depth-ground temperature model developed from the control squares the water depths over the entire drop pattern can be estimated.

[3] Methodology publication (Johnston et al.) in development.

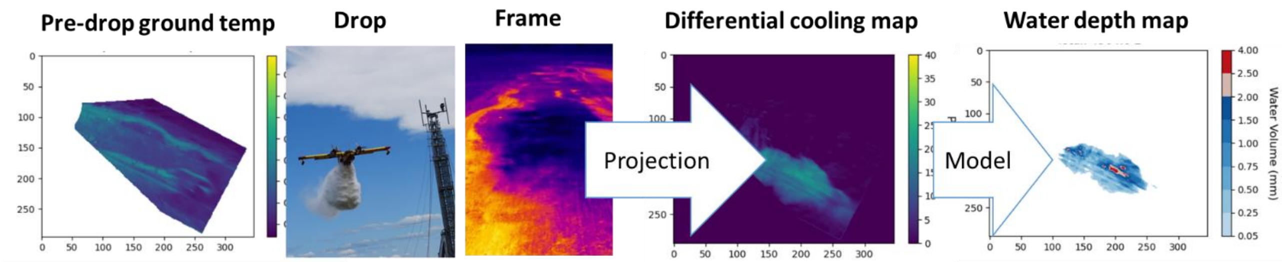


Figure A2-1*: Model flow to determine drop footprints using infrared imagery (temp=temperature; Frame = MWIR camera imagery).*

The drops measured in the open during this experiment at the Dryden airfield are idealized drops as there was no forest overstory and hence no canopy interception of water from the drop (although there are the effects of wind drift and evaporation).

Table A2-2. *Average values for the full extent of the drop footprint in the open (no canopy interception). L= Length (m), W=Width (m), numerical ranges are average water recovered measured in mm.*

Average Depth Contour (mm) Dimensions (Length and Width in metres)																
Airtanker type	***0.05–0.25***		***0.25–0.5***		***0.5–0.75***		***0.75–1.0***		***1.0 –1.5***		***1.5– 2.0***		***2.0 –2.5***		***>2.5***	
	L	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**
CL-415	135	58	118	48	102	39	86	32	65	26	49	15	26	7	22	5
CL-215	124	64	95	54	75	46	61	39	48	35	31	23	27	21	18	9
AT-802F Fire Boss	108	47	86	37	75	29	60	24	42	18	20	10	10	4	5	3
DHC-6 Twin Otter	74	38	58	28	47	21	34	16	16	9	7	2	6	1	0	0
B212 -FAST	55	25	47	18	42	17	40	15	39	14	34	11	31	8	26	4
B212 - SLOW	21	9	21	9	21	9	21	9	21	9	21	9	21	9	21	9

A2.2 Drops in the canopy: cups

The spatially detailed drop mapping done on the airfield with the MWIR camera was not possible in the canopy site. Cups placed within the stand grid, at the highest density portion of the grid, had a 3 m spacing; therefore, this sparser set of observations produced spatially coarser and smoother estimates of drop patterns, though required no calibration. The purpose of the drops in the canopy was to assess the amount of water that reaches the forest floor, within a typical boreal pine stand (C-3) so that the interception capacity of a natural (and commonly occurring) forest canopy could be estimated. The canopy drop site was an even aged mature (~80 yrs.) Jack pine stand located about 6 km from the Dryden airfield; it was very typical of a moderately-stocked mature jack pine in the boreal forest of Canada. The overall height was 19.5 m with an estimated crown closure of 90% (Figure A2-3).

The water values measured across the extent of drop footprints for various airtanker types were contrasted with the observations from the airfield to provide an estimate of how much of the water dropped was hung up (and lost) in the canopy (i.e., lost to interception). This allowed us to evaluate differences between airtanker drop interception and standard models of canopy interception of rainfall. Several canopy drops were carried out by each different airtanker type tested in the airfield.

Figure A2-3. *Crown closure in the C-3 stand in Dryden Ontario where drop tests took place.*

Across this sparser set of cup observations of water depth, the process for estimating drop extents and depths was as follows. Airtankers dropped into the cup grid within the canopy (Figure A2-4). About 10-15 minutes after the drop (time allowed for the majority of canopy dripping to finish) a field crew entered the plot and recorded depth of water in each cup; this measurement of the full cup grid was complete in <20 min. In subsequent analysis, the digitized locations of each cup were used as part of an interpolation to develop a smooth set of contours of water depths (mm of water) across the area of the drop.

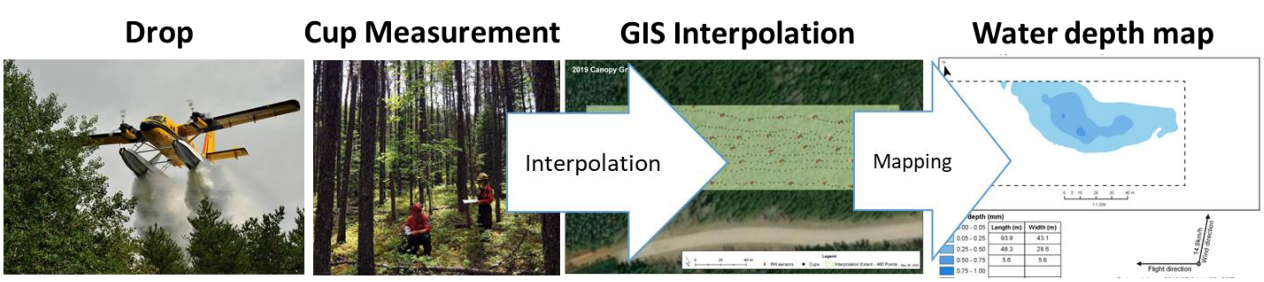


Figure A2-4. *Model flow to determine canopy intercept and drop footprint in a canopy.*

Table A2-3. *Average size (length and width) values for different water depth contours for the drops measured in the canopy (C-3 – mature jack pine). L = Length (m), W = Width (m), numerical ranges are average water recovered measured in mm (1 mm is equivalent to 1 kg/m²).*

Average Depth Contour (mm) Dimensions (Length and Width in metres)																
Airtanker type	***0.05–0.25***		***0.25–0.5***		***0.5–0.75***		***0.75–1.0***		***1.0 –1.5***		***1.5– 2.0***		***2.0 –2.5***		***>2.5***	
	L	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**
CL-415	129	52	96	39	49	29	33	19	19	11	5	4	2	1	1	0.3
CL-215	119	44	59	34	47	27	37	23	31	19	17	12	9	5	7	5
AT-802F Fire Boss	111	44	38	22	8	9	2	2	1	1	0	0	0	0	0	0
DHC-6 Twin Otter	72	44	32	23	8	6	2	2	1	1	0	0	0	0	0	0
B212 -FAST	59	25	51	19	45	16	41	13	33	11	18	8	8	6	3	3
B212 - SLOW	50	28	35	21	27	17	24	14	20	11	10	6	5	3	3	2

The canopy drops allowed us to estimate that the canopy intercepted the equivalent of 0.5 – 1 mm of each drop. This threshold is similar to other throughfall estimates for mature jack pine stands and at its lower end (for smaller drop amounts) is also the interception threshold used in the FFMC model in the FWI System (Van Wagner, 1987). The smaller number of drops in canopy and the difference in the drop pattern estimation technique between canopy and open site, required us to develop the in-stand drop pattern dimensions as a transformation of the open drop patterns. Specifically, observed throughfall in the canopy (from the drop) for each airtanker type and water depth category was compared to similar data observed in the open site. Each water depth category was examined separately to allow for differences due to water amount.

A2.3 DROP FOOTPRINT CONTOURS

Drop footprints are grouped into a series of water contour depth classes (Figure A2-5) based on the amount of water recorded/interpolated from a high-resolution grid (50 cm pixel in the open and 25 cm pixel in the canopy).

Figure A2-5: *Observed water depth categories used to define drop contours used in the guide.*

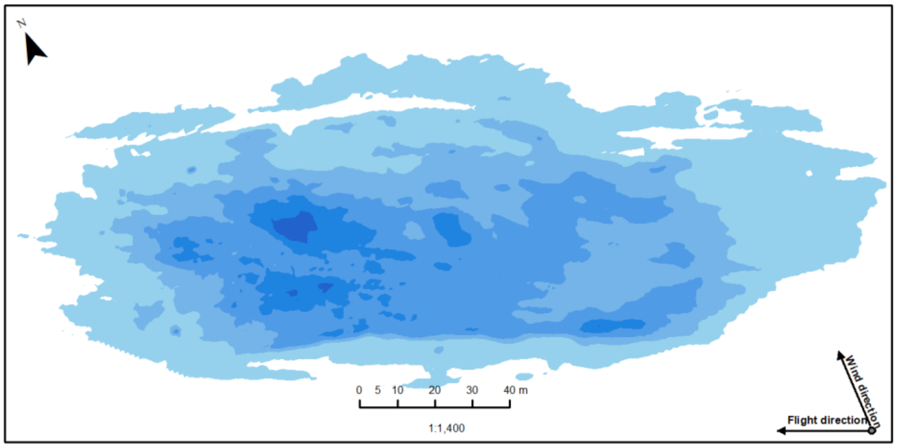
To measure the boundaries of the classes, a series of contours were drawn at the thresholds of the drop depth categories. The length and width of each contour at the low end of each class was measured. For the larger water amounts, contours within the same class are disconnected across the grid as a result of drop pattern, in these cases measurements were combined for an overall length and width.

Where footprints extended beyond the field of view for the MWIR camera in the open, or were outside the cup grid in the canopy, these contours were measured to the border and noted in the dataset and typically not used to create the airtanker drop pattern length and width values.

The following are examples of individual drop footprints from both the open and canopy for each aircraft (Figure A2-6).

Figure A2-6.

Open - Salvo Water Footprint and Volume - CL-415

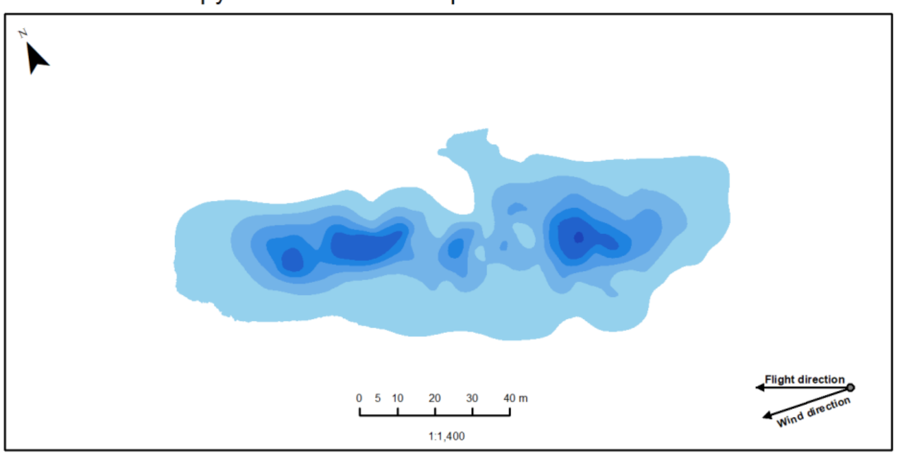


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	178	69
0.25 - 0.50	135	47
0.50 - 0.75	117	37
0.75 - 1.00	99	30
1.00 - 1.50	14	21
1.50 - 2.00		
2.00 - 2.50		
2.50+		

Water drop volume: 6130 L
Water recovered: 4904 L (80 %)
Maximum depth: 1.3 mm
Drop height: 150 ft - 45 m (AGL)
Drop speed: 110 kt - 204 km/h
Temperature: 27.9 °C
Relative humidity: 28 %
Wind speed: 19.3 km/h

Canopy - Salvo Water Footprint and Volume - CL-415



Contour Depth (mm)

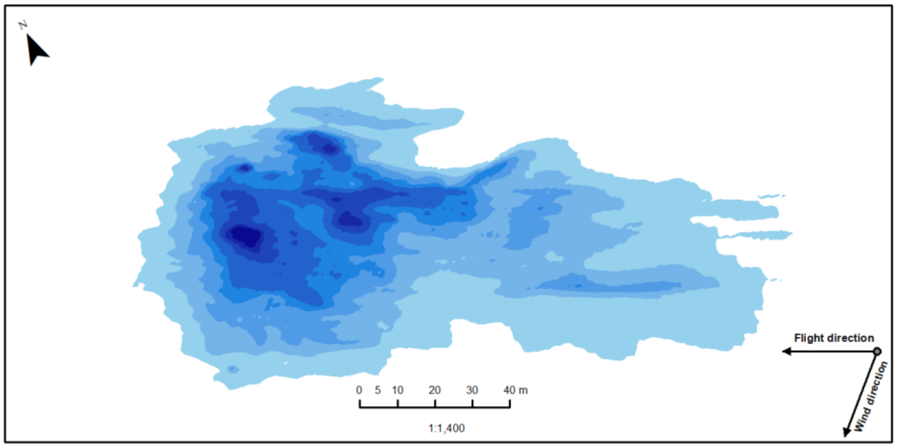
Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	150	40
0.25 - 0.50	115	30
0.50 - 0.75	32	21
0.75 - 1.00	21	15
1.00 - 1.50	15	11
1.50 - 2.00	3	3
2.00 - 2.50		
2.50+		

Water drop volume: 6137 L
Water recovered: 1767 L (29 %)*
Maximum depth: 2.7 mm
Drop height: 150 ft - 46 m (AGL)
Drop speed: 105 kt - 194 km/h
Temperature: 21.8 °C
Relative humidity: 67 %
Wind speed: 8 km/h

* Water recovered based on interpolation estimate.

Figure A2-6 cont.

Open - Salvo Water Footprint and Volume - CL-215

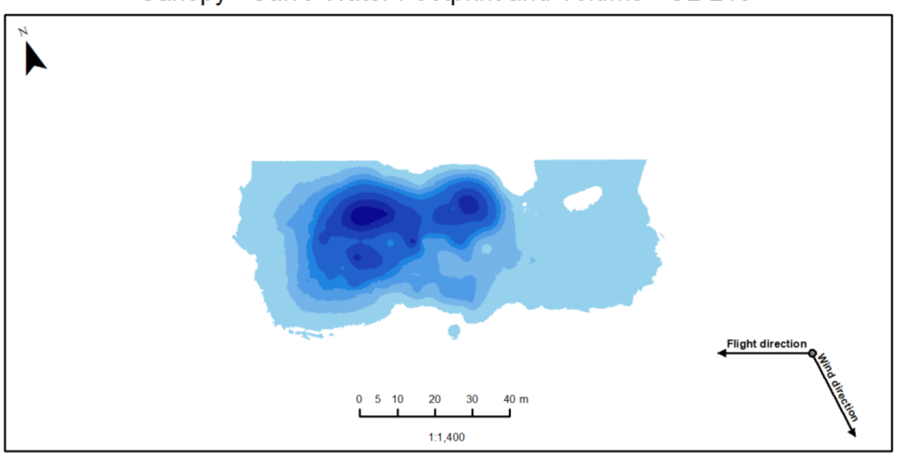


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	139	59
0.25 - 0.50	108	50
0.50 - 0.75	87	43
0.75 - 1.00	61	36
1.00 - 1.50	51	36
1.50 - 2.00	41	29
2.00 - 2.50	33	27
2.50+	8	5

Water drop volume: 5454 L
Water recovered: 4363 L (80 %)
Maximum depth: 3.9 mm
Drop height: 150 ft - 45 m (AGL)
Drop speed: 110 kt - 204 km/h
Temperature: 24.8 °C
Relative humidity: 34 %
Wind speed: 11.3 km/h

Canopy - Salvo Water Footprint and Volume - CL-215



Contour Depth (mm)

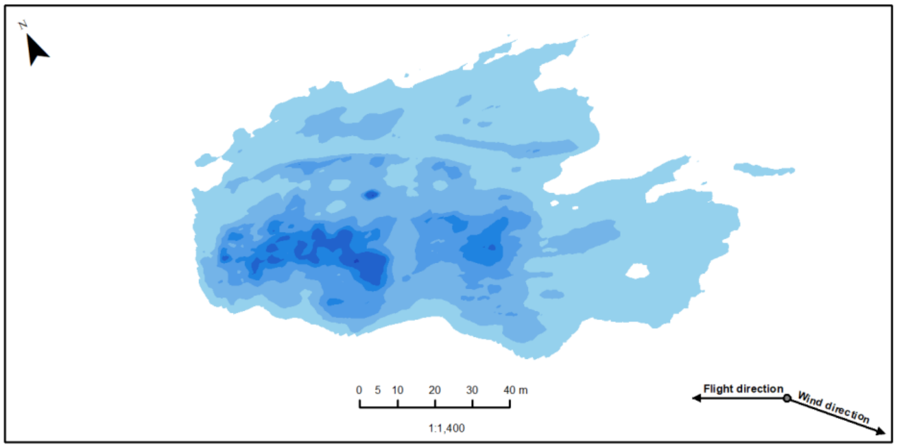
Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	112	45
0.25 - 0.50	64	38
0.50 - 0.75	58	34
0.75 - 1.00	49	29
1.00 - 1.50	47	26
1.50 - 2.00	25	13
2.00 - 2.50	5	5
2.50+	10	5

Water drop volume: 5346 L
Water recovered: 2234 L (42%)*
Maximum depth: 3.3 mm
Drop height: 150ft - 46 m (AGL)
Drop speed: 110 kt - 204 km/h
Temperature: 26.6 °C
Relative humidity: 31 %
Wind speed: 9.7 km/h

* Water recovered based on interpolation estimate.

Figure A2-6 cont.

Open - Salvo Water Footprint and Volume - AT-802F Fire Boss

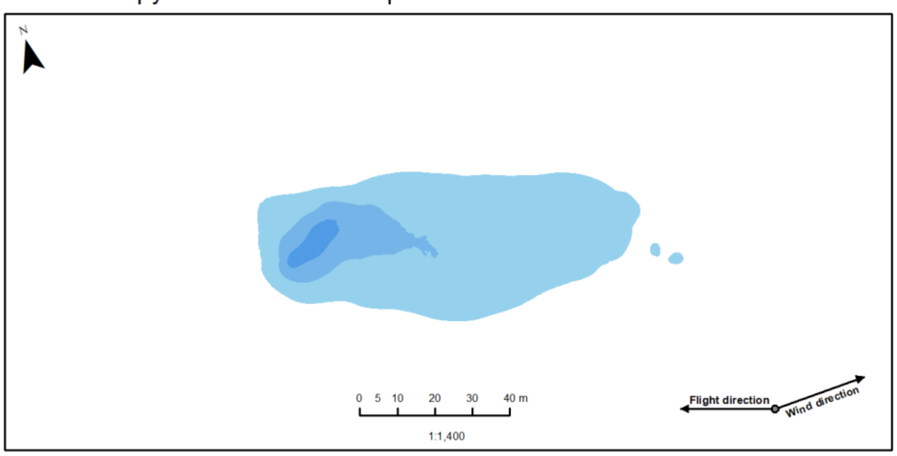


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	118	61
0.25 - 0.50	81	47
0.50 - 0.75	72	28
0.75 - 1.00	67	17
1.00 - 1.50	34	13
1.50 - 2.00	2	1
2.00 - 2.50		
2.50+		

Water drop volume: 3028 L
Water recovered: 2422 L (80 %)
Maximum depth: 1.6 mm
Drop height: 150 ft - 45 m (AGL)
Drop speed: 110 kt - 204 km/h
Temperature: 29.5 °C
Relative humidity: 40 %
Wind speed: 12.9 km/h

Canopy - Salvo Water Footprint and Volume - AT-802F Fire Boss



Contour Depth (mm)

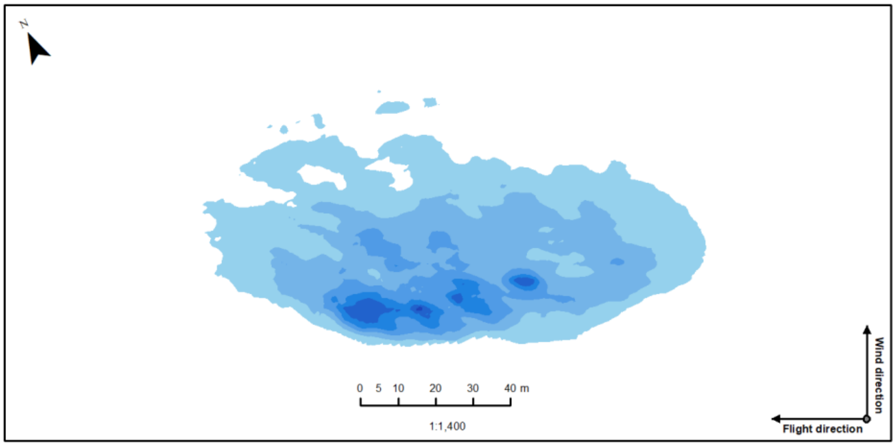
Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	102	39
0.25 - 0.50	42	19
0.50 - 0.75	8	9
0.75 - 1.00		
1.00 - 1.50		
1.50 - 2.00		
2.00 - 2.50		
2.50+		

Water drop volume: 2839 L
Water recovered: 580 L (20 %)*
Maximum depth: 1.3 mm
Drop height: 150ft - 46 m (AGL)
Drop speed: 105 kt - 194 km/h
Temperature: 23.8 °C
Relative humidity: 59 %
Wind speed: 16.1 km/h

* Water recovered based on interpolation estimate.

Figure A2-6 cont.

Open - Salvo Water Footprint and Volume - DHC-6 Twin Otter

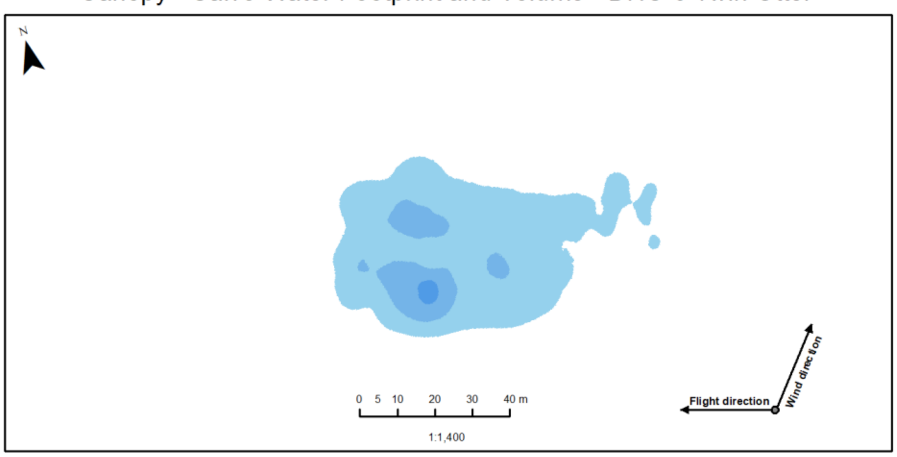


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	108	46
0.25 - 0.50	82	32
0.50 - 0.75	52	23
0.75 - 1.00	47	13
1.00 - 1.50	47	11
1.50 - 2.00	2	2
2.00 - 2.50	1	1
2.50+		

Water drop volume: 2091 L
Water recovered: 1673 L (80 %)
Maximum depth: 2.1 mm
Drop height: 150 ft - 45 m (AGL)
Drop speed: 105 kt - 195 km/h
Temperature: 24.9 °C
Relative humidity: 43 %
Wind speed: 12.9 km/h

Canopy - Salvo Water Footprint and Volume - DHC-6 Twin Otter



Contour Depth (mm)

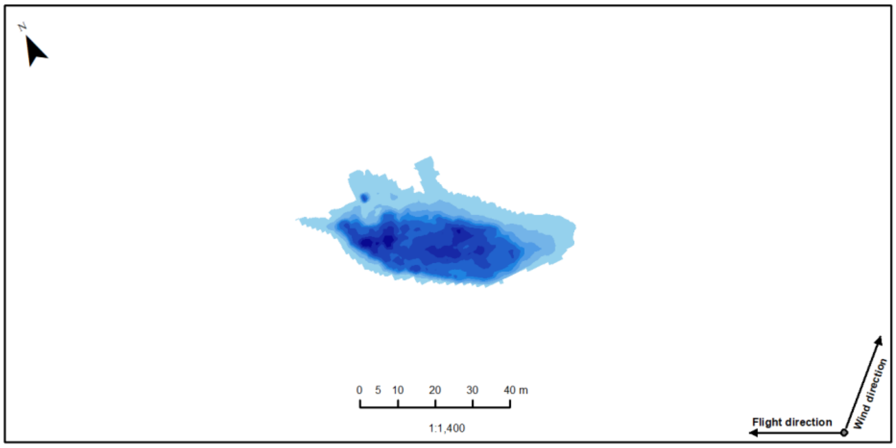
Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	73	48
0.25 - 0.50	20	15
0.50 - 0.75	5	6
0.75 - 1.00		
1.00 - 1.50		
1.50 - 2.00		
2.00 - 2.50		
2.50+		

Water drop volume: 2091 L
Water recovered: 441 L (21 %)*
Maximum depth: 1.3 mm
Drop height: 150ft - 46 m (AGL)
Drop speed: 105 kt - 194 km/h
Temperature: 24.7 °C
Relative humidity: 43 %
Wind speed: 12.9 km/h

* Water recovered based on interpolation estimate.

Figure A2-6 cont.

Open - Salvo Water Footprint and Volume - Bell 212 Bellytank - Fast Drop Speed

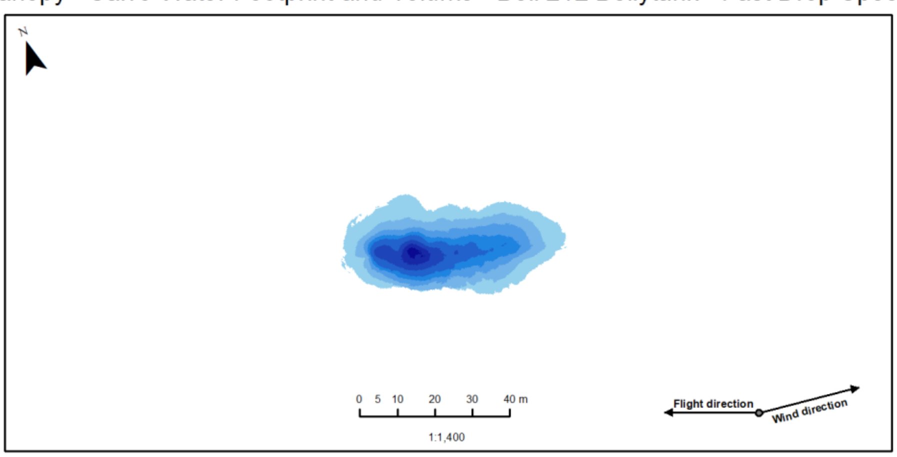


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	55	25
0.25 - 0.50	47	18
0.50 - 0.75	42	17
0.75 - 1.00	40	15
1.00 - 1.50	39	14
1.50 - 2.00	34	11
2.00 - 2.50	31	8
2.50+	26	4

Water drop volume: 1400 L
Water recovered: 1120 L (80 %)
Maximum depth: 3.3 mm
Drop height: 100 ft - 30 m (AGL)
Drop speed: 40 kt - 74 km/h
Temperature: 25.2 °C
Relative humidity: 67 %
Wind speed: 8 km/h

Canopy - Salvo Water Footprint and Volume - Bell 212 Bellytank - Fast Drop Speed



Contour Depth (mm)

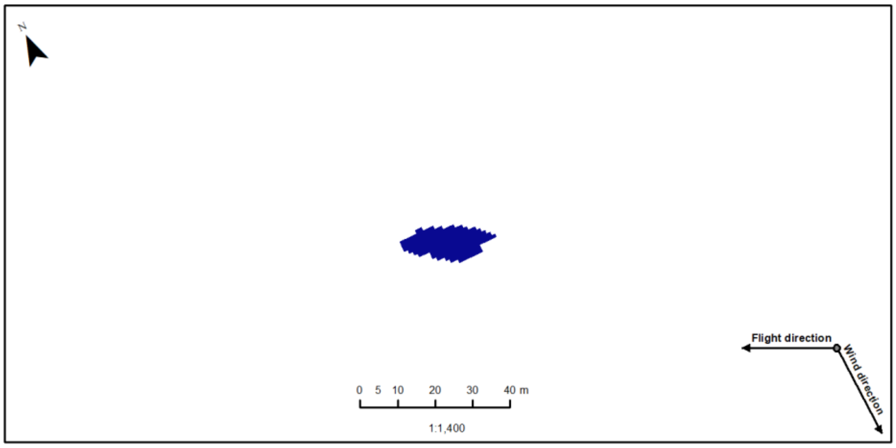
Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	59	25
0.25 - 0.50	51	19
0.50 - 0.75	45	16
0.75 - 1.00	41	13
1.00 - 1.50	33	11
1.50 - 2.00	18	8
2.00 - 2.50	8	6
2.50+	3	3

Water drop volume: 1400 L
Water recovered: 699 L (50%)*
Maximum depth: 3.3 mm
Drop height: 100ft - 30 m (AGL)
Drop speed: 40 kt - 74 km/h
Temperature: 22.3 °C
Relative humidity: 69 %
Wind speed: 14.5 km/h

* Water recovered based on interpolation estimate.

Figure A2-6 cont.

Open - Salvo Water Footprint and Volume - Bell 212 Bellytank - Slow Drop Speed

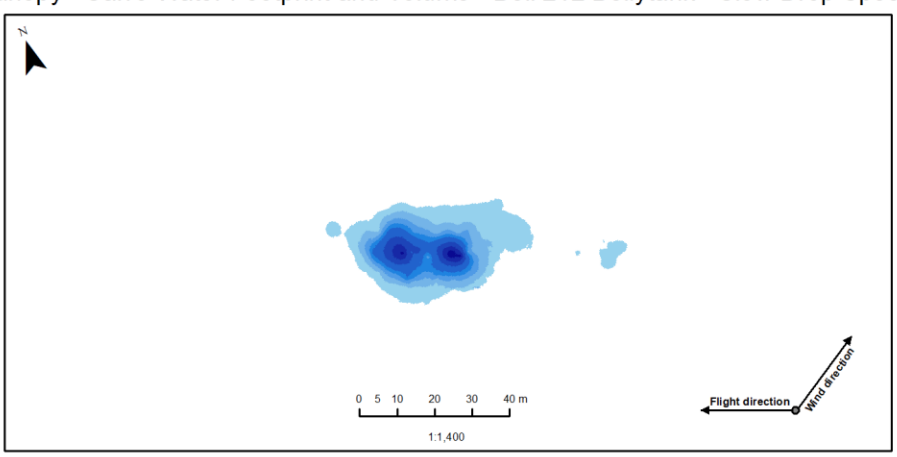


Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	-	-
0.25 - 0.50	-	-
0.50 - 0.75	-	-
0.75 - 1.00	-	-
1.00 - 1.50	-	-
1.50 - 2.00	-	-
2.00 - 2.50	-	-
2.50+	22	9

Water drop volume: 1400 L
Water recovered: 1120 L (80 %)
Maximum depth: 8.9 mm
Drop height: 100 ft - 30 m (AGL)
Drop speed: 20 kt - 37 km/h
Temperature: 25.3 °C
Relative humidity: 62 %
Wind speed: 6.4 km/h

Canopy - Salvo Water Footprint and Volume - Bell 212 Bellytank - Slow Drop Speed



Contour Depth (mm)

Contour Depth (mm)	Length (m)	Width (m)
0.00 - 0.05		
0.05 - 0.25	50	26
0.25 - 0.50	36	20
0.50 - 0.75	29	17
0.75 - 1.00	27	14
1.00 - 1.50	25	12
1.50 - 2.00	7	6
2.00 - 2.50	5	4
2.50+	3	2

Water drop volume: 1400 L
Water recovered: 558 L (40%)*
Maximum depth: 3.8 mm
Drop height: 100ft - 30 m (AGL)
Drop speed: 20 kt - 37 km/h
Temperature: 25 °C
Relative humidity: 59 %
Wind speed: 96.7 km/h

* Water recovered based on interpolation estimate.

A3 Appendix: Overview of Air Attack Missions and Tactics

There are two general types of Air Attack missions, Initial Attack (or Sustained Initial Attack) and Support Missions (AFFES, 2015). There are situations where multiple airtankers are used for each mission type and the following section is a simplification of the tactics used and taught in aerial fire operations programs.

- **Initial Attack (IA):** quick initial action (generally on small fires) to reduce the rate of spread and intensity to facilitate ground crew follow-up.
    - **Sustained IA:** is where bombing action lasts more than two hours. This is more likely with an aggressive or contentious fire under IA
- **Support Mission:** is generally taken after the IA phase and/or on an unstaffed section of a larger fire. Actions include cooling off hotspots, holding a section of line, protecting values, or reduce spot fires to smouldering combustion.

In a real-world setting the objectives for air attack on each fire can vary. In some situations, one, some, or all the following may be the objective of a mission:

- Complete containment of a fire
- Partial containment
- Protect assets
- Reduce fire intensity and/or rate of spread
- Enhance ground attack efforts by firefighters

There are many operational tactics which can be used to achieve mission objectives. Air Attack tactics are normally formulated over the fire by the Air Attack Officer and/or Incident Commander. The Air Attack Officer constantly monitors the effectiveness of the tactics used on the fire and responds accordingly to adjust throughout the mission.

A3.1 Drop targets and configurations

Drop targets are communicated with a reference to previous drops, fire targets (smoke, parts of a fire etc.) or landscape features (roads, lakes, rivers etc.). The configurations of drops are illustrated generally in Figure A3-1 and are as follows:

- **Tagged on**: where drops are connected from the tail (rear) of the drop to a previous drop or reference feature
- **Rolled up:** where drops are connected from the head (front) of the drop to a previous drop or reference feature
- **Lapped on:** where drops are overlapped laterally, with a previous load.

Figures A3-2 to A3-6 show examples of the different tactical approaches to line building (single airtanker in examples). Note, drops are not to scale.

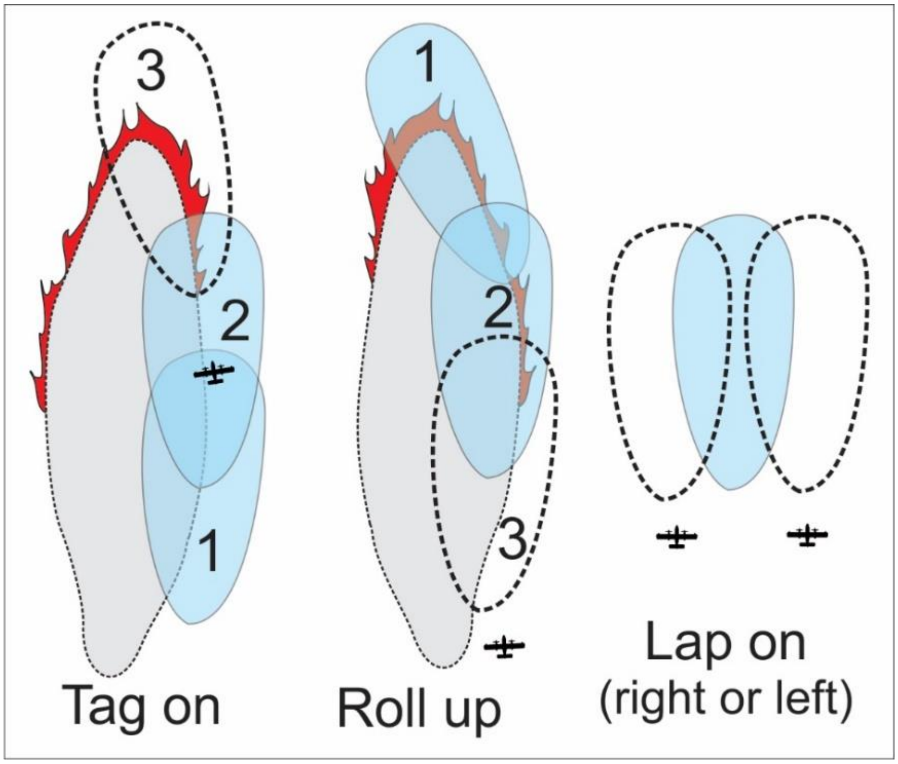


Figure A3-1. *Illustration of Tag on, Roll up and Lap on drops. The degree of overlap is relative to many different factors (e.g., fire intensity) and there are different general rules used for different airtankers. For example, a standard overlap of drops for lapped drops in Ontario is one third overlap (AFFES 2015).*

Figures A3-2 to A3-6 show examples of the different tactical approaches to line building (single airtanker in examples).

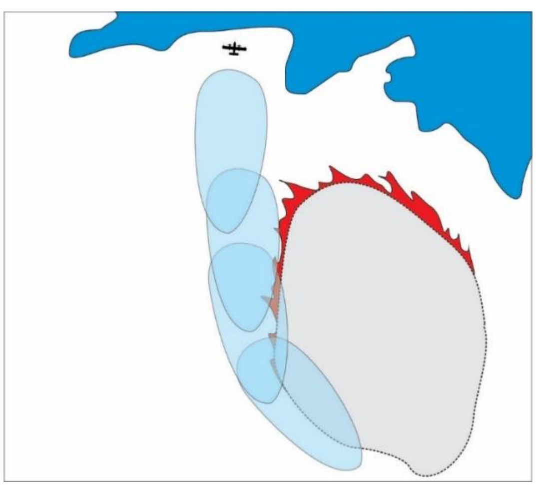


Figure A3-2. *Steering a spreading fire towards a barrier of sufficient size (e.g., a water body, road etc.).*

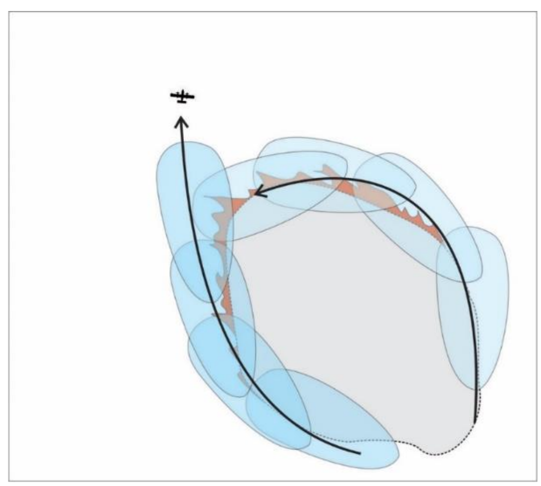
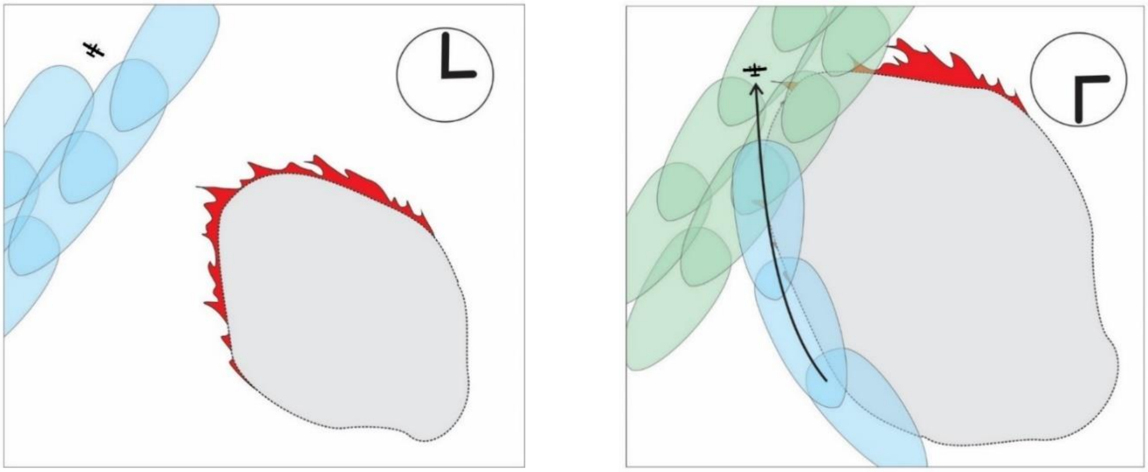


Figure A3-3. *Working the flanks until the head is pinched off.*



(a) (b)

Figure A3-4. A combination of indirect and direct attack. Pre-treating fuels to reduce intensity (a) once the fire arrives (b) working the now reduced intensity on the flank and head.

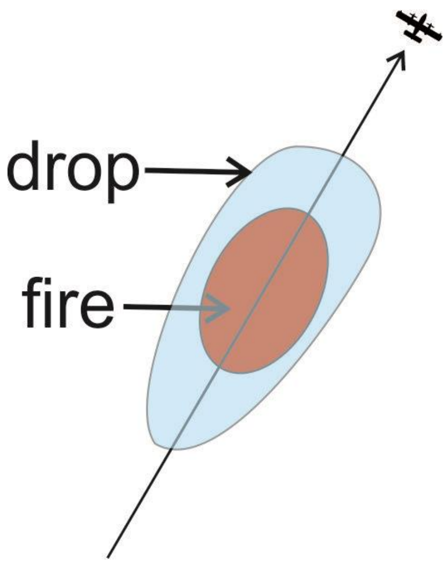


__Figure A3-5.__ Completely drenching the entire fire or active area.

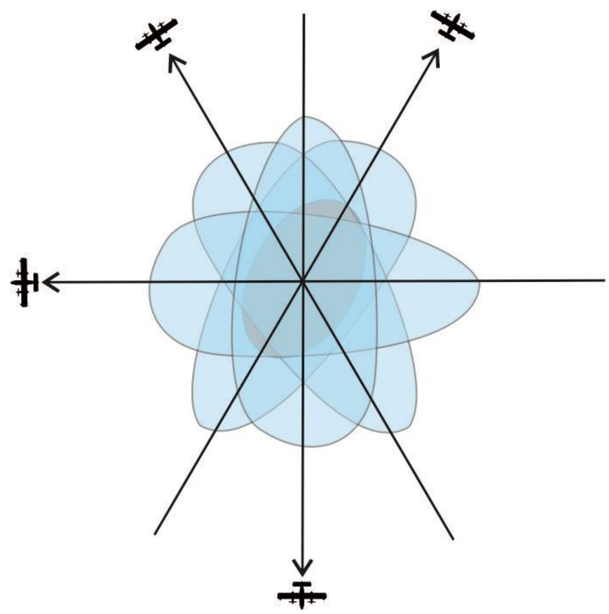
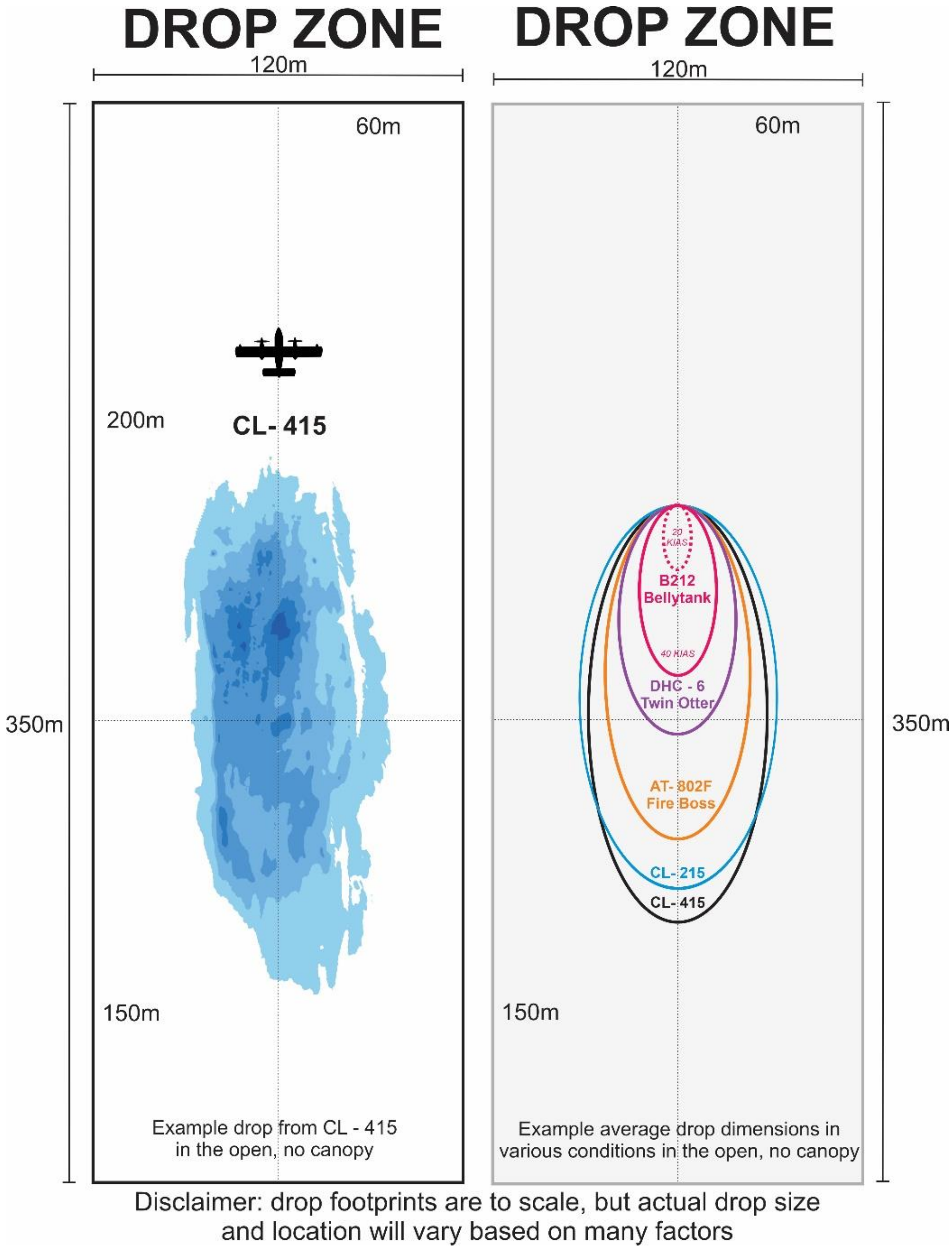


__Figure A3-6.__ Multiple directions of drops used in difficult fuels (e.g., thick canopy, storm damage/windthrow).

A3.2 AIRTANKER DROP ZONE SAFETY (FROM ONTARIO OPERATIONS)

A drop zone is a rectangular safety area that extends 60 metres on each side, 150 m before and 200 m beyond the midpoint of the drop target. Total dimensions are 350 m in length by 120 m wide, or approximately 4 ha in size. The diagrams provide an idea of the scale of the drop zone relative to the drop footprint of different airtanker types[4].



[4] **Note.** drop accuracy can vary and it is critical to maintain situational awareness of air and ground crews' relative locations. The dimensions stated here are from Ontario.

A4 Appendix: Bellytank Use Considerations

This section describes some scenarios and factors where bellytankers can be an effective option, and sometimes the best option. Also, a list of factors favouring either bellytankers or CL-415s, and a decision flow diagram are provided.

For fires that require Air Attack, we are often in the habit of using a heavier option (e.g., CL-215/CL-415) when an intermediate airtanker could do the job, particularly the bellytanker that carries in the initial attack crew. While the extra punch of a heavy airtanker gives the extra assurance of success, it comes at an extra cost. More important, though, is that underuse of bellytankers loses opportunities for response personnel to learn their effectiveness in various situations and get familiar with working bellytankers into suppression operations.

A4.1 CONDITIONS FAVOURING BELLYTANKERS OVER INTERMEDIATE OR HEAVY AIRTANKERS

Decisions about which airtanker to assign to a particular fire are very complex. Here, we list some isolated factors that tend to favour bellytankers over heavier skimming airtankers.

Table A4-1. *Factors and comparison to favour rotary wing belly tankers over heavy airtankers (skimmers).*

Factor	Favouring Bellytanker	Favouring Heavy Airtanker
Effectiveness Considerations		
• Fire size and intensity	Smaller fire or lower-intensity fire (although good at higher intensity hotspotting)	Larger fire and/or higher-intensity fire
• Close for quick attack	Bellytanker is already at fire because it transported the crew	
• Distance to water source	When distance is much closer for bellytanker than fixed wing (because of a quicker pickup time and use of smaller water sources)	When distance is about the same or greater for fixed wing than bellytanker (because over larger distances, fixed wing aircraft are generally more productive)
• Size of water source	Small water sources missions (because snorkel does not require skimming)	
• Duration	Short missions (because snorkel does not require skimming)	Longer or sustained action required
Availability Considerations		
• Availability including remaining duty day of helicopters and heavy airtanker	Heavy airtankers are needed for other fires now and possibly later today	Bellytanker needed at base for initial attack transport now or possibly later today
Cost Considerations		
• Cost	Lower suppression cost	

A4.2 Decision flow for keeping a bellytanker for air attack on an initial attack

These are a series of checks that can be considered to aid an Incident Commander when deciding to request the use of a bellytank helicopter; Figure A4-1 shows an example of this decision flow. The prioritization of fires and coordinated use of aircraft is a different and more complex decision structure done above the Incident Commander.

- **Scenario:** Incident Commander overhead a wildland fire in a bellytank equipped helicopter

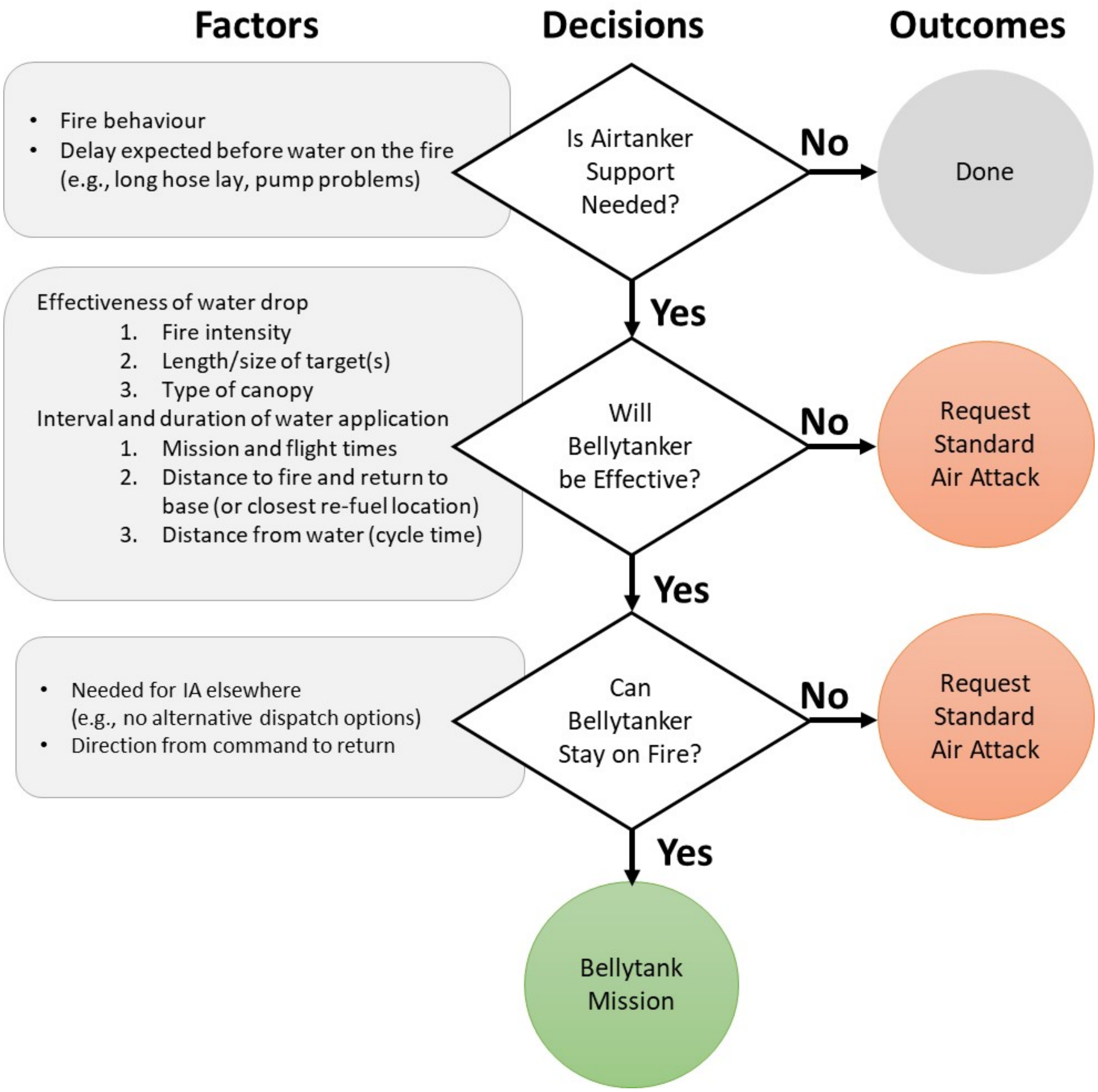


Figure A4-1. *Decision flow for Bellytank use (Standard Air Attack = air attack with intermediate or heavy fixed wing skimmers).*

A4.3 BELLYTANK TANK TIME CALCULATOR

The time a bellytanker helicopter may have available for tanking on a fire is critical in deciding whether to serve both initial attack crew transportation and airtanker support. The distance to and from a fire (either returning to base or to a fuelling depot) is one factor, others being the available fuel given the weight restrictions and mandatory reserves. Table A4-2 shows standard configuration and fuel factors (cruise speed and fuel burn) used in Ontario. Note that in practical use, other factors also affect fuel consumption and cruise speed. Values in Table A4-2 were used in a calculator to estimate the time available for tanking for different distances from base to fire and return to base or to a refuelling point one (Table A4-3 in km and Table A4-4 in NM). The charts are estimates and a discussion must always occur with the pilot-in-command regarding how much time is actually available for air attack.

Table A4-2. Ontario initial attack (IA) configuration for a Bell 212 belly tank with auxiliary fuel.

IA configuration factors	Amounts	Units	*Converted units*
Travel + Air Attack	1340	lbs	*(608 kg)*
Transport Canada Reserve	220	lbs	*(100 kg)*
Loiter over Fire Reserve	140	lbs	*(64 kg)*
Total Fuel	**1700**	lbs	*(771 kg)*
Fuel Burn lbs per h	600	lbs/h	*(272 kg)*
Cruise Speed	195	km/h	*(105 NM/h)*

Total Air Attack + Travel Time	**2.2**	h
Total Mission Time (includes over fire)	**2.5**	h

Notes: fuel burn less in tanking ~520 lbs/h, manage fuel/water weight pending as needed

IA configuration factors	Amounts	Units	*Converted units*
Gross Payload	11200	lbs	*(5080 kg)*
Unit Gear	4100	lbs	*(1860 kg)*
FireRanger Crew	2200	lbs	*(998 kg)*
Pilot	200	lbs	*(91 kg)*
Fuel	1700	lbs	*(771 kg)*
Fuel Burn per min.	10	lbs	*(5 kg)*

The pilot in command will advise of available time and fuel loading.

How to use the airtanking time charts:

1) Identify the distance from the dispatch base to the fire, and
2) Then the distance from the fire to the return location or refuelling point.
3) Where the corresponding column and row intersects is the estimated number of minutes available for air attack.
   - In all cases the pilot in command will determine what is possible.

Table A4-3. Estimated time available for air attack using the B212 given Ontario's IA configuration (Table A4-2) and distances from base to fire and return to base or to a refuelling point in km.

B212 Tanking Time (minutes – IA Configuration)

Distance to Base or to Refuel (km)	103	102	100	99	97	96	94	92	91	89	88	86	85	83	82	80	72
100	103	102	100	99	97	96	94	92	91	89	88	86	85	83	82	80	72
95	104	103	102	100	99	97	96	94	92	91	89	88	86	85	83	82	74
90	106	105	103	102	100	99	97	96	94	92	91	89	88	86	85	83	76
85	108	106	105	103	102	100	99	97	96	94	92	91	89	88	86	85	77
80	109	108	106	105	103	102	100	99	97	96	94	92	91	89	88	86	79
75	111	109	108	106	105	103	102	100	99	97	96	94	92	91	89	88	80
70	112	111	109	108	106	105	103	102	100	99	97	96	94	92	91	89	82
65	114	112	111	109	108	106	105	103	102	100	99	97	96	94	92	91	83
60	115	114	112	111	109	108	106	105	103	102	100	99	97	96	94	92	85
55	117	116	114	112	111	109	108	106	105	103	102	100	99	97	96	94	86
50	118	117	116	114	112	111	109	108	106	105	103	102	100	99	97	96	88
45	120	119	117	116	114	112	111	109	108	106	105	103	102	100	99	97	89
40	121	120	119	117	116	114	112	111	109	108	106	105	103	102	100	99	91
35	123	122	120	119	117	116	114	112	111	109	108	106	105	103	102	100	92
30	124	123	122	120	119	117	116	114	112	111	109	108	106	105	103	102	94
25	126	125	123	122	120	119	117	116	114	112	111	109	108	106	105	103	96
20	128	126	125	123	122	120	119	117	116	114	112	111	109	108	106	105	97
15	129	128	126	125	123	122	120	119	117	116	114	112	111	109	108	106	99
10	131	129	128	126	125	123	122	120	119	117	116	114	112	111	109	108	100
5	132	131	129	128	126	125	123	122	120	119	117	116	114	112	111	109	102
1	133	132	131	129	128	126	124	123	121	120	118	117	115	114	112	111	103
Distance to Base to Fire (km)	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**100**

Disclaimer: the pilot in command will provide accurate accounting of available time, this is a reference only.

Dark blue > two hours, Light blue > one hour and < two hours

Table A4-4: Estimated time available for air attack using the B212 given Ontario's IA configuration (Table A4-2) and distances from base to fire and return to base or to a refuelling point in NM.

B212 Tanking Time (minutes – IA Configuration)

Distance to Base or to Refuel (NM) \ Distance to Base to Fire (NM)	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	100
100	76	74	71	68	66	63	60	57	54	51	49	46	43	40	37	34	20
95	79	77	74	71	68	66	63	60	57	54	51	49	46	43	40	37	23
90	82	80	77	74	71	68	66	63	60	57	54	51	49	46	43	40	26
85	85	83	80	77	74	71	68	66	63	60	57	54	51	49	46	43	29
80	88	86	83	80	77	74	71	68	66	63	60	57	54	51	49	46	31
75	91	88	86	83	80	77	74	71	68	66	63	60	57	54	51	49	34
70	94	91	88	86	83	80	77	74	71	68	66	63	60	57	54	51	37
65	96	94	91	88	86	83	80	77	74	71	68	66	63	60	57	54	40
60	99	97	94	91	88	86	83	80	77	74	71	68	66	63	60	57	43
55	102	100	97	94	91	88	86	83	80	77	74	71	68	66	63	60	46
50	105	103	100	97	94	91	88	86	83	80	77	74	71	68	66	63	49
45	108	106	103	100	97	94	91	88	86	83	80	77	74	71	68	66	51
40	111	108	106	103	100	97	94	91	88	86	83	80	77	74	71	68	54
35	113	111	108	106	103	100	97	94	91	88	86	83	80	77	74	71	57
30	116	114	111	108	106	103	100	97	94	91	88	86	83	80	77	74	60
25	119	117	114	111	108	106	103	100	97	94	91	88	86	83	80	77	63
20	122	120	117	114	111	108	106	103	100	97	94	91	88	86	83	80	66
15	125	123	120	117	114	111	108	106	103	100	97	94	91	88	86	83	68
10	128	125	123	120	117	114	111	108	106	103	100	97	94	91	88	86	71
5	131	128	125	123	120	117	114	111	108	106	103	100	97	94	91	88	74
1	133	131	128	125	122	119	116	113	111	108	105	102	99	96	94	91	76

Disclaimer: the pilot in command will provide accurate accounting of available time, this is a reference only.
Dark blue > two hours, Light blue > one hour and < two hours, Red ≤ one hour

A5 Appendix – Airtanker Energetics

The effect of water dropped on a fire is assessed in this guide with a set of models that systematically look at the balance between the energy in the combustion zone and the 'cooling' effect of water dropped into it as well as the wetting effects of water on unburned fuel. The overall assessment methods rely on simple physical reasoning to capture the most important processes governing the impact of a drop. Fire behaviour and combustion zone properties are defined to be consistent with fuel moisture and fire behaviour models within the Canadian Forest Fire Danger Rating System.

The energetics model developed for use in this guide is not meant to be a detailed and comprehensive physical parameterization of the suppressant-fire interaction; our focus was capturing, to first order, the main factors influencing the success of an idealized drop so that we carry out a relative comparison of airtanker effectiveness across a range of drop scenarios. In actual application there is considerable variability from drop-to-drop in all aspects of the process: water drop depth patterns vary from drop-to-drop, fire behaviour varies along the fire line and from minute-to-minute, fuels both within the combustion zone and just outside the burning perimeter can vary on a fine scale (even when they are classified as the same fuel type).

The energetics model's assessment of drop effectiveness involves estimating a drop's impact on two distinct portions of the ground:

1. First, it looks at energy coming from and stored within the burning fuels in the combustion zone and calculates the amount of water needed to reduce that energy to below the threshold of flaming sustainability (smouldering combustion) for some period of time.
2. Second, to determine the amount of time it will take until the fire can begin to spread again in unburned fuels beside the combustion zone (we define this as the holding time of the drop), the model estimates the change in moisture content in the fine fuels adjacent to the combustion zone (but inside the drop zone). It then examines the drying time (in the heated environment close to the fire front) it takes for fine fuels to shed enough of the moisture absorbed in the drop to be able to sustain active spread in this zone.

The model assumes that, along the length of a single drop, half the width of the drop is applied into the combustion zone and half the drop width is applied to the unburned fuels adjacent to the combustion zone. This assumption is based on information from a structured but informal survey of air attack officers and pilots that we carried out as part of this work; this "half-on/half-off" approach was described as a typical goal of drops once fireline intensities became moderate. This is an important assumption, as the change in moisture in the fine fuels beside the combustion zone is what this energetics model uses to determine the length of time the drop will be considered to 'hold'.

A further assumption is the definition of an effective drop we use. Developing a set of consistently defined scenarios, each anchored in a clearly defined physical state, was important for providing meaningful relative comparisons of airtanker effectiveness within this simple tabular format. In the energetics model we define an effective portion of a drop as one where the water depth within that portion of the drop reduces the combustion zone to a marginal burning state (i.e., the energy in the combusting fuels is reduced essentially to zero and the fire has stopped flaming within the drop limits).This assumption was required to keep the dimensionality of the tables from growing too large, while still allowing relative comparison between airtanker types and different fire intensities.

The model uses spatially detailed characterization of within-drop water depth obtained from numerous airtanker drops carried out as part of the overall development of this guide. Each drop pattern for each specific airtanker consists of a nested series of length and widths (Figure 7-1) each associated with a specific depth of water delivered (i.e., coverage level). (See Appendix A2 for examples of these drops.) Within each drop, greater water amounts reaching the fuels on the ground are associated with smaller drop extents. Losses of water during the drop (due to drift and other factors) are included based on our observations of the total amount of water reaching the ground during the extensive series of drop experiments we carried out. We recognize every drop can have a considerably different spatial distribution of water due to numerous intangible factors; however, the model's calculations must use average conditions.

A5.1 DROP IMPACT ON THE COMBUSTION ZONE

In the tables presented in this guide (e.g., Section 9), idealized airtanker drops are evaluated for a range of fire behaviour scenarios. These fire behaviour scenarios were chosen for the forested fuel types (C-2 and C-3) to cover a realistic and useful range of qualitative and easily observable fire behaviour characteristics (i.e., surface fire, torching/intermittent crowning, and active crown fire spread). This range of intensities produced also spanned the recognized intensity classes (Taylor and Alexander 2018). For the open fuel types (S-1 and O-1a) spread rates, the fire behaviour scenarios were chosen to capture a realistic range of vigour of spread and intensity for those fuel types. Overall, this was accomplished using the Canadian FBP System (FCFDG 1992) and choosing a range of realistic input conditions that resulted in the desired range of fire behaviour. Where possible constant environmental conditions were used between the scenarios.

A5.1.1 Environmental and FBP System inputs

All calculations are carried out for a Build Up Index (BUI) value of 50 and a Foliar Moisture Content (FMC) of 100%. Air temperature and relative humidity are assumed to be 25°C and 25% (representing a warm, dry day); these have a small effect on the drying rate of unburned fuels. To drive baseline scenarios FFMC was held constant (at about 91) except for scenarios where, to achieve lower spread rate values and intensities, FFMC needed to be lowered; while this might seem limiting, the choice of FFMC is simply a repeatable way to achieve the desired fire behaviour level (which is the main input) so this is not a part of the model that has a high level of sensitivity. Wind was the main element that was varied in each scenario (from 0 to ~35 km/h) to create a range of spread rates (calculated using the FBP System) and thereby allow calculation of fireline intensity following the standard Canadian methods.

For the open fuel types the spread rate and intensity calculation is straightforward. For the forested fuel types used in this guide (C-2 and C-3), since torching and crowning were possible, the critical surface fire intensity (Van Wagner 1977), the critical spread rate needed for crowning and the crown fraction burned were calculated and used to assign fire type to each scenario and also to calculate the final total fuel consumption and head fire intensity. Standard FBP System fuel type characteristics and associated fuel type specific models were used for all of these calculations.

A5.1.2 Combustion zone characteristics

The area of the combustion zone was calculated per unit length of fire perimeter using the flame front depth; this facilitated conversion of total head fire intensity to an estimate of energy release per second per unit area. Flame front depth was calculated from the spread rate for each scenario and each fuel type's flame front residence time. Flame front residence time was constant for each fuel type and taken from published (Taylor et al. 2004; Wotton et al. 2011; Kidnie and Wotton 2015) and unpublished estimates obtained from field observations (Table A5-1).

Similarly, combustion zone temperature was estimated using flame length and field-based observations of temperature at the base of a flame from previous studies (Taylor et al. 2004; Wotton and Martin 1998, 2011; Kidnie and Wotton 2015). For very small flames the temperature in the active combustion zone was assumed to be 400°C (which is the upper end of flame tip temperature measured in the field), once flames were >2m in height the flame temperature was constant at 1000°C, which is slightly lower than maximum temperature observed in very large flames (Taylor et al. 2004, Wotton et al 2011). We assume a linear transition between these two states (400 to 1000°C) as flame length increases between 0 and 2m, which, in our opinion is a reasonable approximation based on observations of the temperature variation with height made in previous studies (Wotton and Martin 1998; 2011).

Table A5-1. *Assumed characteristics of fuels and fuel moisture and fire behaviour thresholds for the fuel types used in this guide.*

Fuel Type	**Litter load (kg/m^2)**	**Fraction of SFC consumed**	**Fraction SFC holding heat**	**residence time (s)**	**RAINeff Factor**	**FFMCx**	**FFMCr**
C-2	0.30	0.10	0.25	40	0.1	75	88
C-3	0.30	0.15	0.50	30	0.1	75	87
O-1a	0.35	0	1.0	25	0.5	60	80
S-1	0.60	0.10	0.25	120	0.1	65	80

A5.1.3 Energy in combusting fuels

The total mass of fine fuel on the forest floor being consumed during flame front passage (estimated as mass per square metre of litter and <0.5 cm diameter down and dead twigs) was assumed to be at combustion zone temperature. The thermal energy held within these fuels was estimated based on fuel mass (i.e., fuel load), the difference between ambient temperature and this combustion zone temperature and the specific heats of both water (4.2 kJ/kg/°C) and a typical pine needle litter (1.4 kJ/kg/°C, Anderson 1969). Given that these fine fuels were in the process of being consumed during the drop we conservatively assume 75% of their mass remains and contributes to the 'stored' energy of the combustion zone (i.e., the energy that must be 'cooled' by the water).

A5.1.4 Accounting for heavier fuels

While a significant amount of heavier fuels in and on the forest floor might be consumed in the burn out after the passage of the main flaming front (Prichard et al. 2007; Reinhardt et al. 1997) we assumed that a portion of these heavier fuels in the combustion zone also contributed to overall stored thermal energy and needed to be 'cooled' to reduce the ignition zone to smouldering. This portion of heavier fuels consumed during the passage of the flaming front was taken as a small fraction (Table A5-1) of the overall Surface Fuel Consumption (SFC, calculated using the FBP System) for each fuel type. Heavier fuels not consumed in the passage of the flaming front still had the potential to hold energy and contribute to overall energy in the combustion zone (and support re-ignition of the combustion zone). The fraction of heavier fuels (SFC) (that portion of SFC consumed in the passage of the flaming front) holding combustion zone energy were estimated and assumed to be at a temperature just below that required for combustion (300 °C) (Table A5-1). These fractions were based on expert opinion and considering the amount of down and dead woody material (i.e., dropped branchwood) and organic layer fuels that make up the overall surface fuel load in the fuel types.

A5.1.5 Accounting for water loss due to buoyancy

The upward buoyant force of a spreading fireline increases linearly with fireline intensity (Nelson et al 2011). As buoyancy increases, less of the water dropped will penetrate through upward buoyancy in the flame and heated plume; some water would be carried away in turbulent updrafts and some water would evaporate in the heated flame zone. Estimating how that buoyant force interacts with the water within the drop however is quite complex, due to a lack of knowledge of how quickly the water volume from the airtanker tanks breaks up into small droplets. Small water droplets would have high surface-to-volume (mass) ratio and be influenced by lower buoyant forces (i.e., lower intensities); small droplets would also evaporate faster (again because of the high surface area-to-volume ratios). A simple estimate of the fraction of the drop lost through the upward buoyancy is made for each scenario by: first, assuming that the deepest water contour consistently observed (in multiple, contiguous cups in the field experiment) from the CL-215 (4 mm depth) does not meaningfully impact fireline intensity of >10,000 kW/m (anchoring the top end of the buoyant effect at the accepted limit of heavy airtanker effectiveness (i.e. an Intensity class 6 fire); and, second assuming the amount of water lost to buoyancy varies linearly (with its changing mass) between no drop loss due to the flame at an intensity of 10 KW/m and the upper limit of 10,000 kW/m. It should be recognized that this assumption defines the upper limit of heavy airtanker effectiveness from a single drop to be 10,000 kW/m; thus, the 10,000 kW/m limit in these tables is prescribed and not a result of a physics-based argument.

A5.1.6 Reduction to smouldering and recovery

To provide an anchor in the tables for relative comparisons across all airtanker types and fire behaviour scenarios, the energetics model is configured to examine the portion of drops where water depth delivered can eliminate the flaming energy in the combustion zone. This is done through two separate calculations: 1) the amount of water needed to 'cool' the fuels in combustion zone to a state where flaming combustion ends is calculated; and 2) the effect of water in the drop on lowering moisture in the fine fuels outside the combustion zone is calculated.

A5.1.7 Cooling the combustion zone

The amount of water needed to 'cool' the energy produced in the combustion reaction in surface fuels is estimated as the energy stored in the combustion zone fuels divided by the energy sink capacity of water (i.e., the energy needed to both warm water from lake temperature to the boiling point (~10°C to 100°C) and then to vapourize that water (the latent heat of vapourization being ~2260 kJ/kg)). This led to a mass per unit area of water, or an equivalent depth of water (mm), needed to balance the energy produced in the combustion zone. This water depth is scaled up by a factor that represents an estimate of how much water falling into the combustion zone is actually absorbed by those fuels and does not simply pass through the fuel complex. In the absence of quality observations of this factor (which must be somewhere between 0 and 1), this 'run through' factor was set at 0.5 as a conservative estimate; this effectively increases the required water delivery into the combustion zone for effective cooling by a factor of two.

A5.1.8 Wetting fuels outside the combustion zone

In the energetics model, about 50% of water that is targeted to fall outside the combustion zone on unburned fuel directly adjacent to the fire front has the sole effect of increasing fuel moisture. Those fine unburned fuels beside the combustion zone then start to dry back to a burnable state. While a complex multi-stage process, we use the moisture models in the CFFDRS to provide the backbone of this estimate. For each fuel type we estimate two FFMC values: 1) a moisture content of extinction (FFMCx), below which sustainable flaming spread is improbable is estimated to establish a second estimate of water needed for flaming extinguishment (independent from combustion zone physics and); and 2) a recovery FFMC (FFMCr), which defines a moisture content above which we consider the fire line once again spreading consistently (though at a reduced intensity level to its original state). We used the former (the amount of water needed to get to FFMCx) as a check and potential modifier on the assumption (described above) that 50% of water incident on the combustion zone runs through it without contributing to the 'cooling' of energy in the combustion zone.

The water needed to take fine fuels from pre-drop moisture (assumed to be about an FFMC of 91 or 10% moisture content) to FFMCx can be calculated with the standard FFMC formula that converts between FFMC (the 'code value) and its moisture content equivalent (this conversion is called the FF-scale in the FWI System (Van Wagner 1987). The FFMC rainfall model from the hourly FFMC also allows us to estimate the fraction of the drop that is absorbed into the fine fuel layer (Van Wagner 1977); for lower amounts of rainfall (<3 mm in-stand), this value is consistently about 7% though probably does include some evaporation over the period of a day (due to the daily temporal scale used in the original development of that model). For C-2, C-3, and S-1 we used a value somewhat higher than this (10%) to scale up the water needed to an equivalent 'rainfall' (i.e., the water drop volume delivered to just above the surface fuels). Since the O-1a fuel complex has been observed to be a very efficient absorber of rainfall (Wotton 2009), we used a value of 50%; standing grass (O-1b) by contrast is not at all a good absorber of rainfall.

A5.1.9 Finding the 'effective' size of a drop needed to reduce to smouldering

To estimate the water needed to extinguish flaming for more than an instant, the energetics model uses the smaller of the water estimates between the estimate of water needed from the combustion zone energy calculation and the estimate of 'rainfall' needed from the FFMCx calculation. The depth equivalent of water in the drop that was estimated to be lost due to buoyancy of the flame is then added to this amount to get the total water depth needed from the airtanker to meet the energy reduction criteria. For a specific airtanker, the size of the contour (e.g., Table A2-2, A2-3) delivering at least this depth of water is then selected as the effective size of the drop.

A5.2 DEFINING AN EFFECTIVE DROP

For the purposes of the comparisons in this guide, the calculation of water depth required to reduce the energy in the combustion zone to below the sustainable flaming level is not alone enough to imply an airtanker drop will ultimately be effective at holding spread for a period of time (which we define as ≥1 hour). To be effective at holding spread over the length of the drop it must also be true that:

A. The effective portion of the drop is wide enough over the wetted unburned fuel to act as a temporary barrier preventing the spreading fire from breaching (quickly jumping across) that wetted fuel area.
B. The combustion zone depth (the zone of active flaming) is less than the half width of the effective drop size; that is, the half drop wets entire flaming zone.
C. The fuels outside the drop zone (but within the area wetted by the drop) will not support sustainable spread for a period of approximately an hour or more.

A5.2.1 Breaching

Fire line breaching is the process whereby, due to flame size and intensity, the fire front can cross a barrier directly. In his original work on fire intensity and flame length Byram (1959) suggested fire break breaching would be related to flame length and discussed an example using a breaching guideline that suggested fuel breaks be >1.5 times the flame length. Here we used a modification of that suggestion for breaching in which it is assumed a wetted fuel break might hold if its width is greater than the flame length (this is also described earlier in as described earlier in Appendix A1.4*)*. That is, if the half-width of the effective drop (which falls on unburned fuel adjacent to the flame front) was less than the barrier breaching width, the drop was considered to be ineffective at holding line (though it still could be considered to effectively 'cool' the combustion zone).

A5.2.2 Deep flame fronts

If the combustion zone width is greater than the half width of the drop that lands in the combustion zone, it is assumed that, because there is still flaming in the combustion zone, that some part of that flaming will carry through the drop and find unburned fuel that can support spread. This is conservative assumption seems to rarely plays a role in determining holding capacity, apart from limiting line building on the heads of very fast-moving grassland fires that have very deep flame fronts.

A5.2.3 Drying time for unburned fuel adjacent to the fire front

The third criterion above requires an estimate of how quickly the litter in a fuel type dries to levels that can sustain spread. The typical forest floor litter drying time-lag within the FFMC is around 4 or 5 hours (see Van Wagner 1977) under the typical summer conditions assumed here. The equilibrium moisture content (the dryness to which fuels dry towards) was calculated, using the ambient weather conditions assumed in the model at about 8%. In the standard exponential drying model used in the FFMC, fuels dry about 63% of the way towards the equilibrium value over a time equal to the time-lag (this time is also sometimes called the response time of the fuel layer).

In the energetics model, while the drop on the combustion does temporarily eliminate the energy from flaming combustion, we assume the wetted unburned fuels just adjacent to the fireline dry in a more heated environment, as wind and turbulence move heated, drier air across the combustion zone across the unburned fuel ahead. To account for this enhanced drying, we used two drying rates which speed up the drying of more elevated fine litter fuels and have been used in a modification of the hourly FFMC for exposed heated fuels in grassland (Wotton 2009). The slower of these drying rates, which is around an hour, used the shaded drying rate of elevated fuel from Wotton (2009); the faster drying rate (around 0.75 of an hour) assumed that the energy flow into the combustion zone acted to enhance fuel temperature in a way consistent with the enhancement seen on a partly cloudy day (essentially elevating fuel temperature by about 5 °C; a fully sunny day can elevate temperature of exposed fuel by 20°C or more; Wotton 2009).

If the water dropped in the effective drop contour removed the combustion energy from both the flaming fuels and the heavier fuels in the combustion zone, then it was assumed that the flow of heated air from the burned area to the unburned fuels was somewhat reduced and the slower (but exposed fuel) drying rate was used. The faster drying rate was used if heat was left in the combustion zone after flaming was extinguished; this was indicated by energy left in the heated heavier fuels in the combustion zone and was assumed to provide an effective source of reignition throughout the combustion zone and consequent heat transfer to the unburned fuels.

The drying rate determined from an assessment of residual combustion zone energy was used to estimate the time it would take the fuel to dry back to the FFMCr level; this value of FFMC is estimated from the FBP System spread rate fuel types and is associated with a value lower than the original spread rate but representative of the re-establishment of sustained spread. This calculation estimates time required using the exponential drying model from the FFMC and the equilibrium moisture value described above. The water depth dropped by the airtanker along the fireline must be enough that sustainable spread is not attained for at least an hour.

Once the effective drop size from an airtanker has been estimated then the effective length of that drop contour is used to estimate length of line buildable in an hour (Section 9) and also the number of drops needed to hold 100 m of line (Tables 8-2 and Appendix A8). The area (both length and width) of the effective drop is used to estimate the number of drops needed to cover 1 ha of an active fire (Table 8-3 and Appendix A9).

A5.3 ASSUMPTIONS AND CAVEATS

It is important to remember that, despite the many elements considered (Figure A5-1), this energetics model is meant to provide a simple and systematic way to evaluate the relative impact water on balance between the energy of the fire and the energy sink from water. To produce a manageable number of tables for these relative comparisons a considerable number of simplifications and assumptions have been made in the overall system; the dynamics of water drops into real wildland fires are quite complex and scenario dependent. Like the relative nature of the outputs of the Canadian FWI System, the outputs of this model are best used in evaluating relative effectiveness of different airtankers in the same suppression scenario.

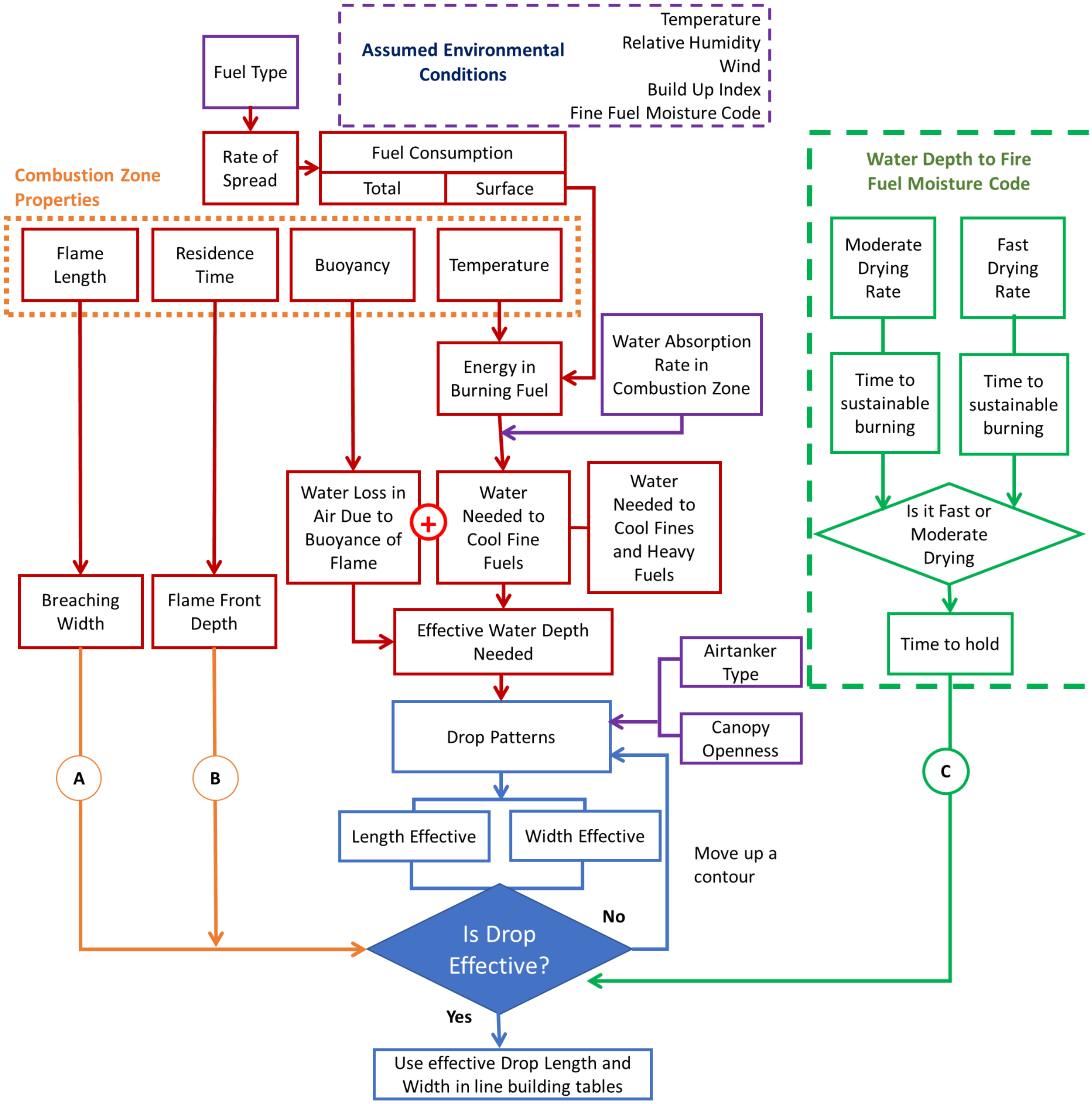


Figure A5-1: *Flow chart of the general information and calculation flow in the Energetics model for drop effectiveness.*

A6 APPENDIX - VALIDATION/ASSESSMENT

The purpose of this exploration is to compare the performance of the energetics model between the historically observed number of drops to successfully contain a fire. Historical airtanker mission data from the Ontario air attack archive for 2007-2019 were used to determine the number of drops to successfully contain a fire at different classifications of fire behaviour. Qualitative observations of fire behaviour (i.e., fire rank[5]) were recorded for each air attack mission at the start of airtanker operations along with the number of drops applied during the mission.

This analysis contains missions that used only the CL-415 or only the Twin Otter; any missions that used a combination of the CL-415 and Twin Otter were removed. Only fires which burned in either conifer, mixed wood, or deciduous fuels were examined. To determine the number of drops to successfully contain a fire, a definition of success was used of if the fire was considered "Being Held" by 1300 local time the day following attack, or the final size was less than or equal to 4 ha. Only air attack missions occurring before 1300 local time the following day were included to ensure that all missions were conducted in the initial attack phase of the fire.

The qualitative observations of fire behaviour by the AAOs were roughly converted to an intensity using FBP system classifications of fire type for the specific fuel type (similar to Table A1-5). The median number of drops to successfully contain a fire in each fire rank grouping was then compared to the output from energetics model for a similar intensity level (Figure A6-1 and A6-2). The perimeter for the median fire size observed in each fire rank grouping was divided by the effective drop length from the energetics model to estimate the number of drops needed. The line building model predicted a median number of drops around the 25th percentile of the observed. This result fits with what was expected; operationally it was expected that airtanker missions would likely provide more drops that theoretically needed to ensure their suppression actions were effective and long lasting. The model predicts an ideal best case for the most part, with many assumptions, such as perfect positioning of drop locations, uniform fuels and fire behaviour etc.

While we did not have direct observations of individual drop effectiveness to compare with the energetics model outputs, Figure A6-3 shows the model outputs for water required as a function of fireline intensity. Similar models developed from extensive field observation in Australia are also included in that plot for comparison. The model for the woodland forest type from Australia agrees well with the models for C-2 and C-3. The open grassland results from this current model also agree reasonably with the Australian grassland results.

[5] https://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-response/about-wildfire/wildfire-rank

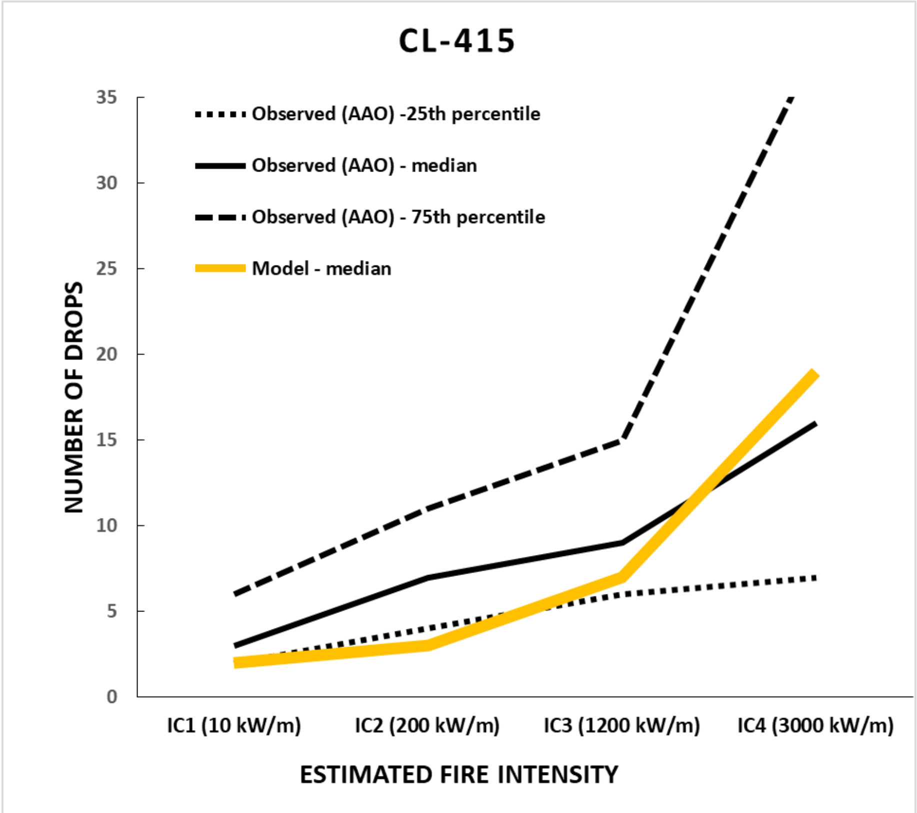


Figure A6-1. *Comparison of historical airtanker mission data (for CL-415 tankers) from the Ontario air attack archive for 2007-2019 of the number of drops to successfully contain a fire at different classifications of fire behaviour and the energetics model (yellow).*

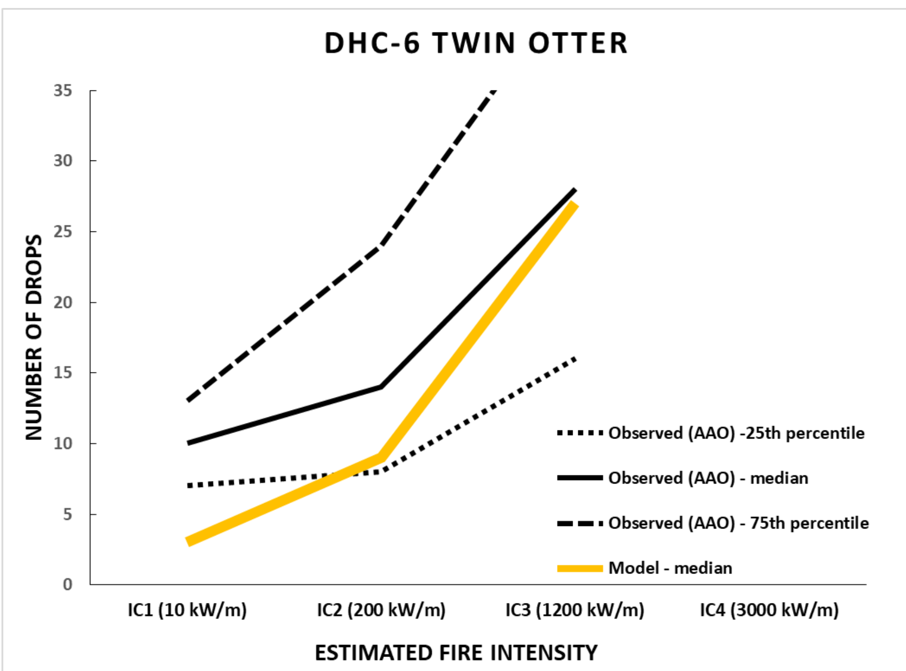


Figure A6-2. *Comparison of historical airtanker mission data (for DHC-6 Twin Otter) from the Ontario air attack archive for 2007-2019 of the number of drops to successfully contain a fire at different classifications of fire behaviour and the energetics model (yellow).*

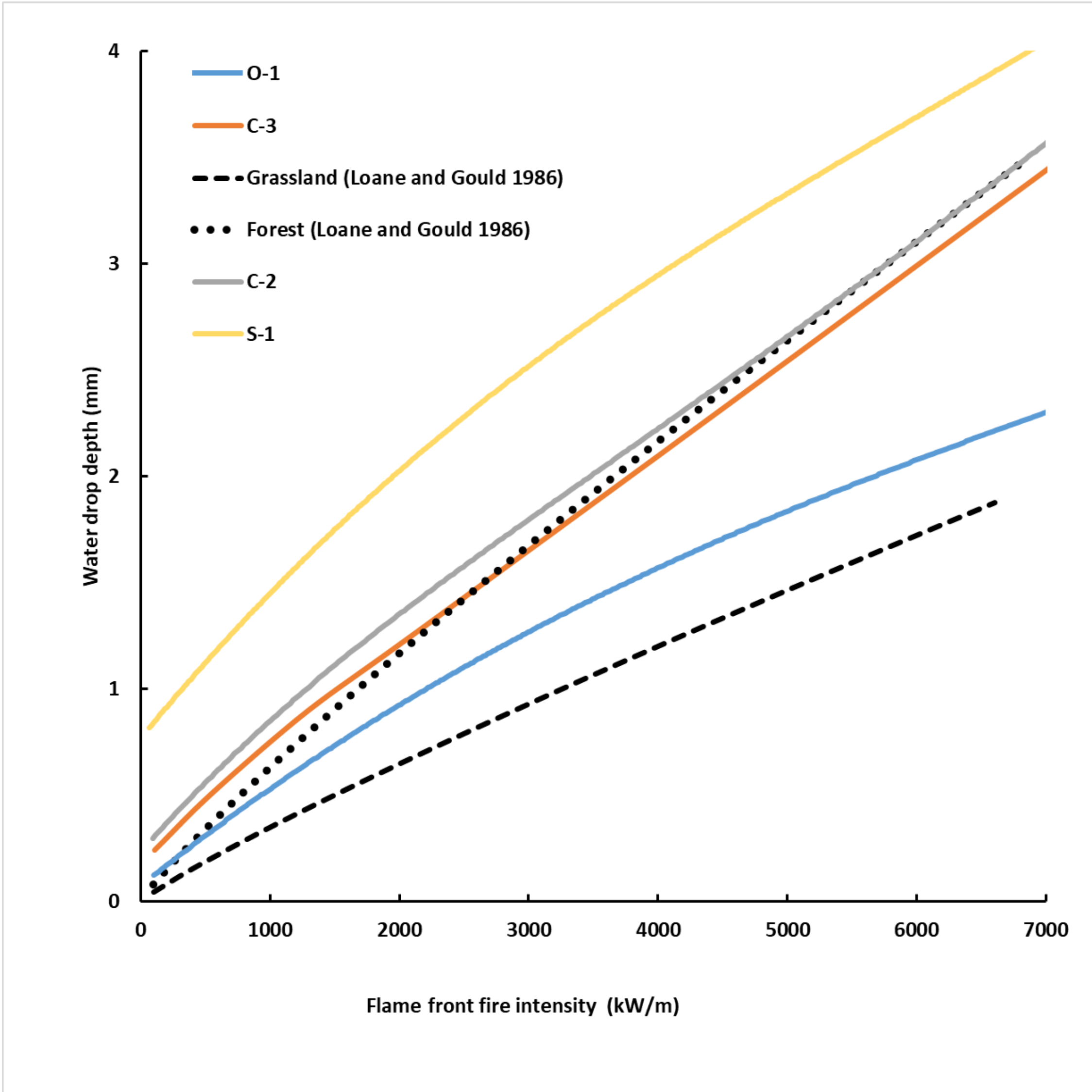


Figure A6-3. *Water required to suppress fire line of various intensities (kW/m). Outputs from the energetics model for C-2, C-3 (closed canopy forest) and O-1a and S-1 (open fuels) are shown along with outputs from Australian models from field experiments (summarized in Loane and Gould 1986).*

A7 Appendix - Comparison of Effective Drop Dimensions from Different Airtanker Types for Different Fire Intensities

A7.1 C-2 Full Canopy

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		130:50 (1)	90:40 (1)	90:40 (1)	90:40 (1)	70:30 (1)	Br	Br	Br
CL-215		110:60 (1)	70:40 (1)	70:40 (1)	70:40 (1)	50:30 (2)	30:20 (2)	Br	Br
CL-215T		110:60 (1)	70:40 (1)	70:40 (1)	70:40 (1)	50:30 (2)	30:20 (2)	Br	Br
AT-802F Fire Boss		100:40 (1)	70:30 (1)	70:30 (1)	70:30 (1)	40:20 (2)	NA	NA	NA
DHC-6 Twin Otter		70:30 (1)	40:20 (1)	40:20 (1)	40:20 (2)	20:9 (3)	NA	NA	NA
Bell 212 Belly Tank Fast		50:20 (1)	40:20 (1)	40:20 (1)	40:20 (1)	40:10 (1)	NA	NA	NA
Bell 212 Belly Tank Slow		20:10 (1)	20:9 (1)	20:9 (1)	20:9 (1)	20:9 (1)	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A7.2 C-2 Sparse Canopy

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		130:60 (1)	110:40 (1)	110:40 (1)	110:40 (1)	80:30 (1)	Br	Br	Br
CL-215		120:60 (1)	80:50 (1)	80:50 (1)	80:50 (1)	60:40 (2)	40:30 (2)	Br	Br
CL-215T		120:60 (1)	80:50 (1)	80:50 (1)	80:50 (1)	60:40 (2)	40:30 (2)	Br	Br
AT-802F Fire Boss		100:40 (1)	80:30 (1)	80:30 (1)	80:30 (1)	60:20 (2)	NA	NA	NA
DHC-6 Twin Otter		70:40 (1)	50:20 (1)	50:20 (1)	50:20 (2)	30:20 (3)	NA	NA	NA
Bell 212 Belly Tank Fast		50:20 (1)	40:20 (1)	40:20 (1)	40:20 (1)	40:20 (1)	NA	NA	NA
Bell 212 Belly Tank Slow		20:10 (1)	20:9 (1)	20:9 (1)	20:9 (1)	20:9 (1)	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone).

A7.3 C-3 FULL CANOPY

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW /m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,200 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.75mm	1mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		130:50 (1)	130:50 (1)	70:30 (1)	50:20 (1)	Br	Br	Br	Br
CL-215		110:60 (1)	110:60 (1)	50:30 (1)	30:20 (1)	30:20 (2)	Br	Br	Br
CL-215T		110:60 (1)	110:60 (1)	50:30 (1)	30:20 (1)	30:20 (2)	Br	Br	Br
AT-802F Fire Boss		100:40 (1)	100:40 (1)	40:20 (1)	20:10 (1)	Br	NA	NA	NA
DHC-6 Twin Otter		70:30 (1)	70:30 (1)	20:9 (1)	Br	Br	NA	NA	NA
Bell 212 Belly Tank Fast		50:20 (1)	50:20 (1)	40:10 (1)	30:10 (1)	Br	NA	NA	NA
Bell 212 Belly Tank Slow		20:10 (1)	20:9 (1)	20:9 (1)	Br	Br	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A7.4 C-3 Sparse canopy

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,200 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.75mm	1mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		130:60 (1)	130:60 (1)	80:30 (1)	70: 20 (1)	50: 20 (1)	Br	Br	Br
CL-215		120:60 (1)	120:60 (1)	60:40 (1)	50: 30 (1)	40: 30 (2)	Br	Br	Br
CL-215T		120:60 (1)	120:60 (1)	60:40 (1)	50: 30 (1)	40: 30 (2)	Br	Br	Br
AT-802F		100:40 (1)	100:40 (1)	60:20 (1)	40: 20 (1)	Br	NA	NA	NA
DHC-6 Twin Otter		70:40 (1)	70:40 (1)	30:20 (1)	20:9 (2)	Br	NA	NA	NA
Bell 212 BT Fast		50:20 (1)	50:20 (1)	40:20 (1)	40:10 (1)	Br	NA	NA	NA
Bell 212 BT Slow		20:10 (1)	20:9 (1)	20:9 (1)	Br	Br	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A7.5 O-1A

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

Airtanker	Fire Type	Smould.	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.5mm	0.75mm	1.5mm	1.5mm	2mm	2mm
CL-415		130:60 (1)	130:60 (1)	120:50 (1)	100:40 (1)	70:30 (1)	70:30 (2)	Br	Br
CL-215		120:60 (1)	120:60 (1)	100:50 (1)	80:50 (1)	50:30 (2)	50:30 (2)	Br	Br
CL-215T		120:60 (1)	120:60 (1)	100:50 (1)	80:50 (1)	50:30 (2)	50:30 (2)	Br	Br
AT-802F Fire Boss		110:50 (1)	110:50 (1)	90:40 (1)	70:30 (1)	40:20 (2)	Br	Br	Br
DHC-6 Twin Otter		70:40 (1)	70:40 (1)	60:30 (1)	50:20 (2)	Br	Br	Br	Br
Bell 212 Belly Tank Fast		60:30 (1)	60:30 (1)	50:20 (1)	40:20 (1)	Br	Br	Br	Br
Bell 212 Belly Tank Slow		20:10 (1)	20:9 (1)	20:9 (1)	20:9 (1)	Br	Br	Br	Br

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A7.6 S-1

Dimensions of drop that correspond to the depth of water and number of stacked drops required to cool combustion zone
Length: Width in metres (# of stacked drops)

Fire behaviour

	Fire Type	Smould.	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.75mm	1.5mm	2mm	2mm	2.5mm	4mm	>4mm
CL-415		130:60 (1)	100:40 (1)	70:30 (1)	50:20 (1)	50:20 (1)	Br	Br	Br
CL-215		120:60 (1)	80:50 (1)	50:30 (1)	30:20 (1)	30:20 (2)	30:20 (2)	Br	Br
CL-215T		120:60 (1)	80:50 (1)	50:30 (1)	30:20 (1)	30:20 (2)	30:20 (2)	Br	Br
AT-802F Fire Boss		110:50 (1)	70:30 (1)	40:20 (1)	20:10 (1)	Br	Br	Br	Br
DHC-6 Twin Otter		70:40 (1)	50:20 (1)	20:9 (1)	Br	Br	Br	Br	Br
Bell 212 Belly Tank Fast		60:30 (1)	40:20 (1)	40: 10(1)	30:10 (1)	Br	Br	Br	Br
Bell 212 Belly Tank Slow		20:10 (1)	20:9 (1)	20: 9(1)	20:9 (1)	Br	Br	Br	Br

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A8 APPENDIX - COMPARISON OF THE NUMBER OF DROPS NEEDED BY DIFFERENT AIRTANKERS TO HOLD 100 M OF UNIFORM FIRE PERIMETER

A8.1 C-2 FULL CANOPY

Airtanker	Minimum number of drops needed to build 100m of line — Fire behaviour along a fireline segment								
	Fire Type	**Smould.**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		1	1	1	1	2	Br	Br	Br
CL-215		1	1	1	1	2	7	Br	Br
CL-215T		1	1	1	1	2	7	Br	Br
AT-802F Fire Boss		1	1	1	1	2	NA	NA	NA
DHC-6 Twin Otter		2	2	2	2	12	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	2	2	3	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	5	5	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A8.2 C-2 Sparse Canopy

	Minimum number of drops needed to build 100m of line								
	Fire behaviour along a fireline segment								
Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		1	1	1	1	1	Br	Br	Br
CL-215		1	1	1	1	2	5	Br	Br
CL-215T		1	1	1	1	2	5	Br	Br
AT-802F Fire Boss		1	1	1	1	2	NA	NA	NA
DHC-6 Twin Otter		1	2	2	2	6	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	2	2	2	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	5	5	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A8.3 C-3 FULL CANOPY

Minimum number of drops needed to build 100m of line

Fire behaviour along a fireline segment

Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.75mm	1.0mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		1	1	2	2	Br	Br	Br	Br
CL-215		1	1	2	6	7	Br	Br	Br
CL-215T		1	1	2	6	7	BR	Br	Br
AT-802F Fire Boss		1	1	2	10	Br	NA	NA	NA
DHC-6 Twin Otter		2	2	12	Br	Br	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	3	3	Br	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	Br	Br	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A8.4 C-3 Sparse Canopy

Minimum number of drops needed to build 100m of line

Fire behaviour along a fireline segment

	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.75mm	1mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		1	1	1	1	4	Br	Br	Br
CL-215		1	1	2	4	5	Br	Br	Br
CL-215T		1	1	2	4	5	BR	Br	Br
AT-802F Fire Boss		1	1	2	5	Br	NA	NA	NA
DHC-6 Twin Otter		1	1	6	14	Br	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	2	3	Br	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	Br	Br	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A8.5 O-1A

	Minimum number of drops needed to build 100m of line Fire behaviour along a fireline segment								
Airtanker	Fire Type	Smould.	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.5mm	.75mm	1.5mm	1.5mm	2mm	2mm
CL-415		1	1	1	1	3	3	Br	Br
CL-215		1	1	1	1	4	4	Br	Br
CL-215T		1	1	1	1	4	4	Br	Br
AT-802F Fire Boss		1	1	1	1	5	Br	Br	NA
DHC-6 Twin Otter		1	1	2	4	Br	Br	Br	NA
Bell 212 Belly Tank Fast		2	2	2	2	Br	Br	Br	NA
Bell 212 Belly Tank Slow		5	5	5	5	Br	Br	Br	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone).

A8.6 S-1

Minimum number of drops needed to build 100m of line

Fire behaviour along a fireline segment

	Fire Type	Smould.	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface mod)	Surface (mod-high)	Surface (high)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.75mm	1.5mm	2mm	2mm	2.5mm	4mm	>4mm
CL-415		1	1	3	6	6	Br	Br	NA
CL-215		1	1	4	10	10	15	Br	NA
CL-215T		1	1	4	10	10	15	Br	NA
AT-802F Fire Boss		1	1	5	15	Br	NA	NA	NA
DHC-6 Twin Otter		1	4	18	Br	Br	NA	NA	NA
Bell 212 Belly Tank Fast		2	2	3	6	Br	NA	NA	NA
Bell 212 Belly Tank Slow		5	5	5	5	Br	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A9 Appendix - Comparison of the number of drops needed by different airtankers to hold a 1 hectare 'hotspot'

A9.1 C-2 Full canopy

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		2	3	3	3	6	53	96	###
CL-215		2	3	3	3	6	18	65	###
CL-215T		2	3	3	3	6	18	65	###
AT-802F Fire Boss		3	6	6	6	14	NA	NA	NA
DHC-6 Twin Otter		5	13	13	13	67	NA	NA	NA
Bell 212 Belly Tank Fast		9	15	15	15	18	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A9.2 C-2 SPARSE CANOPY

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

Airtanker	**Fire Type**	**Smould.**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
	ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.5mm	0.5mm	0.75mm	1.5mm	2.5mm	>4mm
CL-415		1	2	2	2	4	13	70	###
CL-215		1	3	3	3	4	10	31	###
CL-215T		1	3	3	3	4	10	31	###
AT-802F Fire Boss		2	4	4	4	7	NA	NA	NA
DHC-6 Twin Otter		4	9	9	9	21	NA	NA	NA
Bell 212 Belly Tank Fast		8	13	13	13	16	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A9.3 C-3 Full canopy

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

Airtanker	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.75mm	1mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		2	2	6	13	53	96	###	###
CL-215		2	2	6	14	18	65	###	###
CL-215T		2	2	6	14	18	65	###	###
AT-802F Fire Boss		3	3	14	52	###	NA	NA	NA
DHC-6 Twin Otter		5	5	67	###	###	NA	NA	NA
Bell 212 Belly Tank Fast		9	9	18	27	41	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

A9.4 C-3 Sparse Canopy

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

	Fire Type	Smould.	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Airtanker	ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.5mm	0.75mm	1mm	1.5mm	2.5mm	>4mm	>4mm
CL-415		1	1	4	6	13	70	###	###
CL-215		1	1	4	7	10	31	###	###
CL-215T		1	1	4	7	10	31	###	###
AT-802F Fire Boss		2	2	7	15	35	NA	NA	NA
DHC-6 Twin Otter		4	4	21	52	###	NA	NA	NA
Bell 212 Belly Tank Fast		8	8	16	21	26	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot or turbulent for aircraft to drop into combustion zone.

A9.5 O-1A

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

Airtanker	Fire Type	Smould.	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	100 (IC2)	500 (IC3)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
	Required Water Depth (mm*)	0.25mm	0.25mm	0.5mm	0.75mm	1.5mm	1.5mm	2mm	2mm
CL-415		1	1	2	3	6	6	13	13
CL-215		1	1	2	3	6	6	14	14
CL-215T		1	1	2	3	6	6	14	14
AT-802F Fire Boss		2	2	3	5	14	14	52	NA
DHC-6 Twin Otter		4	4	6	10	67	67	###	NA
Bell 212 Belly Tank Fast		7	7	12	14	18	18	27	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	52	52	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone.

A9.6 S-1

Minimum number of drops to effectively cover a 1 ha area

Fire behaviour of area

	Fire Type	**Smould.**	**Surface (very low)**	**Surface (low)**	**Surface (low)**	**Surface (mod)**	**Surface (mod)**	**Surface (mod-high)**	**Surface (high)**
Airtanker	**ROS m/min (CFB)**	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Intensity kW/m (Class)	<10 (ICI)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
	Required Water Depth (mm*)	0.25mm	0.75mm	1.5mm	2mm	2mm	2.5mm	4mm	>4mm
CL-415		1	3	6	13	13	53	96	NA
CL-215		1	3	6	14	14	18	65	NA
CL-215T		1	3	6	14	14	18	65	NA
AT-802F Fire Boss		2	5	14	52	52	NA	NA	NA
DHC-6 Twin Otter		4	10	67	###	###	NA	NA	NA
Bell 212 Belly Tank Fast		7	14	18	27	27	NA	NA	NA
Bell 212 Belly Tank Slow		52	52	52	52	52	NA	NA	NA

*Minimum depth of water delivered to the combustion zone required to drop fire behaviour to IC1.

(if present) indicates this intensity level requires an unreasonable number of drops (>100).

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone.

A10 APPENDIX - TOTAL NUMBER OF DROPS NEEDED FOR THREE FIRE SIZE SCENARIOS

A10.1 CL-415, C-2 FULL CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	4 (100%)	3 (66%)	2 (52%)	2 (43%)	1 (24%)		
	IC3		2 (34%)	3 (48%)	4 (57%)	3 (38%)	3 (36%)	2 (25%)
	IC4					12 (39%)	6 (18%)	6 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**4 (100%)**	**5 (100%)**	**5 (100%)**	**6 (100%)**	**16 (100%)**	*9 (55%)*	*8 (41%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	10 (100%)	6 (66%)	5 (52%)	4 (43%)	3 (24%)		
	IC3		5 (34%)	7 (48%)	8 (57%)	5 (38%)	5 (36%)	4 (25%)
	IC4					13 (39%)	7 (18%)	5 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**10 (100%)**	**11 (100%)**	**12 (100%)**	**12 (100%)**	**21 (100%)**	*12 (55%)*	*9 (41%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	13 (100%)	9 (66%)	7 (52%)	6 (43%)	3 (24%)		
	IC3		7 (34%)	9 (48%)	11 (57%)	7 (38%)	7 (36%)	5 (25%)
	IC4					18 (39%)	9 (18%)	7 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**13 (100%)**	**16 (100%)**	**16 (100%)**	**17 (100%)**	**28 (100%)**	*16 (55%)*	*12 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.2 CL-415, C-2 Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
	IC1							
Area (ha)	IC2	4 (100%)	3 (66%)	2 (52%)	2 (43%)	1 (24%)		
1	IC3		2 (34%)	3 (48%)	3 (57%)	2 (38%)	2 (36%)	2 (25%)
Perimeter (m)	IC4					8 (39%)	4 (18%)	4 (15%)
400	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**4 (100%)**	**5 (100%)**	**5 (100%)**	**5 (100%)**	**11 (100%)**	*6 (55%)*	*6 (41%)*
	IC1							
Area (ha)	IC2	9 (100%)	6 (66%)	5 (52%)	4 (43%)	2 (24%)		
5	IC3		4 (34%)	5 (48%)	6 (57%)	4 (38%)	4 (36%)	3 (25%)
Perimeter (m)	IC4					8 (39%)	4 (18%)	3 (15%)
900	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**9 (100%)**	**10 (100%)**	**10 (100%)**	**10 (100%)**	**14 (100%)**	*8 (55%)*	*6 (41%)*
	IC1							
Area (ha)	IC2	12 (100%)	8 (66%)	6 (52%)	5 (43%)	3 (24%)		
10	IC3		5 (34%)	7 (48%)	8 (57%)	6 (38%)	6 (36%)	4 (25%)
Perimeter (m)	IC4					11 (39%)	5 (18%)	4 (15%)
1,200	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**12 (100%)**	**13 (100%)**	**13 (100%)**	**13 (100%)**	**20 (100%)**	*11 (55%)*	*8 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.3 CL-415, C-3 Full canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	0 (4%)						
	IC2	4 (96%)	2 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		5 (70%)	3 (37%)	2 (26%)	2 (23%)	1 (17%)	1 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**4 (100%)**	**7 (100%)**	*4 (52%)*	*3 (38%)*	*3 (32%)*	*2 (24%)*	*2 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	9 (96%)	3 (30%)	2 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		10 (70%)	5 (37%)	4 (26%)	3 (23%)	3 (17%)	2 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**10 (100%)**	**13 (100%)**	*7 (52%)*	*5 (38%)*	*4 (32%)*	*4 (24%)*	*3 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	13 (96%)	4 (30%)	2 (15%)	2 (11%)	2 (9%)	1 (7%)	1 (6%)
	IC3		13 (70%)	7 (37%)	5 (26%)	4 (23%)	3 (17%)	3 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**14 (100%)**	**17 (100%)**	*9 (52%)*	*7 (38%)*	*6 (32%)*	*4 (24%)*	*4 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.4 CL-415, C-3 Sparse Canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	0 (4%)						
	IC2	4 (96%)	1 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		4 (70%)	2 (37%)	2 (26%)	1 (23%)	1 (17%)	1 (15%)
	IC4			4 (48%)	4 (43%)	2 (24%)	2 (17%)	2 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**4 (100%)**	**5 (100%)**	**7 (100%)**	*7 (81%)*	*4 (56%)*	*4 (41%)*	*4 (35%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	8 (96%)	3 (30%)	2 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		8 (70%)	4 (37%)	3 (26%)	3 (23%)	2 (17%)	2 (15%)
	IC4			10 (48%)	8 (43%)	5 (24%)	4 (17%)	3 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**9 (100%)**	**11 (100%)**	**16 (100%)**	*12 (81%)*	*9 (56%)*	*7 (41%)*	*6 (35%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	11 (96%)	4 (30%)	2 (15%)	2 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		10 (70%)	6 (37%)	4 (26%)	4 (23%)	3 (17%)	2 (15%)
	IC4			13 (48%)	12 (43%)	7 (24%)	5 (17%)	4 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**12 (100%)**	**14 (100%)**	**21 (100%)**	*18 (81%)*	*12 (56%)*	*9 (41%)*	*7 (35%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.5 CL-415, O-1A

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW/m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
	IC1							
Area (ha)	IC2	4 (100%)	4 (100%)	2 (50%)	1 (31%)	1 (18%)		
1	IC3			2 (50%)	2 (56%)	2 (43%)	2 (50%)	2 (44%)
Perimeter (m)	IC4				2 (14%)	6 (39%)	6 (36%)	4 (26%)
400	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**4 (100%)**	**4 (100%)**	**4 (100%)**	**5 (100%)**	**9 (100%)**	*8 (87%)*	*6 (69%)*
	IC1							
Area (ha)	IC2	8 (100%)	8 (100%)	4 (50%)	3 (31%)	2 (18%)		
5	IC3			4 (50%)	4 (56%)	4 (43%)	4 (50%)	4 (44%)
Perimeter (m)	IC4				2 (14%)	6 (39%)	5 (36%)	4 (26%)
900	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**8 (100%)**	**8 (100%)**	**8 (100%)**	**9 (100%)**	**12 (100%)**	*9 (87%)*	*8 (69%)*
	IC1							
Area (ha)	IC2	10 (100%)	10 (100%)	5 (50%)	3 (31%)	2 (18%)		
10	IC3			5 (50%)	6 (56%)	5 (43%)	5 (50%)	5 (44%)
Perimeter (m)	IC4				3 (14%)	7 (39%)	7 (36%)	5 (26%)
1,200	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**10 (100%)**	**10 (100%)**	**10 (100%)**	**12 (100%)**	**14 (100%)**	*12 (87%)*	*10 (69%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.6 CL-415, S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**

Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	4 (100%)	2 (55%)	1 (25%)				
	IC3		6 (45%)	6 (47%)	6 (47%)	6 (38%)	4 (28%)	2 (14%)
	IC4			9 (29%)	9 (30%)	6 (21%)	6 (19%)	6 (23%)
	IC5				Br (23%)	Br (41%)	Br (53%)	Br (31%)
	IC6							NA (31%)
	Total*	**4 (100%)**	**8 (100%)**	**16 (100%)**	*15 (77%)*	*12 (59%)*	*10 (47%)*	*8 (38%)*

Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	9 (100%)	5 (55%)	2 (25%)				
	IC3		6 (45%)	7 (47%)	7 (47%)	5 (38%)	4 (28%)	2 (14%)
	IC4			5 (29%)	6 (30%)	4 (21%)	4 (19%)	4 (23%)
	IC5				Br (23%)	Br (41%)	Br (53%)	Br (31%)
	IC6							NA (31%)
	Total*	**9 (100%)**	**11 (100%)**	**14 (100%)**	*13 (77%)*	*9 (59%)*	*8 (47%)*	*6 (38%)*

Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	12 (100%)	7 (55%)	3 (25%)				
	IC3		9 (45%)	9 (47%)	9 (47%)	7 (38%)	5 (28%)	3 (14%)
	IC4			7 (29%)	8 (30%)	5 (21%)	5 (19%)	6 (23%)
	IC5				Br (23%)	Br (41%)	Br (53%)	Br (31%)
	IC6							NA (31%)
	Total*	**12 (100%)**	**16 (100%)**	**19 (100%)**	*17 (77%)*	*12 (59%)*	*10 (47%)*	*9 (38%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter

A10.7 CL-215, C-2 FULL CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class) [6]

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	6 (100%)	4 (66%)	3 (52%)	3 (43%)	2 (24%)		
	IC3		3 (34%)	4 (48%)	5 (57%)	3 (38%)	3 (36%)	2 (25%)
	IC4					12 (39%)	6 (18%)	6 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**6 (100%)**	**7 (100%)**	**7 (100%)**	**8 (100%)**	**17 (100%)**	*9 (55%)*	*8 (41%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	13 (100%)	9 (66%)	7 (52%)	6 (43%)	3 (24%)		
	IC3		7 (34%)	9 (48%)	11 (57%)	7 (38%)	7 (36%)	5 (25%)
	IC4					13 (39%)	6 (18%)	5 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**13 (100%)**	**16 (100%)**	**16 (100%)**	**17 (100%)**	**23 (100%)**	*13 (55%)*	*10 (41%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	18 (100%)	12 (66%)	9 (52%)	8 (43%)	4 (24%)		
	IC3		9 (34%)	12 (48%)	15 (57%)	10 (38%)	9 (36%)	7 (25%)
	IC4					18 (39%)	9 (18%)	7 (15%)
	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**18 (100%)**	**21 (100%)**	**21 (100%)**	**23 (100%)**	**32 (100%)**	*18 (55%)*	*14 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

[6] **Note.** the CL-215 T uses the same drop pattern in this model and therefore there is no difference in effectiveness in these charts.

A10.8 CL-215, C-2 Sparse Canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
	IC1							
Area (ha)	IC2	5 (100%)	3 (66%)	3 (52%)	2 (43%)	1 (24%)		
1	IC3		2 (34%)	3 (48%)	4 (57%)	3 (38%)	3 (36%)	2 (25%)
Perimeter (m)	IC4					8 (39%)	4 (18%)	4 (15%)
400	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**5 (100%)**	**5 (100%)**	**6 (100%)**	**6 (100%)**	**12 (100%)**	*7 (55%)*	*6 (41%)*
	IC1							
Area (ha)	IC2	11 (100%)	7 (66%)	6 (52%)	5 (43%)	3 (24%)		
5	IC3		5 (34%)	7 (48%)	8 (57%)	6 (38%)	5 (36%)	4 (25%)
Perimeter (m)	IC4					9 (39%)	5 (18%)	4 (15%)
900	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**11 (100%)**	**12 (100%)**	**13 (100%)**	**13 (100%)**	**18 (100%)**	*10 (55%)*	*8 (41%)*
	IC1							
Area (ha)	IC2	15 (100%)	10 (66%)	8 (52%)	7 (43%)	4 (24%)		
10	IC3		7 (34%)	10 (48%)	11 (57%)	8 (38%)	7 (36%)	5 (25%)
Perimeter (m)	IC4					13 (39%)	6 (18%)	5 (15%)
1,200	IC5						Br (45%)	Br (32%)
	IC6							NA (27%)
	Total*	**15 (100%)**	**17 (100%)**	**18 (100%)**	**18 (100%)**	**25 (100%)**	*13 (55%)*	*10 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.9 CL-215, C-3 Full Canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	0 (4%)						
	IC2	6 (96%)	2 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		6 (70%)	3 (37%)	2 (26%)	2 (23%)	2 (17%)	2 (15%)
	IC4			14 (48%)	14 (43%)	8 (24%)	6 (17%)	4 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**6 (100%)**	**8 (100%)**	**18 (100%)**	*17 (81%)*	*11 (56%)*	*9 (41%)*	*7 (35%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	13 (96%)	4 (30%)	2 (15%)	2 (11%)	2 (9%)	1 (7%)	1 (6%)
	IC3		13 (70%)	7 (37%)	5 (26%)	4 (23%)	3 (17%)	3 (15%)
	IC4			16 (48%)	14 (43%)	8 (24%)	6 (17%)	5 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**14 (100%)**	**17 (100%)**	**25 (100%)**	*21 (81%)*	*14 (56%)*	*10 (41%)*	*9 (35%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	17 (96%)	6 (30%)	3 (15%)	2 (11%)	2 (9%)	2 (7%)	1 (6%)
	IC3		18 (70%)	10 (37%)	7 (26%)	6 (23%)	5 (17%)	4 (15%)
	IC4			22 (48%)	20 (43%)	11 (24%)	8 (17%)	7 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**18 (100%)**	**24 (100%)**	**35 (100%)**	*29 (81%)*	*19 (56%)*	*15 (41%)*	*12 (35%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.10 CL-215, C-3 SPARSE CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	0 (4%)						
	IC2	5 (96%)	2 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		5 (70%)	3 (37%)	2 (26%)	2 (23%)	1 (17%)	1 (15%)
	IC4			10 (48%)	10 (43%)	6 (24%)	4 (17%)	4 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**5 (100%)**	**7 (100%)**	**14 (100%)**	*13 (81%)*	*9 (56%)*	*6 (41%)*	*6 (35%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	11 (96%)	4 (30%)	2 (15%)	2 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		10 (70%)	6 (37%)	4 (26%)	4 (23%)	3 (17%)	2 (15%)
	IC4			12 (48%)	10 (43%)	6 (24%)	4 (17%)	4 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**12 (100%)**	**14 (100%)**	**20 (100%)**	*16 (81%)*	*11 (56%)*	*8 (41%)*	*7 (35%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	14 (96%)	5 (30%)	2 (15%)	2 (11%)	2 (9%)	1 (7%)	1 (6%)
	IC3		14 (70%)	8 (37%)	5 (26%)	5 (23%)	4 (17%)	3 (15%)
	IC4			16 (48%)	14 (43%)	8 (24%)	6 (17%)	5 (14%)
	IC5				Br (19%)	Br (44%)	Br (31%)	Br (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**15 (100%)**	**19 (100%)**	**26 (100%)**	*21 (81%)*	*15 (56%)*	*11 (41%)*	*9 (35%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.11 CL-215, O-1A

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW/m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
	IC1							
Area (ha)	IC2	4 (100%)	4 (100%)	2 (50%)	2 (31%)	1 (18%)		
1	IC3			2 (50%)	3 (56%)	2 (43%)	2 (50%)	2 (44%)
Perimeter (m)	IC4				2 (14%)	6 (39%)	6 (36%)	4 (26%)
400	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**4 (100%)**	**4 (100%)**	**4 (100%)**	**7 (100%)**	**9 (100%)**	*8 (87%)*	*6 (69%)*
	IC1							
Area (ha)	IC2	9 (100%)	9 (100%)	5 (50%)	3 (31%)	2 (18%)		
5	IC3			5 (50%)	5 (56%)	4 (43%)	5 (50%)	4 (44%)
Perimeter (m)	IC4				3 (14%)	7 (39%)	7 (36%)	5 (26%)
900	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**9 (100%)**	**9 (100%)**	**10 (100%)**	**11 (100%)**	**13 (100%)**	*12 (87%)*	*9 (69%)*
	IC1							
Area (ha)	IC2	13 (100%)	13 (100%)	7 (50%)	4 (31%)	3 (18%)		
10	IC3			7 (50%)	7 (56%)	6 (43%)	7 (50%)	6 (44%)
Perimeter (m)	IC4				4 (14%)	10 (39%)	9 (36%)	7 (26%)
1,200	IC5						Br (13%)	Br (31%)
	IC6							
	Total*	**13 (100%)**	**13 (100%)**	**14 (100%)**	**15 (100%)**	**19 (100%)**	*16 (87%)*	*13 (69%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.12 CL-215, S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

		Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	5 (100%)	3 (55%)	2 (25%)				
	IC3		8 (45%)	8 (47%)	8 (47%)	6 (38%)	6 (28%)	2 (14%)
	IC4			12 (29%)	12 (30%)	9 (21%)	9 (19%)	9 (23%)
	IC5				16 (23%)	24 (41%)	32 (53%)	20 (31%)
	IC6							NA (31%)
	Total*	**5 (100%)**	**11 (100%)**	**22 (100%)**	**36 (100%)**	**39 (100%)**	**47 (100%)**	*31 (69%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	12 (100%)	7 (55%)	3 (25%)				
	IC3		9 (45%)	9 (47%)	9 (47%)	7 (38%)	5 (28%)	3 (14%)
	IC4			8 (29%)	9 (30%)	6 (21%)	6 (19%)	7 (23%)
	IC5				8 (23%)	14 (41%)	17 (53%)	11 (31%)
	IC6							NA (31%)
	Total*	**12 (100%)**	**16 (100%)**	**20 (100%)**	**26 (100%)**	**27 (100%)**	**28 (100%)**	*21 (69%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	16 (100%)	9 (55%)	4 (25%)				
	IC3		12 (45%)	12 (47%)	12 (47%)	10 (38%)	7 (28%)	4 (14%)
	IC4			11 (29%)	12 (30%)	9 (21%)	8 (19%)	9 (23%)
	IC5				11 (23%)	19 (41%)	24 (53%)	14 (31%)
	IC6							NA (31%)
	Total*	**16 (100%)**	**21 (100%)**	**27 (100%)**	**35 (100%)**	**38 (100%)**	**39 (100%)**	*27 (69%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.13 AT-802F, C-2 Full Canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	6 (100%)	4 (66%)	3 (52%)	3 (43%)	2 (24%)		
	IC3		3 (34%)	5 (48%)	6 (57%)	4 (38%)	4 (36%)	3 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**6 (100%)**	**7 (100%)**	**8 (100%)**	**9 (100%)**	*6 (61%)*	*4 (36%)*	*3 (25%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	13 (100%)	9 (66%)	7 (52%)	6 (43%)	3 (24%)		
	IC3		7 (34%)	10 (48%)	12 (57%)	8 (38%)	8 (36%)	6 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**13 (100%)**	**16 (100%)**	**17 (100%)**	**18 (100%)**	*11 (61%)*	*8 (36%)*	*6 (25%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	18 (100%)	12 (66%)	10 (52%)	8 (43%)	5 (24%)		
	IC3		10 (34%)	14 (48%)	16 (57%)	11 (38%)	11 (36%)	8 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**18 (100%)**	**22 (100%)**	**24 (100%)**	**24 (100%)**	*16 (61%)*	*11 (36%)*	*8 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.14 AT-802F, C-2 SPARSE CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

		Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	5 (100%)	4 (66%)	3 (52%)	3 (43%)	2 (24%)		
	IC3		3 (34%)	4 (48%)	4 (57%)	3 (38%)	3 (36%)	2 (25%)
	IC4					12 (39%)	6 (18%)	6 (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**5 (100%)**	**7 (100%)**	**7 (100%)**	**7 (100%)**	**17 (100%)**	*9 (55%)*	*8 (41%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	12 (100%)	8 (66%)	6 (52%)	5 (43%)	3 (24%)		
	IC3		5 (34%)	8 (48%)	9 (57%)	6 (38%)	6 (36%)	4 (25%)
	IC4					13 (39%)	6 (18%)	5 (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**12 (100%)**	**13 (100%)**	**14 (100%)**	**14 (100%)**	**22 (100%)**	*12 (55%)*	*9 (41%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	16 (100%)	11 (66%)	8 (52%)	7 (43%)	4 (24%)		
	IC3		7 (34%)	10 (48%)	12 (57%)	8 (38%)	8 (36%)	6 (25%)
	IC4					18 (39%)	9 (18%)	7 (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**16 (100%)**	**18 (100%)**	**18 (100%)**	**19 (100%)**	**30 (100%)**	*17 (55%)*	*13 (41%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.15 AT-802F, C-3 Full canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
	IC1	0 (4%)						
Area (ha)	IC2	6 (96%)	2 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
1	IC3		7 (70%)	4 (37%)	3 (26%)	2 (23%)	2 (17%)	2 (15%)
Perimeter (m)	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
400	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**6 (100%)**	**9 (100%)**	*5 (52%)*	*4 (38%)*	*3 (32%)*	*3 (24%)*	*3 (21%)*
	IC1	1 (4%)						
Area (ha)	IC2	13 (96%)	4 (30%)	2 (15%)	2 (11%)	2 (9%)	1 (7%)	1 (6%)
5	IC3		15 (70%)	8 (37%)	6 (26%)	5 (23%)	4 (17%)	3 (15%)
Perimeter (m)	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
900	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**14 (100%)**	**19 (100%)**	*10 (52%)*	*8 (38%)*	*7 (32%)*	*5 (24%)*	*4 (21%)*
	IC1	1 (4%)						
Area (ha)	IC2	17 (96%)	6 (30%)	3 (15%)	2 (11%)	2 (9%)	2 (7%)	1 (6%)
10	IC3		20 (70%)	11 (37%)	8 (26%)	7 (23%)	5 (17%)	5 (15%)
Perimeter (m)	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
1,200	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**18 (100%)**	**26 (100%)**	*14 (52%)*	*10 (38%)*	*9 (32%)*	*7 (24%)*	*6 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.16 AT-802F, C-3 Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	0 (4%)						
	IC2	5 (96%)	2 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		5 (70%)	3 (37%)	2 (26%)	2 (23%)	1 (17%)	1 (15%)
	IC4			14 (48%)	14 (43%)	8 (24%)	6 (17%)	4 (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**5 (100%)**	**7 (100%)**	**18 (100%)**	*17 (81%)*	*11 (56%)*	*8 (41%)*	*6 (35%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	11 (96%)	4 (30%)	2 (15%)	2 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		11 (70%)	6 (37%)	4 (26%)	4 (23%)	3 (17%)	3 (15%)
	IC4			16 (48%)	15 (43%)	8 (24%)	6 (17%)	5 (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**12 (100%)**	**15 (100%)**	**24 (100%)**	*21 (81%)*	*13 (56%)*	*10 (41%)*	*9 (35%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	15 (96%)	5 (30%)	3 (15%)	2 (11%)	2 (9%)	1 (7%)	1 (6%)
	IC3		15 (70%)	8 (37%)	6 (26%)	5 (23%)	4 (17%)	3 (15%)
	IC4			22 (48%)	20 (43%)	11 (24%)	8 (17%)	7 (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**16 (100%)**	**20 (100%)**	**33 (100%)**	*28 (81%)*	*18 (56%)*	*13 (41%)*	*11 (35%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.17 AT-802F, O-1A

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW/m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	5 (100%)	5 (100%)	3 (50%)	2 (31%)	1 (18%)		
	IC3			3 (50%)	3 (56%)	2 (43%)	3 (50%)	2 (44%)
	IC4				4 (14%)	8 (39%)	8 (36%)	6 (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**5 (100%)**	**5 (100%)**	**6 (100%)**	**9 (100%)**	**11 (100%)**	*11 (87%)*	*8 (69%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	10 (100%)	10 (100%)	5 (50%)	3 (31%)	2 (18%)		
	IC3			5 (50%)	6 (56%)	5 (43%)	5 (50%)	5 (44%)
	IC4				3 (14%)	8 (39%)	8 (36%)	6 (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**10 (100%)**	**10 (100%)**	**10 (100%)**	**12 (100%)**	**15 (100%)**	*13 (87%)*	*11 (69%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	14 (100%)	14 (100%)	7 (50%)	5 (31%)	3 (18%)		
	IC3			7 (50%)	8 (56%)	6 (43%)	7 (50%)	6 (44%)
	IC4				4 (14%)	11 (39%)	11 (36%)	8 (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**14 (100%)**	**14 (100%)**	**14 (100%)**	**17 (100%)**	**20 (100%)**	*18 (87%)*	*14 (69%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.18 AT-802F, S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	6 (100%)	3 (55%)	2 (25%)				
	IC3		8 (45%)	10 (47%)	10 (47%)	8 (38%)	6 (28%)	4 (14%)
	IC4			18 (29%)	18 (30%)	12 (21%)	12 (19%)	15 (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**6 (100%)**	**11 (100%)**	**30 (100%)**	*28 (77%)*	*20 (59%)*	*18 (47%)*	*19 (38%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	12 (100%)	7 (55%)	3 (25%)				
	IC3		10 (45%)	10 (47%)	10 (47%)	8 (38%)	6 (28%)	3 (14%)
	IC4			13 (29%)	13 (30%)	9 (21%)	9 (19%)	10 (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**12 (100%)**	**17 (100%)**	**26 (100%)**	*23 (77%)*	*17 (59%)*	*15 (47%)*	*13 (38%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	16 (100%)	9 (55%)	4 (25%)				
	IC3		13 (45%)	14 (47%)	14 (47%)	11 (38%)	8 (28%)	4 (14%)
	IC4			17 (29%)	18 (30%)	13 (21%)	12 (19%)	14 (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**16 (100%)**	**22 (100%)**	**35 (100%)**	*32 (77%)*	*24 (59%)*	*20 (47%)*	*18 (38%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.19 DHC-6 Twin Otter, C-2 Full canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	10 (100%)	7 (66%)	5 (52%)	5 (43%)	3 (24%)		
	IC3		8 (34%)	12 (48%)	14 (57%)	9 (38%)	9 (36%)	6 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**10 (100%)**	**15 (100%)**	**17 (100%)**	**19 (100%)**	*12 (61%)*	*9 (36%)*	*6 (25%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	22 (100%)	15 (66%)	11 (52%)	10 (43%)	5 (24%)		
	IC3		18 (34%)	26 (48%)	31 (57%)	20 (38%)	20 (36%)	14 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**22 (100%)**	**33 (100%)**	**37 (100%)**	**41 (100%)**	*25 (61%)*	*20 (36%)*	*14 (25%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	30 (100%)	20 (66%)	16 (52%)	13 (43%)	7 (24%)		
	IC3		25 (34%)	36 (48%)	42 (57%)	28 (38%)	27 (36%)	19 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**30 (100%)**	**45 (100%)**	**52 (100%)**	**55 (100%)**	*35 (61%)*	*27 (36%)*	*19 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.20 DHC-6 Twin Otter, C-2 Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

		Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	8 (100%)	6 (66%)	4 (52%)	4 (43%)	2 (24%)		
	IC3		5 (34%)	6 (48%)	7 (57%)	5 (38%)	5 (36%)	3 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**8 (100%)**	**11 (100%)**	**10 (100%)**	**11 (100%)**	*7 (61%)*	*5 (36%)*	*3 (25%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	18 (100%)	12 (66%)	10 (52%)	8 (43%)	4 (24%)		
	IC3		10 (34%)	14 (48%)	16 (57%)	11 (38%)	10 (36%)	7 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**18 (100%)**	**22 (100%)**	**24 (100%)**	**24 (100%)**	*15 (61%)*	*10 (36%)*	*7 (25%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	25 (100%)	16 (66%)	13 (52%)	11 (43%)	6 (24%)		
	IC3		13 (34%)	19 (48%)	22 (57%)	15 (38%)	14 (36%)	10 (25%)
	IC4					Br (39%)	Br (18%)	Br (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**25 (100%)**	**29 (100%)**	**32 (100%)**	**33 (100%)**	*21 (61%)*	*14 (36%)*	*10 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.21 DHC-6 Twin Otter, C-3 Full canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	1 (4%)						
	IC2	10 (96%)	3 (30%)	2 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		34 (70%)	18 (37%)	14 (26%)	12 (23%)	8 (17%)	8 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**11 (100%)**	**37 (100%)**	*20 (52%)*	*15 (38%)*	*13 (32%)*	*9 (24%)*	*9 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	21 (96%)	7 (30%)	3 (15%)	3 (11%)	2 (9%)	2 (7%)	2 (6%)
	IC3		38 (70%)	20 (37%)	14 (26%)	12 (23%)	9 (17%)	8 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**22 (100%)**	**45 (100%)**	*23 (52%)*	*17 (38%)*	*14 (32%)*	*11 (24%)*	*10 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	29 (96%)	9 (30%)	5 (15%)	4 (11%)	3 (9%)	3 (7%)	2 (6%)
	IC3		52 (70%)	28 (37%)	20 (26%)	17 (23%)	13 (17%)	11 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**30 (100%)**	**61 (100%)**	*33 (52%)*	*24 (38%)*	*20 (32%)*	*16 (24%)*	*13 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.22 DHC-6 Twin Otter, C-3 Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	1 (4%)						
	IC2	8 (96%)	3 (30%)	1 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		18 (70%)	10 (37%)	8 (26%)	6 (23%)	4 (17%)	4 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**9 (100%)**	**21 (100%)**	*11 (52%)*	*9 (38%)*	*7 (32%)*	*5 (24%)*	*5 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	17 (96%)	6 (30%)	3 (15%)	2 (11%)	2 (9%)	2 (7%)	1 (6%)
	IC3		20 (70%)	11 (37%)	8 (26%)	7 (23%)	5 (17%)	4 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**18 (100%)**	**26 (100%)**	*14 (52%)*	*10 (38%)*	*9 (32%)*	*7 (24%)*	*5 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	24 (96%)	8 (30%)	4 (15%)	3 (11%)	3 (9%)	2 (7%)	2 (6%)
	IC3		27 (70%)	14 (37%)	10 (26%)	9 (23%)	7 (17%)	6 (15%)
	IC4			Br (48%)	Br (43%)	Br (24%)	Br (17%)	Br (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**25 (100%)**	**35 (100%)**	*18 (52%)*	*13 (38%)*	*12 (32%)*	*9 (24%)*	*8 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.23 DHC-6 Twin Otter, O-1A

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW/m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	7 (100%)	7 (100%)	4 (50%)	2 (31%)	2 (18%)		
	IC3			4 (50%)	4 (56%)	3 (43%)	4 (50%)	3 (44%)
	IC4				Br (14%)	Br (39%)	Br (36%)	Br (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**7 (100%)**	**7 (100%)**	**8 (100%)**	*6 (86%)*	*5 (61%)*	*4 (50%)*	*3 (44%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	15 (100%)	15 (100%)	8 (50%)	5 (31%)	3 (18%)		
	IC3			8 (50%)	9 (56%)	7 (43%)	8 (50%)	7 (44%)
	IC4				Br (14%)	Br (39%)	Br (36%)	Br (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**15 (100%)**	**15 (100%)**	**16 (100%)**	*14 (86%)*	*10 (61%)*	*8 (50%)*	*7 (44%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	21 (100%)	21 (100%)	11 (50%)	7 (31%)	4 (18%)		
	IC3			11 (50%)	12 (56%)	9 (43%)	11 (50%)	9 (44%)
	IC4				Br (14%)	Br (39%)	Br (36%)	Br (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**21 (100%)**	**21 (100%)**	**22 (100%)**	19 (86%)	13 (61%)	11 (50%)	9 (44%)

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.24 DHC-6 Twin Otter, S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	18 (100%)	10 (55%)	4 (25%)				
	IC3		33 (45%)	33 (47%)	36 (47%)	27 (38%)	21 (28%)	12 (14%)
	IC4			Br (29%)	Br (30%)	Br (21%)	Br (19%)	Br (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**18 (100%)**	**43 (100%)**	*37 (71%)*	*36 (47%)*	*27 (38%)*	*21 (28%)*	*12 (14%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	19 (100%)	11 (55%)	5 (25%)				
	IC3		24 (45%)	25 (47%)	25 (47%)	21 (38%)	15 (28%)	8 (14%)
	IC4			Br (29%)	Br (30%)	Br (21%)	Br (19%)	Br (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**19 (100%)**	**35 (100%)**	*30 (71%)*	*25 (47%)*	*21 (38%)*	*15 (28%)*	*8 (14%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	26 (100%)	14 (55%)	7 (25%)				
	IC3		34 (45%)	35 (47%)	35 (47%)	29 (38%)	21 (28%)	11 (14%)
	IC4			Br (29%)	Br (30%)	Br (21%)	Br (19%)	Br (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**26 (100%)**	**48 (100%)**	*42 (71%)*	*35 (47%)*	*29 (38%)*	*21 (28%)*	*11 (14%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.25 Bell 212 – Belly tank (fast), C-2 Full canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	10 (100%)	7 (66%)	5 (52%)	4 (43%)	3 (24%)		
	IC3		4 (34%)	5 (48%)	6 (57%)	4 (38%)	4 (36%)	3 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**10 (100%)**	**11 (100%)**	**10 (100%)**	**10 (100%)**	*7 (61%)*	*4 (36%)*	*3 (25%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	22 (100%)	14 (66%)	11 (52%)	9 (43%)	5 (24%)		
	IC3		8 (34%)	11 (48%)	13 (57%)	9 (38%)	8 (36%)	6 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**22 (100%)**	**22 (100%)**	**22 (100%)**	**22 (100%)**	*14 (61%)*	*8 (36%)*	*6 (25%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	30 (100%)	20 (66%)	15 (52%)	13 (43%)	7 (24%)		
	IC3		11 (34%)	15 (48%)	18 (57%)	12 (38%)	12 (36%)	8 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**30 (100%)**	**31 (100%)**	**30 (100%)**	**31 (100%)**	*19 (61%)*	*12 (36%)*	*8 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.26 Bell 212 – Belly tank (fast), C-2 Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW/m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	9 (100%)	6 (66%)	5 (52%)	4 (43%)	2 (24%)		
	IC3		4 (34%)	5 (48%)	6 (57%)	4 (38%)	4 (36%)	3 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**9 (100%)**	**10 (100%)**	**10 (100%)**	**10 (100%)**	*6 (61%)*	*4 (36%)*	*3 (25%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	20 (100%)	13 (66%)	11 (52%)	9 (43%)	5 (24%)		
	IC3		8 (34%)	11 (48%)	13 (57%)	8 (38%)	8 (36%)	6 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**20 (100%)**	**21 (100%)**	**22 (100%)**	**22 (100%)**	*13 (61%)*	*8 (36%)*	*6 (25%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	28 (100%)	18 (66%)	14 (52%)	12 (43%)	7 (24%)		
	IC3		10 (34%)	15 (48%)	17 (57%)	11 (38%)	11 (36%)	8 (25%)
	IC4					NA (39%)	NA (18%)	NA (15%)
	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**28 (100%)**	**28 (100%)**	**29 (100%)**	**29 (100%)**	*18 (61%)*	*11 (36%)*	*8 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.27 BELL 212 – BELLY TANK (FAST), C-3 FULL CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
Head Fire Intensity kW /m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**

		Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Area (ha) 1 Perimeter (m) 400	IC1	1 (4%)						
	IC2	9 (96%)	3 (30%)	2 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		7 (70%)	4 (37%)	3 (26%)	3 (23%)	2 (17%)	2 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**10 (100%)**	**10 (100%)**	*6 (52%)*	*4 (38%)*	*4 (32%)*	*3 (24%)*	*3 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	21 (96%)	7 (30%)	3 (15%)	3 (11%)	2 (9%)	2 (7%)	2 (6%)
	IC3		16 (70%)	9 (37%)	6 (26%)	5 (23%)	4 (17%)	4 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**22 (100%)**	**23 (100%)**	*12 (52%)*	*9 (38%)*	*7 (32%)*	*6 (24%)*	*6 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	28 (96%)	9 (30%)	5 (15%)	4 (11%)	3 (9%)	3 (7%)	2 (6%)
	IC3		22 (70%)	12 (37%)	8 (26%)	7 (23%)	5 (17%)	5 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**29 (100%)**	**31 (100%)**	*17 (52%)*	*12 (38%)*	*10 (32%)*	*8 (24%)*	*7 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.28 BELL 212 – BELLY TANK (FAST), C-3 SPARSE CANOPY

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	1 (4%)						
	IC2	9 (96%)	3 (30%)	2 (15%)	1 (11%)	1 (9%)	1 (7%)	1 (6%)
	IC3		7 (70%)	4 (37%)	3 (26%)	3 (23%)	2 (17%)	2 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**10 (100%)**	**10 (100%)**	*6 (52%)*	*4 (38%)*	*4 (32%)*	*3 (24%)*	*3 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	1 (4%)						
	IC2	19 (96%)	6 (30%)	3 (15%)	3 (11%)	2 (9%)	2 (7%)	2 (6%)
	IC3		15 (70%)	8 (37%)	6 (26%)	5 (23%)	4 (17%)	3 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**20 (100%)**	**21 (100%)**	*11 (52%)*	*9 (38%)*	*7 (32%)*	*6 (24%)*	*5 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	1 (4%)						
	IC2	27 (96%)	8 (30%)	4 (15%)	3 (11%)	3 (9%)	2 (7%)	2 (6%)
	IC3		21 (70%)	11 (37%)	8 (26%)	7 (23%)	5 (17%)	5 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**28 (100%)**	**29 (100%)**	*15 (52%)*	*11 (38%)*	*10 (32%)*	*7 (24%)*	*7 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.29 Bell 212 – Belly tank (fast), O-1a

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW /m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	9 (100%)	9 (100%)	4 (50%)	3 (31%)	2 (18%)		
	IC3			4 (50%)	5 (56%)	4 (43%)	4 (50%)	4 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**9 (100%)**	**9 (100%)**	**8 (100%)**	*8 (86%)*	*6 (61%)*	*4 (50%)*	*4 (44%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	19 (100%)	19 (100%)	10 (50%)	6 (31%)	4 (18%)		
	IC3			10 (50%)	11 (56%)	8 (43%)	10 (50%)	8 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**19 (100%)**	**19 (100%)**	**20 (100%)**	*17 (86%)*	*12 (61%)*	*10 (50%)*	*8 (44%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	26 (100%)	26 (100%)	13 (50%)	8 (31%)	5 (18%)		
	IC3			13 (50%)	15 (56%)	11 (43%)	13 (50%)	11 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**26 (100%)**	**26 (100%)**	**26 (100%)**	*23 (86%)*	*16 (61%)*	*13 (50%)*	*11 (44%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.30 Bell 212 – Belly tank (fast), S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	10 (100%)	5 (55%)	3 (25%)				
	IC3		5 (45%)	5 (47%)	5 (47%)	4 (38%)	3 (28%)	2 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**10 (100%)**	**10 (100%)**	*8 (71%)*	*5 (47%)*	*4 (38%)*	*3 (28%)*	*2 (14%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	21 (100%)	12 (55%)	5 (25%)				
	IC3		10 (45%)	11 (47%)	11 (47%)	9 (38%)	7 (28%)	4 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**21 (100%)**	**22 (100%)**	*16 (71%)*	*11 (47%)*	*9 (38%)*	*7 (28%)*	*4 (14%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	29 (100%)	16 (55%)	7 (25%)				
	IC3		14 (45%)	15 (47%)	15 (47%)	12 (38%)	9 (28%)	5 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**29 (100%)**	**30 (100%)**	*22 (71%)*	*15 (47%)*	*12 (38%)*	*9 (28%)*	*5 (14%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.31 Bell 212 – Belly tank (slow), C-2 Full/Sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
	Head Fire Intensity kW /m (Class)	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
	IC1							
Area (ha)	IC2	19 (100%)	12 (66%)	10 (52%)	8 (43%)	5 (24%)		
1	IC3		7 (34%)	9 (48%)	11 (57%)	7 (38%)	7 (36%)	5 (25%)
Perimeter (m)	IC4					NA (39%)	NA (18%)	NA (15%)
400	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**19 (100%)**	**19 (100%)**	**19 (100%)**	**19 (100%)**	*12 (61%)*	*7 (36%)*	*5 (25%)*
	IC1							
Area (ha)	IC2	41 (100%)	27 (66%)	21 (52%)	18 (43%)	10 (24%)		
5	IC3		14 (34%)	20 (48%)	23 (57%)	16 (38%)	15 (36%)	11 (25%)
Perimeter (m)	IC4					NA (39%)	NA (18%)	NA (15%)
900	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**41 (100%)**	**41 (100%)**	**41 (100%)**	**41 (100%)**	*26 (61%)*	*15 (36%)*	*11 (25%)*
	IC1							
Area (ha)	IC2	56 (100%)	37 (66%)	29 (52%)	25 (43%)	14 (24%)		
10	IC3		19 (34%)	27 (48%)	32 (57%)	21 (38%)	21 (36%)	15 (25%)
Perimeter (m)	IC4					NA (39%)	NA (18%)	NA (15%)
1,200	IC5						NA (45%)	NA (32%)
	IC6							NA (27%)
	Total*	**56 (100%)**	**56 (100%)**	**56 (100%)**	57 (100%)	*35 (61%)*	*21 (36%)*	*15 (25%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone)
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.32 Bell 212 – Belly tank (slow), C-3 Full/sparse canopy

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
	ROS m/min (CFB)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1	1 (4%)						
	IC2	18 (96%)	6 (30%)	3 (15%)	2 (11%)	2 (9%)	2 (7%)	1 (6%)
	IC3		13 (70%)	7 (37%)	5 (26%)	4 (23%)	3 (17%)	3 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**19 (100%)**	**19 (100%)**	*10 (52%)*	*7 (38%)*	*6 (32%)*	*5 (24%)*	*4 (21%)*
Area (ha) 5 Perimeter (m) 900	IC1	2 (4%)						
	IC2	39 (96%)	12 (30%)	6 (15%)	5 (11%)	4 (9%)	3 (7%)	3 (6%)
	IC3		29 (70%)	15 (37%)	11 (26%)	9 (23%)	7 (17%)	6 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**41 (100%)**	**41 (100%)**	*21 (52%)*	*16 (38%)*	*13 (32%)*	*10 (24%)*	*9 (21%)*
Area (ha) 10 Perimeter (m) 1,200	IC1	3 (4%)						
	IC2	54 (96%)	17 (30%)	9 (15%)	7 (11%)	5 (9%)	4 (7%)	4 (6%)
	IC3		40 (70%)	21 (37%)	15 (26%)	13 (23%)	10 (17%)	9 (15%)
	IC4			NA (48%)	NA (43%)	NA (24%)	NA (17%)	NA (14%)
	IC5				NA (19%)	NA (44%)	NA (31%)	NA (22%)
	IC6						NA (28%)	NA (43%)
	Total*	**57 (100%)**	**57 (100%)**	*30 (52%)*	*22 (38%)*	*18 (32%)*	*14 (24%)*	*13 (21%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone)
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.33 Bell 212 – Belly tank (slow), O-1a

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
	ROS m/min (CFB)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
	Head Fire Intensity kW/m (Class)	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	19 (100%)	19 (100%)	9 (50%)	6 (31%)	4 (18%)		
	IC3			9 (50%)	10 (56%)	8 (43%)	9 (50%)	8 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**19 (100%)**	**19 (100%)**	**18 (100%)**	*16 (86%)*	*12 (61%)*	*9 (50%)*	*8 (44%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	41 (100%)	41 (100%)	21 (50%)	13 (31%)	8 (18%)		
	IC3			21 (50%)	23 (56%)	18 (43%)	21 (50%)	18 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**41 (100%)**	**41 (100%)**	**42 (100%)**	*36 (86%)*	*26 (61%)*	*21 (50%)*	*18 (44%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	56 (100%)	56 (100%)	28 (50%)	17 (31%)	10 (18%)		
	IC3			28 (50%)	31 (56%)	25 (43%)	28 (50%)	25 (44%)
	IC4				NA (14%)	NA (39%)	NA (36%)	NA (26%)
	IC5						NA (13%)	NA (31%)
	IC6							
	Total*	**56 (100%)**	**56 (100%)**	**56 (100%)**	*48 (86%)*	*35 (61%)*	*28 (50%)*	*25 (44%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.

NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).

* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A10.34 Bell 212 – Belly tank (slow), S-1

Minimum number of drops to contain perimeter around an ellipse shaped fire (% of perimeter at the intensity class)

	Fire Type	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
	ROS m/min (CFB)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
	Head Fire Intensity kW/m (Class)	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
Area (ha) 1 Perimeter (m) 400	IC1							
	IC2	19 (100%)	10 (55%)	5 (25%)				
	IC3		9 (45%)	9 (47%)	9 (47%)	7 (38%)	5 (28%)	3 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**19 (100%)**	**19 (100%)**	*14 (71%)*	*9 (47%)*	*7 (38%)*	*5 (28%)*	*3 (14%)*
Area (ha) 5 Perimeter (m) 900	IC1							
	IC2	41 (100%)	23 (55%)	10 (25%)				
	IC3		19 (45%)	19 (47%)	19 (47%)	16 (38%)	12 (28%)	6 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**41 (100%)**	**42 (100%)**	*29 (71%)*	*19 (47%)*	*16 (38%)*	*12 (28%)*	*6 (14%)*
Area (ha) 10 Perimeter (m) 1,200	IC1							
	IC2	56 (100%)	31 (55%)	14 (25%)				
	IC3		26 (45%)	26 (47%)	27 (47%)	22 (38%)	16 (28%)	8 (14%)
	IC4			NA (29%)	NA (30%)	NA (21%)	NA (19%)	NA (23%)
	IC5				NA (23%)	NA (41%)	NA (53%)	NA (31%)
	IC6							NA (31%)
	Total*	**56 (100%)**	**57 (100%)**	*40 (71%)*	*27 (47%)*	*22 (38%)*	*16 (28%)*	*8 (14%)*

Br = Breaching, when the flame front depth is wider than the half the drop width or the flame length is greater than the half of the drop on the unburned fuel.
NA = Does not meet modeled operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone).
* If the percentage in brackets is less than 100% that percentage represents the amount of containable perimeter.

A11 APPENDIX – LINE BUILDING AND HOTSPOTTING CHARTS

A11.1 CL-415, C-2 FULL CANOPY

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	**Smoulder**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
			ROS m/min (CFB)	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
1 (6)	**60**	295,000		8,000	3,000	3,000	3,000	3,000			
2 (3)	**30**	147,000		4,000	2,000	2,000	2,000	2,000			
3 (2)	**20**	98,000		3,000	1,000	1,000	1,000	1,000			
4 (2)	**15**	74,000		2,000	800	800	800	800			
5 (2)	**12**	59,000		2,000	700	700	700	600			
6 (1)	**10**	49,000		1,000	600	600	600	500			
7 (1)	**9**	42,000		1,000	500	500	500	400			
8 (1)	**8**	37,000		900	400	400	400	400			
9 (1)	**7**	33,000		800	400	400	400	300			
10 (1)	**6**	29,000		800	300	300	300	300			
30 (1)	**2**	10,000		300	100	100	100	100			

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.52	0.26	0.26	0.26	0.13	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	90	90	90	70	30	20	0
Effective WIDTH of a single drop (metres)*		50	40	40	40	30	7	5	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.2 CL-415, C-2 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes **(# of airtankers)** *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	**Max. # drops per hour** ⇩	**Max. Vol (litres)** *Adjusted for drift and other losses* ⇩	**Fire Type**	**Smoulder**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
			ROS m/min (CFB) ⇨	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
1 (6)	**60**	295,000		8,000	4,000	4,000	4,000	4,000	1,000		
2 (3)	**30**	147,000		4,000	2,000	2,000	2,000	2,000	700		
3 (2)	**20**	98,000		3,000	1,000	1,000	1,000	1,000	500		
4 (2)	**15**	74,000		2,000	1,000	1,000	1,000	1,000	300		
5 (2)	**12**	59,000		2,000	800	800	800	800	300		
6 (1)	**10**	49,000		1,000	700	700	700	700	200		
7 (1)	**9**	42,000		1,000	600	600	600	600	200		
8 (1)	**8**	37,000		1,000	500	500	500	500	200		
9 (1)	**7**	33,000		900	400	400	400	400	200		
10 (1)	**6**	29,000		800	400	400	400	400	100		
30 (1)	**2**	10,000		300	100	100	100	100	50		

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000- <3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.57	0.34	0.34	0.34	0.21	0.06	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	110	110	110	80	50	20	0
Effective WIDTH of a single drop (metres)*		60	40	40	40	30	20	6	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.3 CL-415, C-3 Full canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	295,000		8,000	6,000	4,000	3,000				
2 (3)	30	147,000		4,000	3,000	2,000	1,000				
3 (2)	20	98,000		3,000	2,000	1,000	1,000				
4 (2)	15	74,000		2,000	2,000	1,000	700				
5 (2)	12	59,000		2,000	1,000	800	600				
6 (1)	10	49,000		1,000	1,000	700	500				
7 (1)	9	42,000		1,000	900	600	400				
8 (1)	8	37,000		900	800	500	400				
9 (1)	7	33,000		800	700	400	300				
10 (1)	6	29,000		800	600	400	300				
30 (1)	2	10,000		300	200	100	100				

Holdable line for at least 1 h. allowing for tagged on “line building”	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	“Area treatable” if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.52	0.52	0.13	0.06	0.01	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	130	70	50	30	20	0	0
Effective WIDTH of a single drop (metres)*		50	50	30	20	7	5	0	0
Number of drops ‘stacked’ for coverage**		1	1	1	1	2	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An ‘effective’ drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire’s high spread rate.

A11.4 CL-415, C-3 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	295,000		8,000	6,000	5,000	4,000	1,000			
2 (3)	30	147,000		4,000	3,000	3,000	2,000	700			
3 (2)	20	98,000		3,000	2,000	2,000	1,000	500			
4 (2)	15	74,000		2,000	2,000	1,000	1,000	300			
5 (2)	12	59,000		2,000	1,000	1,000	800	300			
6 (1)	10	49,000		1,000	1,000	800	700	200			
7 (1)	9	42,000		1,000	900	700	600	200			
8 (1)	8	37,000		1,000	800	600	500	200			
9 (1)	7	33,000		900	700	600	500	200			
10 (1)	6	29,000		800	600	500	400	100			
30 (1)	2	10,000		300	200	200	100	50			

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone)	NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.57	0.57	0.21	0.12	0.06	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	130	80	70	50	20	0	0
Effective WIDTH of a single drop (metres)*		60	60	30	20	20	6	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	2	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.5 CL-415, O-1A

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
1 (6)	60	295,000		8,000	6,000	6,000	6,000	2,000	2,000		
2 (3)	30	147,000		4,000	3,000	3,000	3,000	1,000	1,000		
3 (2)	20	98,000		3,000	2,000	2,000	2,000	700	700		
4 (2)	15	74,000		2,000	2,000	2,000	2,000	500	500		
5 (2)	12	59,000		2,000	1,000	1,000	1,000	400	400		
6 (1)	10	49,000		1,000	1,000	1,000	1,000	300	300		
7 (1)	9	42,000		1,000	900	900	900	300	300		
8 (1)	8	37,000		1,000	800	800	800	200	200		
9 (1)	7	33,000		900	700	700	700	200	200		
10 (1)	6	29,000		800	600	600	600	200	200		
30 (1)	2	10,000		300	200	200	200	70	70		

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) | NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.61	0.61	0.44	0.31	0.13	0.13	0.1	0.06
Effective LENGTH of a single drop (metres)*		130	130	120	100	70	70	50	50
Effective WIDTH of a single drop (metres)*		60	60	50	40	30	30	20	20
Number of drops 'stacked' for coverage**		1	1	1	1	2	2	3	3
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.50**	**0.75**	**1.50**	**1.50**	**2.00**	**2.00**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.6 CL-415, S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	**Smoulder**	**Surface (very low)**	**Surface (low)**	**Surface (low)**	**Surface (mod)**	**Surface (mod)**	**Surface (mod-high)**	**Surface (high)**
			ROS m/min (CFB) ⇨	**0 (0.0)**	**0.1 (0.0)**	**0.5 (0.0)**	**1 (0.0)**	**3 (0.0)**	**4 (0.0)**	**5 (0.0)**	**7 (0.0)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
1 (6)	**60**	295,000		8,000	900	500	500	500			NA
2 (3)	**30**	147,000		4,000	500	300	300	300			NA
3 (2)	**20**	98,000		3,000	300	200	200	200			NA
4 (2)	**15**	74,000		2,000	200	100	100	100			NA
5 (2)	**12**	59,000		2,000	200	100	100	100			NA
6 (1)	**10**	49,000		1,000	200	90	90	90			NA
7 (1)	**9**	42,000		1,000	100	80	70	70			NA
8 (1)	**8**	37,000		1,000	100	70	60	60			NA
9 (1)	**7**	33,000		900	100	60	60	60			NA
10 (1)	**6**	29,000		800	90	50	50	50			NA
30 (1)	**2**	10,000		300	30	20	20	20			NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.61	0.31	0.13	0.06	0.06	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		130	100	70	50	50	30	20	0
Effective WIDTH of a single drop (metres)*		60	40	30	20	20	7	5	0
Number of drops 'stacked' for coverage**		1	1	2	3	3	3	4	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.7 CL-215, C-2 FULL CANOPY

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops) [7]

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB)	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (7)	60	259,000		7,000	2,000	2,000	2,000	2,000	800		
2 (4)	30	130,000		3,000	1,000	1,000	1,000	1,000	400		
3 (3)	20	86,000		2,000	800	800	800	700	300		
4 (2)	15	65,000		2,000	600	600	600	600	200		
5 (2)	12	52,000		1,000	500	500	500	400	200		
6 (2)	10	43,000		1,000	400	400	400	400	100		
7 (1)	9	37,000		900	300	300	300	300	100		
8 (1)	8	32,000		800	300	300	300	300	100		
9 (1)	7	29,000		700	300	300	300	200	90		
10 (1)	6	26,000		700	200	200	200	200	80		
30 (1)	2	9,000		200	80	80	80	70	30		

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.51	0.23	0.23	0.23	0.13	0.04	0.0	0.00
Effective LENGTH of a single drop (metres)*		110	70	70	70	50	30	20	0
Effective WIDTH of a single drop (metres)*		60	40	40	40	30	20	9	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	4	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

[7] **Note:** the CL-215T uses the same drop pattern in this model and therefore there is no difference in effectiveness. However, due to the increase in speed of the CL-215T the minimum number of airtankers required to achieve cycle time given a distance to water of 2.7 NM is fewer.

A11.8 CL-215, C-2 Sparse Canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (7)	60	259,000		7,000	3,000	3,000	3,000	3,000	1,000		
2 (4)	30	130,000		3,000	1,000	1,000	1,000	1,000	600		
3 (3)	20	86,000		2,000	1,000	1,000	1,000	1,000	400		
4 (2)	15	65,000		2,000	700	700	700	700	300		
5 (2)	12	52,000		1,000	600	600	600	600	200		
6 (2)	10	43,000		1,000	500	500	500	500	200		
7 (1)	9	37,000		1,000	400	400	400	400	200		
8 (1)	8	32,000		900	400	400	400	400	100		
9 (1)	7	29,000		800	300	300	300	300	100		
10 (1)	6	26,000		700	300	300	300	300	100		
30 (1)	2	9,000		200	100	100	100	100	40		

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.56	0.31	0.31	0.31	0.20	0.08	0.0	0.00
Effective LENGTH of a single drop (metres)*		120	80	80	80	60	40	20	0
Effective WIDTH of a single drop (metres)*		60	50	50	50	40	30	10	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	4	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.9 CL-215, C-3 Full Canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (7)	60	259,000		7,000	5,000	3,000	900	800			
2 (4)	30	130,000		3,000	3,000	1,000	500	400			
3 (3)	20	86,000		2,000	2,000	1,000	300	300			
4 (2)	15	65,000		2,000	1,000	700	200	200			
5 (2)	12	52,000		1,000	1,000	600	200	200			
6 (2)	10	43,000		1,000	900	500	200	100			
7 (1)	9	37,000		900	800	400	100	100			
8 (1)	8	32,000		800	700	400	100	100			
9 (1)	7	29,000		700	600	300	100	90			
10 (1)	6	26,000		700	500	300	90	80			
30 (1)	2	9,000		200	200	100	30	30			

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.51	0.51	0.13	0.06	0.04	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		110	110	50	30	30	20	0	0
Effective WIDTH of a single drop (metres)*		60	60	30	20	20	9	0	0
Number of drops 'stacked' for coverage**		1	1	1	2	2	4	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.10 CL-215, C-3 Sparse Canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)*	Max. # drops per hour	Max. Vol (litres) *Adjusted for drift and other losses*	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class)	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (7)	60	259,000		7,000	6,000	4,000	1,000	1,000			
2 (4)	30	130,000		3,000	3,000	2,000	700	600			
3 (3)	20	86,000		2,000	2,000	1,000	500	400			
4 (2)	15	65,000		2,000	1,000	900	300	300			
5 (2)	12	52,000		1,000	1,000	700	300	200			
6 (2)	10	43,000		1,000	900	600	200	200			
7 (1)	9	37,000		1,000	800	500	200	200			
8 (1)	8	32,000		900	700	500	200	100			
9 (1)	7	29,000		800	600	400	200	100			
10 (1)	6	26,000		700	600	400	100	100			
30 (1)	2	9,000		200	200	100	50	40			

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.56	0.56	0.20	0.11	0.08	0.03	0.0	0.00
Effective LENGTH of a single drop (metres)*		120	120	60	50	40	20	0	0
Effective WIDTH of a single drop (metres)*		60	60	40	30	30	10	0	0
Number of drops 'stacked' for coverage**		1	1	1	2	2	4	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.11 CL-215, O-1A

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
1 (7)	60	259,000		7,000	5,000	5,000	5,000	1,000	1,000		
2 (4)	30	130,000		4,000	2,000	2,000	2,000	700	700		
3 (3)	20	86,000		2,000	2,000	2,000	2,000	500	500		
4 (2)	15	65,000		2,000	1,000	1,000	1,000	400	400		
5 (2)	12	52,000		1,000	900	900	900	300	300		
6 (2)	10	43,000		1,000	800	800	800	200	200		
7 (1)	9	37,000		1,000	600	600	600	200	200		
8 (1)	8	32,000		900	600	600	600	200	200		
9 (1)	7	29,000		800	500	500	500	200	200		
10 (1)	6	26,000		700	500	500	500	100	100		
30 (1)	2	9,000		200	200	200	200	50	50		

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) | **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.62	0.62	0.40	0.28	0.13	0.13	0.1	0.06
Effective LENGTH of a single drop (metres)*		120	120	100	80	50	50	30	30
Effective WIDTH of a single drop (metres)*		60	60	50	50	30	30	20	20
Number of drops 'stacked' for coverage**		1	1	1	1	2	2	3	3
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.50**	**0.75**	**1.50**	**1.50**	**2.00**	**2.00**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.12 CL-215, S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
1 (7)	60	259,000		7,000	700	400	300	300	200		NA
2 (4)	30	130,000		4,000	300	200	200	200	100		NA
3 (3)	20	86,000		2,000	200	100	100	100	80		NA
4 (2)	15	65,000		2,000	200	100	80	80	60		NA
5 (2)	12	52,000		1,000	100	80	60	60	50		NA
6 (2)	10	43,000		1,000	100	70	50	50	40		NA
7 (1)	9	37,000		1,000	100	60	50	50	30		NA
8 (1)	8	32,000		900	90	50	40	40	30		NA
9 (1)	7	29,000		800	80	40	40	40	30		NA
10 (1)	6	26,000		700	70	40	30	30	20		NA
30 (1)	2	9,000		200	20	10	10	10	10		NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone)	NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.62	0.28	0.13	0.06	0.06	0.04	0.0	0.00
Effective LENGTH of a single drop (metres)*		120	80	50	30	30	30	20	0
Effective WIDTH of a single drop (metres)*		60	50	30	20	20	20	9	0
Number of drops 'stacked' for coverage**		1	1	2	3	3	4	5	-
Is the effective drop wide enough to avoid fireline breaching?* **		**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.13 AT-802F, C-2 FULL CANOPY

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (6)	60	144,000		6,000	2,000	2,000	2,000	2,000	NA	NA	NA
2 (3)	30	72,000		3,000	1,000	1,000	1,000	1,000	NA	NA	NA
3 (2)	20	48,000		2,000	800	800	800	700	NA	NA	NA
4 (2)	15	36,000		1,000	600	600	600	500	NA	NA	NA
5 (2)	12	29,000		1,000	500	500	500	400	NA	NA	NA
6 (1)	10	24,000		1,000	400	400	400	300	NA	NA	NA
7 (1)	9	21,000		800	300	300	300	300	NA	NA	NA
8 (1)	8	18,000		700	300	300	300	200	NA	NA	NA
9 (1)	7	16,000		600	300	300	300	200	NA	NA	NA
10 (1)	6	14,000		600	200	200	200	200	NA	NA	NA
30 (1)	2	5,000		200	80	80	80	70	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.32	0.14	0.14	0.14	0.06	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		100	70	70	70	40	10	5	0
Effective WIDTH of a single drop (metres)*		40	30	30	30	20	4	3	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.14 AT-802F, C-2 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (6)	60	144,000		6,000	3,000	3,000	3,000	3,000	NA	NA	NA
2 (3)	30	72,000		3,000	1,000	1,000	1,000	1,000	NA	NA	NA
3 (2)	20	48,000		2,000	900	900	900	900	NA	NA	NA
4 (2)	15	36,000		2,000	700	700	700	700	NA	NA	NA
5 (2)	12	29,000		1,000	500	500	500	500	NA	NA	NA
6 (1)	10	24,000		1,000	500	500	500	500	NA	NA	NA
7 (1)	9	21,000		900	400	400	400	400	NA	NA	NA
8 (1)	8	18,000		800	300	300	300	300	NA	NA	NA
9 (1)	7	16,000		700	300	300	300	300	NA	NA	NA
10 (1)	6	14,000		600	300	300	300	300	NA	NA	NA
30 (1)	2	5,000		200	90	90	90	90	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.36	0.19	0.19	0.19	0.11	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		100	80	80	80	60	30	7	0
Effective WIDTH of a single drop (metres)*		40	30	30	30	20	10	4	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	2	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.15 AT-802F, C-3 Full Canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	144,000		6,000	5,000	3,000	600		NA	NA	NA
2 (3)	30	72,000		3,000	2,000	1,000	300		NA	NA	NA
3 (2)	20	48,000		2,000	2,000	800	200		NA	NA	NA
4 (2)	15	36,000		1,000	1,000	600	200		NA	NA	NA
5 (2)	12	29,000		1,000	900	500	100		NA	NA	NA
6 (1)	10	24,000		1,000	800	400	100		NA	NA	NA
7 (1)	9	21,000		800	700	400	90		NA	NA	NA
8 (1)	8	18,000		700	600	300	80		NA	NA	NA
9 (1)	7	16,000		600	500	300	70		NA	NA	NA
10 (1)	6	14,000		600	500	300	60		NA	NA	NA
30 (1)	2	5,000		200	200	80	20		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.32	0.32	0.06	0.02	0.00	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		100	100	40	20	10	5	0	0
Effective WIDTH of a single drop (metres)*		40	40	20	10	4	3	0	0
Number of drops 'stacked' for coverage**		1	1	1	2	2	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.16 AT-802F, C-3 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	144,000		6,000	5,000	4,000	1,000	800	NA	NA	NA
2 (3)	30	72,000		3,000	2,000	2,000	600	400	NA	NA	NA
3 (2)	20	48,000		2,000	2,000	1,000	400	300	NA	NA	NA
4 (2)	15	36,000		2,000	1,000	900	300	200	NA	NA	NA
5 (2)	12	29,000		1,000	1,000	700	200	200	NA	NA	NA
6 (1)	10	24,000		1,000	800	600	200	100	NA	NA	NA
7 (1)	9	21,000		900	700	500	200	100	NA	NA	NA
8 (1)	8	18,000		800	600	400	200	100	NA	NA	NA
9 (1)	7	16,000		700	600	400	100	90	NA	NA	NA
10 (1)	6	14,000		600	500	400	100	80	NA	NA	NA
30 (1)	2	5,000		200	200	100	40	30	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.36	0.36	0.11	0.05	0.02	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		100	100	60	40	30	7	0	0
Effective WIDTH of a single drop (metres)*		40	40	20	20	10	4	0	0
Number of drops 'stacked' for coverage**		1	1	1	2	2	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.17 AT-802F, O-1A

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)*	Max. # drops per hour	Max. Vol (litres) *Adjusted for drift and other losses*	Fire Behaviour: Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
			ROS m/min (CFB)	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
			Intensity kW/m (Class)	<10 (IC1)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
1 (6)	60	144,000		7,000	4,000	4,000	4,000	1,000			NA
2 (3)	30	72,000		3,000	2,000	2,000	2,000	600			NA
3 (2)	20	48,000		2,000	1,000	1,000	1,000	400			NA
4 (2)	15	36,000		2,000	1,000	1,000	1,000	300			NA
5 (2)	12	29,000		1,000	900	900	900	300			NA
6 (1)	10	24,000		1,000	700	700	700	200			NA
7 (1)	9	21,000		900	600	600	600	200			NA
8 (1)	8	18,000		800	600	600	600	200			NA
9 (1)	7	16,000		700	500	500	500	100			NA
10 (1)	6	14,000		700	400	400	400	100			NA
30 (1)	2	5,000		200	100	100	100	40			NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.40	0.40	0.25	0.17	0.06	0.06	0.0	0.02
Effective LENGTH of a single drop (metres)*		110	110	90	70	40	40	20	20
Effective WIDTH of a single drop (metres)*		50	50	40	30	20	20	10	10
Number of drops 'stacked' for coverage**		1	1	1	1	2	2	3	3
Is the effective drop wide enough to avoid fireline breaching?***		YES	YES	YES	YES	YES	NO	NO	NO
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		0.25	0.25	0.50	0.75	1.50	1.50	2.00	2.00

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.18 AT-802F, S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	3 (0.0)	4 (0.0)	5 (0.0)	7 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
1 (6)	60	144,000		7,000	700	400	200		NA	NA	NA
2 (3)	30	72,000		3,000	300	200	100		NA	NA	NA
3 (2)	20	48,000		2,000	200	100	70		NA	NA	NA
4 (2)	15	36,000		2,000	200	90	50		NA	NA	NA
5 (2)	12	29,000		1,000	100	70	40		NA	NA	NA
6 (1)	10	24,000		1,000	100	60	40		NA	NA	NA
7 (1)	9	21,000		900	100	50	30		NA	NA	NA
8 (1)	8	18,000		800	80	40	30		NA	NA	NA
9 (1)	7	16,000		700	80	40	20		NA	NA	NA
10 (1)	6	14,000		700	70	40	20		NA	NA	NA
30 (1)	2	5,000		200	20	10	10		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on “line building”	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	“Area treatable” if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.40	0.17	0.06	0.02	0.02	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		110	70	40	20	20	10	5	0
Effective WIDTH of a single drop (metres)*		50	30	20	10	10	4	3	0
Number of drops ‘stacked’ for coverage**		1	1	2	3	3	3	7	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An ‘effective’ drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire’s high spread rate.

A11.19 DHC-6 Twin Otter, C-2 Full canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (6)	60	97,000		4,000	1,000	1,000	1,000	400	NA	NA	NA
2 (3)	30	49,000		2,000	700	700	700	200	NA	NA	NA
3 (2)	20	32,000		1,000	500	500	500	100	NA	NA	NA
4 (2)	15	24,000		1,000	400	400	400	90	NA	NA	NA
5 (2)	12	19,000		800	300	300	300	80	NA	NA	NA
6 (1)	10	16,000		700	200	200	200	60	NA	NA	NA
7 (1)	9	14,000		600	200	200	200	50	NA	NA	NA
8 (1)	8	12,000		500	200	200	200	50	NA	NA	NA
9 (1)	7	11,000		400	200	200	200	40	NA	NA	NA
10 (1)	6	10,000		400	100	100	100	40	NA	NA	NA
30 (1)	2	3,000		100	50	50	50	10	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.17	0.06	0.06	0.06	0.01	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	40	40	40	20	6	0	0
Effective WIDTH of a single drop (metres)*		30	20	20	20	9	1	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	2	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.20 DHC-6 Twin Otter, C-2 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
1 (6)	**60**	97,000		4,000	2,000	2,000	2,000	700	NA	NA	NA
2 (3)	**30**	49,000		2,000	900	900	900	400	NA	NA	NA
3 (2)	**20**	32,000		1,000	600	600	600	200	NA	NA	NA
4 (2)	**15**	24,000		1,000	400	400	400	200	NA	NA	NA
5 (2)	**12**	19,000		800	400	400	400	100	NA	NA	NA
6 (1)	**10**	16,000		700	300	300	300	100	NA	NA	NA
7 (1)	**9**	14,000		600	300	300	300	100	NA	NA	NA
8 (1)	**8**	12,000		500	200	200	200	90	NA	NA	NA
9 (1)	**7**	11,000		500	200	200	200	80	NA	NA	NA
10 (1)	**6**	10,000		400	200	200	200	70	NA	NA	NA
30 (1)	**2**	3,000		100	60	60	60	20	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.20	0.09	0.09	0.09	0.04	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	50	50	50	30	10	3	0
Effective WIDTH of a single drop (metres)*		40	20	20	20	20	5	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	2	3	4	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.21 DHC-6 Twin Otter, C-3 Full canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	97,000		4,000	3,000	500			NA	NA	NA
2 (3)	30	49,000		2,000	2,000	200			NA	NA	NA
3 (2)	20	32,000		1,000	1,000	200			NA	NA	NA
4 (2)	15	24,000		1,000	800	100			NA	NA	NA
5 (2)	12	19,000		800	600	100			NA	NA	NA
6 (1)	10	16,000		700	500	80			NA	NA	NA
7 (1)	9	14,000		600	500	70			NA	NA	NA
8 (1)	8	12,000		500	400	60			NA	NA	NA
9 (1)	7	11,000		400	400	50			NA	NA	NA
10 (1)	6	10,000		400	300	50			NA	NA	NA
30 (1)	2	3,000		100	100	20			NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.17	0.17	0.01	0.00	0.00	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	70	20	7	6	0	0	0
Effective WIDTH of a single drop (metres)*		30	30	9	2	1	0	0	0
Number of drops 'stacked' for coverage**		1	1	2	3	3	-	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.22 DHC-6 Twin Otter, C-3 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	97,000		4,000	3,000	900	400		NA	NA	NA
2 (3)	30	49,000		2,000	2,000	500	200		NA	NA	NA
3 (2)	20	32,000		1,000	1,000	300	100		NA	NA	NA
4 (2)	15	24,000		1,000	800	200	100		NA	NA	NA
5 (2)	12	19,000		800	700	200	80		NA	NA	NA
6 (1)	10	16,000		700	600	200	70		NA	NA	NA
7 (1)	9	14,000		600	500	100	60		NA	NA	NA
8 (1)	8	12,000		500	400	100	50		NA	NA	NA
9 (1)	7	11,000		500	400	100	50		NA	NA	NA
10 (1)	6	10,000		400	300	90	40		NA	NA	NA
30 (1)	2	3,000		100	100	30	10		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.20	0.20	0.04	0.02	0.00	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	70	30	20	10	3	0	0
Effective WIDTH of a single drop (metres)*		40	40	20	9	5	0	0	0
Number of drops 'stacked' for coverage**		1	1	2	3	3	4	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.23 DHC-6 Twin Otter, O-1A

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes **(# of airtankers)** *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour: Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	1 (0.0)	5 (0.0)	10 (0.0)	20 (0.0)	30 (0.0)	40 (0.0)	50 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	100 (IC2)	500 (IC2)	1,000 (IC3)	2,100 (IC4)	3,200 (IC4)	4,200 (IC5)	5,300 (IC5)
1 (6)	60	97,000		4,000	2,000	2,000	1,000				NA
2 (3)	30	49,000		2,000	1,000	1,000	700				NA
3 (2)	20	32,000		1,000	700	700	500				NA
4 (2)	15	24,000		1,000	500	500	400				NA
5 (2)	12	19,000		900	400	400	300				NA
6 (1)	10	16,000		700	300	300	200				NA
7 (1)	9	14,000		600	300	300	200				NA
8 (1)	8	12,000		600	300	300	200				NA
9 (1)	7	11,000		500	200	200	200				NA
10 (1)	6	10,000		400	200	200	100				NA
30 (1)	2	3,000		100	70	70	50				NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.22	0.22	0.13	0.08	0.01	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	70	60	50	20	20	7	7
Effective WIDTH of a single drop (metres)*		40	40	30	20	9	9	2	2
Number of drops 'stacked' for coverage**		1	1	1	2	3	3	4	4
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.50**	**0.75**	**1.50**	**1.50**	**2.00**	**2.00**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.24 DHC-6 Twin Otter, S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type / ROS m/min (CFB) ⇨ / Intensity kW/m (Class) ⇨	Fire Behaviour: Smoulder 0 (0.0) <10 (IC1)	Surface (very low) 0.1 (0.0) 200 (IC2)	Surface (low) 0.5 (0.0) 900 (IC3)	Surface (low) 1 (0.0) 2,600 (IC4)	Surface (mod) 3 (0.0) 4,600 (IC5)	Surface (mod) 4 (0.0) 6,400 (IC5)	Surface (mod-high) 5 (0.0) 9,200 (IC5)	Surface (high) 7 (0.0) 13,000 (IC6)
1 (6)	60	97,000		4,000	200	90			NA	NA	NA
2 (3)	30	49,000		2,000	100	50			NA	NA	NA
3 (2)	20	32,000		1,000	70	30			NA	NA	NA
4 (2)	15	24,000		1,000	50	20			NA	NA	NA
5 (2)	12	19,000		900	40	20			NA	NA	NA
6 (1)	10	16,000		700	40	20			NA	NA	NA
7 (1)	9	14,000		600	30	10			NA	NA	NA
8 (1)	8	12,000		600	30	10			NA	NA	NA
9 (1)	7	11,000		500	20	10			NA	NA	NA
10 (1)	6	10,000		400	20	10			NA	NA	NA
30 (1)	2	3,000		100	10	0			NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.22	0.08	0.01	0.00	0.00	0.00	0.0	0.00
Effective LENGTH of a single drop (metres)*		70	50	20	7	7	6	0	0
Effective WIDTH of a single drop (metres)*		40	20	9	2	2	1	0	0
Number of drops 'stacked' for coverage**		1	2	3	4	4	4	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.25 BELL 212 BELLY TANK (FAST), C-2 FULL CANOPY

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.4 (0.0)	1 (0.0)	1 (0.0)	2 (0.1)	4 (0.5)	9 (0.8)	14 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	300 (IC2)	700 (IC3)	900 (IC3)	1,300 (IC3)	3,200 (IC4)	7,700 (IC5)	12,000 (IC6)
1 (6)	60	67,000		3,000	2,000	2,000	2,000	2,000	NA	NA	NA
2 (3)	30	34,000		2,000	900	900	900	900	NA	NA	NA
3 (2)	20	22,000		1,000	600	600	600	600	NA	NA	NA
4 (2)	15	17,000		800	500	500	500	500	NA	NA	NA
5 (2)	12	13,000		600	400	400	400	400	NA	NA	NA
6 (1)	10	11,000		500	300	300	300	300	NA	NA	NA
7 (1)	9	10,000		400	300	300	300	300	NA	NA	NA
8 (1)	8	8,000		400	200	200	200	200	NA	NA	NA
9 (1)	7	7,000		300	200	200	200	200	NA	NA	NA
10 (1)	6	7,000		300	200	200	200	200	NA	NA	NA
30 (1)	2	2,000		100	60	60	60	60	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.09	0.05	0.05	0.05	0.04	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		50	40	40	40	40	30	30	0
Effective WIDTH of a single drop (metres)*		20	20	20	20	10	8	4	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.26 BELL 212 BELLY TANK (FAST), C-2 SPARSE CANOPY

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (**# of airtankers**) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩		**Max. # drops per hour** ⇩	**Max. Vol (litres)** *Adjusted for drift and other losses* ⇩	**Fire Behaviour** / **Fire Type**	**Smoulder**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
				ROS m/min (CFB) ⇨	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
				Intensity kW/m (Class) ⇨	**<10 (IC1)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
1	**(6)**	**60**	67,000		3,000	2,000	2,000	2,000	2,000	NA	NA	NA
2	**(3)**	**30**	34,000		2,000	1,000	1,000	1,000	1,000	NA	NA	NA
3	**(2)**	**20**	22,000		1,000	700	700	700	700	NA	NA	NA
4	**(2)**	**15**	17,000		800	500	500	500	500	NA	NA	NA
5	**(2)**	**12**	13,000		600	400	400	400	400	NA	NA	NA
6	**(1)**	**10**	11,000		500	300	300	300	300	NA	NA	NA
7	**(1)**	**9**	10,000		500	300	300	300	300	NA	NA	NA
8	**(1)**	**8**	8,000		400	300	300	300	300	NA	NA	NA
9	**(1)**	**7**	7,000		400	200	200	200	200	NA	NA	NA
10	**(1)**	**6**	7,000		300	200	200	200	200	NA	NA	NA
30	**(1)**	**2**	2,000		100	70	70	70	70	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone)	**NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.10	0.06	0.06	0.06	0.05	0.03	0.0	0.00
Effective LENGTH of a single drop (metres)*		50	40	40	40	40	30	30	0
Effective WIDTH of a single drop (metres)*		20	20	20	20	20	10	6	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	3	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.27 Bell 212 Belly Tank (fast), C-3 Full canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes			**Fire Behaviour**								
			Fire Type	**Smoulder**	**Surface (low)**	**Surface (mod)**	**Surface (high)**	**Torching (low)**	**Torching (mod)**	**Torching (high)**	**Crown (mod)**
(# of airtankers) *minimum # to achieve cycle*			**ROS m/min (CFB)** ⇨	**0 (0.0)**	**0.6 (0.0)**	**3 (0.0)**	**7 (0.0)**	**10 (0.1)**	**13 (0.5)**	**17 (0.8)**	**21 (0.9)**
time given a distance to water of 2.7 NM (5KM) ⇩	**Max. # drops per hour** ⇩	**Max. Vol (litres)** *Adjusted for drift and other losses* ⇩	**Intensity kW/m (Class)** ⇨	**<10 (IC1)**	**200 (IC2)**	**1,200 (IC3)**	**2,900 (IC4)**	**4,300 (IC5)**	**7,400 (IC5)**	**12,000 (IC6)**	**15,000 (IC6)**
1 (6)	**60**	67,000		3,000	2,000	2,000	2,000		NA	NA	NA
2 (3)	**30**	34,000		2,000	1,000	1,000	1,000		NA	NA	NA
3 (2)	**20**	22,000		1,000	800	800	700		NA	NA	NA
4 (2)	**15**	17,000		800	600	600	500		NA	NA	NA
5 (2)	**12**	13,000		600	500	500	400		NA	NA	NA
6 (1)	**10**	11,000		500	400	400	300		NA	NA	NA
7 (1)	**9**	10,000		400	400	300	300		NA	NA	NA
8 (1)	**8**	8,000		400	300	300	300		NA	NA	NA
9 (1)	**7**	7,000		300	300	300	200		NA	NA	NA
10 (1)	**6**	7,000		300	200	200	200		NA	NA	NA
30 (1)	**2**	2,000		100	80	80	70		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.09	0.09	0.04	0.03	0.02	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		50	50	40	30	30	30	0	0
Effective WIDTH of a single drop (metres)*		20	20	10	10	8	4	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.28 Bell 212 Belly Tank (fast), C-3 Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)*	Max. # drops per hour	Max. Vol (litres) *Adjusted for drift and other losses*	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB)	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class)	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	67,000		3,000	3,000	2,000	2,000	2,000	NA	NA	NA
2 (3)	30	34,000		2,000	1,000	1,000	1,000	1,000	NA	NA	NA
3 (2)	20	22,000		1,000	900	800	700	700	NA	NA	NA
4 (2)	15	17,000		800	600	600	600	500	NA	NA	NA
5 (2)	12	13,000		600	500	500	400	400	NA	NA	NA
6 (1)	10	11,000		500	400	400	400	300	NA	NA	NA
7 (1)	9	10,000		500	400	300	300	300	NA	NA	NA
8 (1)	8	8,000		400	300	300	300	300	NA	NA	NA
9 (1)	7	7,000		400	300	300	200	200	NA	NA	NA
10 (1)	6	7,000		300	300	200	200	200	NA	NA	NA
30 (1)	2	2,000		100	90	80	70	70	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.10	0.10	0.05	0.04	0.03	0.01	0.0	0.00
Effective LENGTH of a single drop (metres)*		50	50	40	40	30	30	0	0
Effective WIDTH of a single drop (metres)*		20	20	20	10	10	6	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	3	-	-
Is the effective drop wide enough to avoid fireline breaching?***		YES	YES	YES	YES	YES	NO	NO	NO
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		0.25	0.25	0.75	1.00	1.50	2.50	>4	>4

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.29 BELL 212 BELLY TANK (FAST), O-1A

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour. Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes			Fire Behaviour								
			Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (high)	Surface (high)
(# of airtankers) *minimum # to achieve cycle*	**Max. # drops per hour**	**Max. Vol (litres)** *Adjusted for drift and other losses*	**ROS m/min (CFB)** ⇨	**0 (0.0)**	**1 (0.0)**	**5 (0.0)**	**10 (0.0)**	**20 (0.0)**	**30 (0.0)**	**40 (0.0)**	**50 (0.0)**
time given a distance to water of 2.7 NM (5KM) ⇩	⇩	⇩	**Intensity kW/m (Class)** ⇨	**<10 (IC1)**	**200 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
1 (6)	**60**	67,000		3,000	3,000	3,000	3,000				NA
2 (3)	**30**	34,000		2,000	1,000	1,000	1,000				NA
3 (2)	**20**	22,000		1,000	800	800	800				NA
4 (2)	**15**	17,000		800	600	600	600				NA
5 (2)	**12**	13,000		700	500	500	500				NA
6 (1)	**10**	11,000		600	400	400	400				NA
7 (1)	**9**	10,000		500	400	400	400				NA
8 (1)	**8**	8,000		400	300	300	300				NA
9 (1)	**7**	7,000		400	300	300	300				NA
10 (1)	**6**	7,000		300	300	300	300				NA
30 (1)	**2**	2,000		100	80	80	80				NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.11	0.11	0.07	0.06	0.04	0.04	0.0	0.03
Effective LENGTH of a single drop (metres)*		60	60	50	40	40	40	30	30
Effective WIDTH of a single drop (metres)*		30	30	20	20	10	10	10	10
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	2	2
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.50**	**0.75**	**1.50**	**1.50**	**2.00**	**2.00**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).

** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.

*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.30 BELL 212 BELLY TANK (FAST), S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	Smoulder	Surface (very low)	Surface (low)	Surface (low)	Surface (mod)	Surface (mod)	Surface (mod-high)	Surface (high)
			ROS m/min (CFB) ⇨	0 (0.0)	0.1 (0.0)	0.5 (0.0)	1 (0.0)	20 (0.0)	3 (0.0)	5 (0.0)	7 (0.0)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	900 (IC3)	2,600 (IC4)	4,600 (IC5)	6,400 (IC5)	9,200 (IC5)	13,000 (IC6)
1 (6)	60	67,000		3,000	600	600	500	500	NA	NA	NA
2 (3)	30	34,000		2,000	300	300	300	300	NA	NA	NA
3 (2)	20	22,000		1,000	200	200	200	200	NA	NA	NA
4 (2)	15	17,000		800	200	200	100	100	NA	NA	NA
5 (2)	12	13,000		700	100	100	100	100	NA	NA	NA
6 (1)	10	11,000		600	100	100	90	90	NA	NA	NA
7 (1)	9	10,000		500	90	90	80	80	NA	NA	NA
8 (1)	8	8,000		400	80	80	70	70	NA	NA	NA
9 (1)	7	7,000		400	70	70	60	60	NA	NA	NA
10 (1)	6	7,000		300	60	60	50	50	NA	NA	NA
30 (1)	2	2,000		100	20	20	20	20	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.11	0.06	0.04	0.03	0.03	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		60	40	40	30	30	30	30	0
Effective WIDTH of a single drop (metres)*		30	20	10	10	10	8	4	0
Number of drops 'stacked' for coverage**		1	1	1	2	2	3	6	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.31 Bell 212 Belly Tank (slow), C-2 Full/sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩		Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
				ROS m/min (CFB) ⇨	**0 (0.0)**	**0.4 (0.0)**	**1 (0.0)**	**1 (0.0)**	**2 (0.1)**	**4 (0.5)**	**9 (0.8)**	**14 (0.9)**
				Intensity kW/m (Class) ⇨	**<10 (IC1)**	**300 (IC2)**	**700 (IC3)**	**900 (IC3)**	**1,300 (IC3)**	**3,200 (IC4)**	**7,700 (IC5)**	**12,000 (IC6)**
1	**(6)**	**60**	67,000		1,000	1,000	1,000	1,000	1,000	NA	NA	NA
2	**(3)**	**30**	34,000		600	600	600	600	600	NA	NA	NA
3	**(2)**	**20**	22,000		400	400	400	400	400	NA	NA	NA
4	**(2)**	**15**	17,000		300	300	300	300	300	NA	NA	NA
5	**(2)**	**12**	13,000		300	300	300	300	300	NA	NA	NA
6	**(1)**	**10**	11,000		200	200	200	200	200	NA	NA	NA
7	**(1)**	**9**	10,000		200	200	200	200	200	NA	NA	NA
8	**(1)**	**8**	8,000		200	200	200	200	200	NA	NA	NA
9	**(1)**	**7**	7,000		100	100	100	100	100	NA	NA	NA
10	**(1)**	**6**	7,000		100	100	100	100	100	NA	NA	NA
30	**(1)**	**2**	2,000		40	40	40	40	40	NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

		Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
Effective AREA of a single drop (hectares)*		0.02	0.02	0.02	0.02	0.02	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		20	20	20	20	20	20	20	0
Effective WIDTH of a single drop (metres)*		9	9	9	9	9	9	9	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	1	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.50**	**0.50**	**0.50**	**0.75**	**1.50**	**2.50**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.33 Bell 212 Belly Tank (slow), C-3 Full/Sparse canopy

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Type	Smoulder	Surface (low)	Surface (mod)	Surface (high)	Torching (low)	Torching (mod)	Torching (high)	Crown (mod)
			ROS m/min (CFB) ⇨	0 (0.0)	0.6 (0.0)	3 (0.0)	7 (0.0)	10 (0.1)	13 (0.5)	17 (0.8)	21 (0.9)
			Intensity kW/m (Class) ⇨	<10 (IC1)	200 (IC2)	1,200 (IC3)	2,900 (IC4)	4,300 (IC5)	7,400 (IC5)	12,000 (IC6)	15,000 (IC6)
1 (6)	60	67,000		1,000	1,000	1,000	1,000		NA	NA	NA
2 (3)	30	34,000		600	600	600	600		NA	NA	NA
3 (2)	20	22,000		400	400	400	400		NA	NA	NA
4 (2)	15	17,000		300	300	300	300		NA	NA	NA
5 (2)	12	13,000		300	300	300	300		NA	NA	NA
6 (1)	10	11,000		200	200	200	200		NA	NA	NA
7 (1)	9	10,000		200	200	200	200		NA	NA	NA
8 (1)	8	8,000		200	200	200	200		NA	NA	NA
9 (1)	7	7,000		100	100	100	100		NA	NA	NA
10 (1)	6	7,000		100	100	100	100		NA	NA	NA
30 (1)	2	2,000		40	40	40	40		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	<1,000 metres	1,000-<3,000 metres	3,000-5,000 metres	>5,000 metres	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	<0.05 ha	0.05 - 0.5 ha	0.5 – 1 ha	> 1ha

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — NA

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.02	0.02	0.02	0.02	0.02	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		20	20	20	20	20	20	0	0
Effective WIDTH of a single drop (metres)*		9	9	9	9	9	9	0	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	-	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.75**	**1.00**	**1.50**	**2.50**	**>4**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
***It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.34 Bell 212 Belly Tank (slow), O-1a

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes **(# of airtankers)** *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	**Max. # drops per hour** ⇩	**Max. Vol (litres)** *Adjusted for drift and other losses* ⇩	**Fire Behaviour**								
			Fire Type	**Smoulder**	**Surface (very low)**	**Surface (low)**	**Surface (low)**	**Surface (mod)**	**Surface (mod)**	**Surface (high)**	**Surface (high)**
			ROS m/min (CFB) ⇨	**0 (0.0)**	**1 (0.0)**	**5 (0.0)**	**10 (0.0)**	**20 (0.0)**	**30 (0.0)**	**40 (0.0)**	**50 (0.0)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**100 (IC2)**	**500 (IC2)**	**1,000 (IC3)**	**2,100 (IC4)**	**3,200 (IC4)**	**4,200 (IC5)**	**5,300 (IC5)**
1 (6)	**60**	67,000		1,000	1,000	1,000	1,000				NA
2 (3)	**30**	34,000		600	600	600	600				NA
3 (2)	**20**	22,000		400	400	400	400				NA
4 (2)	**15**	17,000		300	300	300	300				NA
5 (2)	**12**	13,000		300	300	300	300				NA
6 (1)	**10**	11,000		200	200	200	200				NA
7 (1)	**9**	10,000		200	200	200	200				NA
8 (1)	**8**	8,000		200	200	200	200				NA
9 (1)	**7**	7,000		100	100	100	100				NA
10 (1)	**6**	7,000		100	100	100	100				NA
30 (1)	**2**	2,000		40	40	40	40				NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.02	0.02	0.02	0.02	0.02	0.02	0.0	0.02
Effective LENGTH of a single drop (metres)*		20	20	20	20	20	20	20	20
Effective WIDTH of a single drop (metres)*		9	9	9	9	9	9	9	9
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	1	1
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.25**	**0.50**	**0.75**	**1.50**	**1.50**	**2.00**	**2.00**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

A11.35 Bell 212 Belly Tank (slow), S-1

Amount of line (metres) given a single drop will reduce combustion zone to smouldering and hold for a least one hour.
Blue-drop is not breached/Red-drop is breached (coloured by cumulative area of the effective portion of the drops)

Time between drops in minutes (# of airtankers) *minimum # to achieve cycle* *time given a distance to water of 2.7 NM (5KM)* ⇩	Max. # drops per hour ⇩	Max. Vol (litres) *Adjusted for drift and other losses* ⇩	Fire Behaviour								
			Fire Type	**Smoulder**	**Surface (very low)**	**Surface (low)**	**Surface (low)**	**Surface (mod)**	**Surface (mod)**	**Surface (mod-high)**	**Surface (high)**
			ROS m/min (CFB) ⇨	**0 (0.0)**	**0.1 (0.0)**	**0.5 (0.0)**	**1 (0.0)**	**3 (0.0)**	**4 (0.0)**	**5 (0.0)**	**7 (0.0)**
			Intensity kW/m (Class) ⇨	**<10 (IC1)**	**200 (IC2)**	**900 (IC3)**	**2,600 (IC4)**	**4,600 (IC5)**	**6,400 (IC5)**	**9,200 (IC5)**	**13,000 (IC6)**
1 (6)	**60**	67,000		1,000	1,000	1,000	1,000		NA	NA	NA
2 (3)	**30**	34,000		600	500	500	500		NA	NA	NA
3 (2)	**20**	22,000		400	400	400	400		NA	NA	NA
4 (2)	**15**	17,000		300	300	300	300		NA	NA	NA
5 (2)	**12**	13,000		300	200	200	200		NA	NA	NA
6 (1)	**10**	11,000		200	200	200	200		NA	NA	NA
7 (1)	**9**	10,000		200	200	200	200		NA	NA	NA
8 (1)	**8**	8,000		200	100	100	100		NA	NA	NA
9 (1)	**7**	7,000		100	100	100	100		NA	NA	NA
10 (1)	**6**	7,000		100	100	100	100		NA	NA	NA
30 (1)	**2**	2,000		40	40	40	40		NA	NA	NA

Holdable line for at least 1 h. allowing for tagged on "line building"	**<1,000 metres**	**1,000-<3,000 metres**	**3,000-5,000 metres**	**>5,000 metres**	"Area treatable" if effective portion of drop perfectly aligned. (note, colour only cells)	**<0.05 ha**	**0.05 - 0.5 ha**	**0.5 – 1 ha**	**> 1ha**

Does not meet model operational suitability (i.e., too hot, or turbulent for aircraft to drop into combustion zone) — **NA**

Dimensions of a single effective drop (without considering aircraft operation suitability constraints)

Effective AREA of a single drop (hectares)*		0.02	0.02	0.02	0.02	0.02	0.02	0.0	0.00
Effective LENGTH of a single drop (metres)*		20	20	20	20	20	20	20	0
Effective WIDTH of a single drop (metres)*		9	9	9	9	9	9	9	0
Number of drops 'stacked' for coverage**		1	1	1	1	1	1	1	-
Is the effective drop wide enough to avoid fireline breaching?***		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**
Minimum depth of water in effective drop* (equivalent to rainfall in mm)		**0.25**	**0.75**	**1.50**	**2.00**	**2.00**	**2.50**	**4.00**	**>4**

*An 'effective' drop is one with enough water to reduce the combustion zone to IC1 (smouldering for some time).
** This is the number of drops which must be stacked on top of each other to equal or surpass the required water depth over the full extent of the drop.
*** It is assumed that for fires of IC3 or above 50% of the width of the drop goes on the combustion zone and 50% goes on the unburned fuels adjacent, wetting those unburned fine fuels and breaching is defined as occurring when the half width of drop is less than the flame length or when the drop cannot cover the full extent of the active fireline in one drop due to the fire's high spread rate.

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