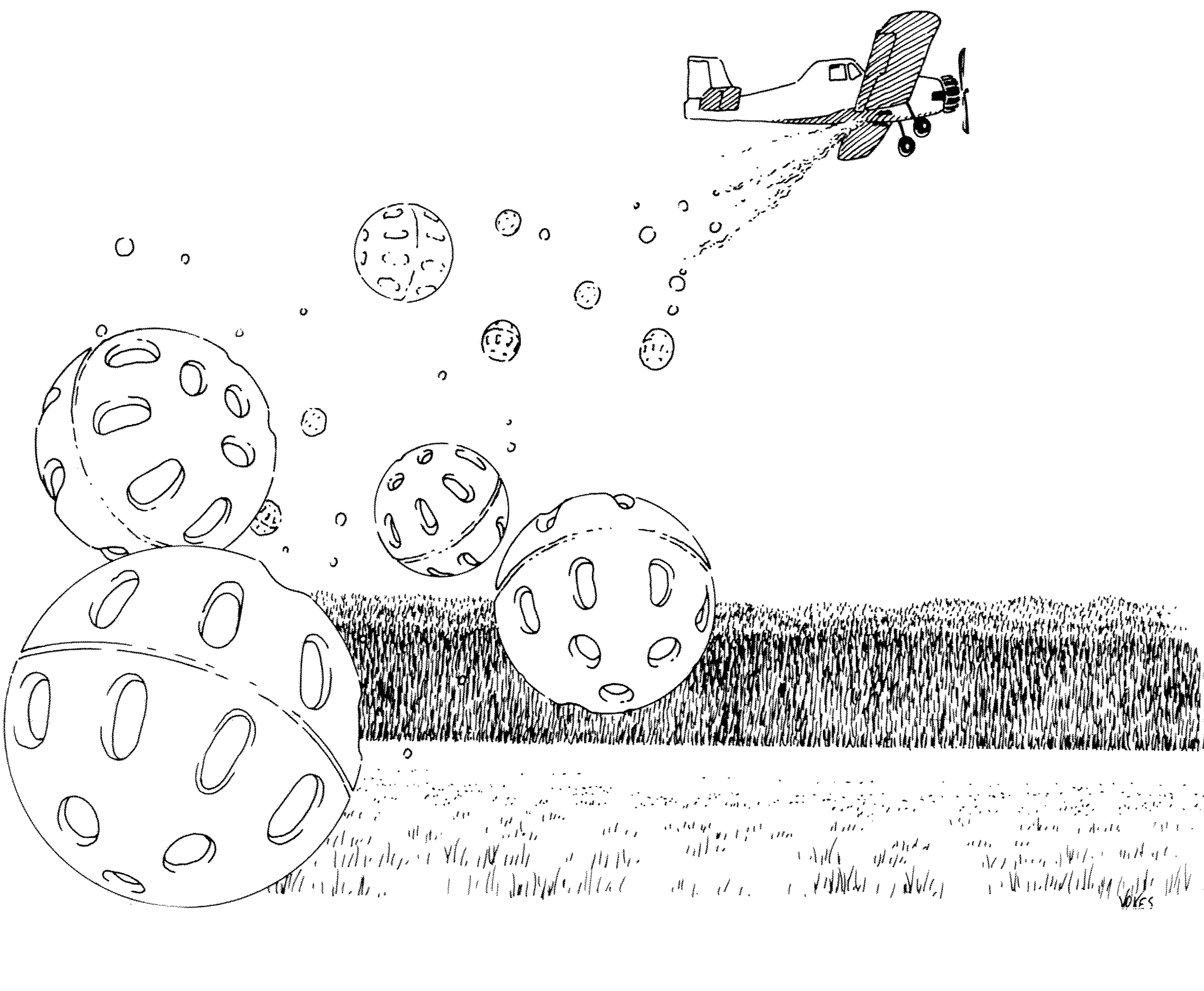
Government of Canada
Gouvernement du Canada

Canadian Forestry Service
Service canadien des forêts

Dromader M-18 Load Transposition

E. Stechishen

Information Report PI-X-64
Petawawa National Forestry Institute



DROMADER M-18 LOAD TRANSPOSITION

Information Report PI-X-64

E. Stechishen

Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
1986

Catalogue No. Fo46-11/64-1986E
ISSN 0706-1854
ISBN 0-662-14749-9

Additional copies of this publication can
be obtained from

Technical Information and Distribution Centre
Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ont.
K0J 1J0

Telephone: 613 589-2880

Cette publication est aussi disponible en français
sous le titre **Transposition du chargement du
Dromader M-18.**

Contents

v Abstract/Résumé

1 Introduction

1 Method

2 Results

2 Discussion

3 Conclusion

Figures

4 1. Tracer-ball distribution at ground level reflecting the load exit sequence for unthinned water.

5 2. Tracer-ball distribution at ground level reflecting the load exit sequence for Poly-Trol 200-thickened water having a viscosity of 460 mPa•s.

6 3. Zone demarkation and density distribution of the floating and weighted tracer-balls for unthickened water drop at ground level.

7 4. Zone demarkation and density distribution of the floating and weighted tracer-balls for Poly-Trol 200-thickened water drop at ground level.

8 5. Contour lines from comparable Poly-Trol 200 drop superimposed on tracer-ball distribution.

9 6. Contour lines from comparable water drop superimposed on tracer-ball distribution.

ABSTRACT

Dromader M-18 air tanker drop tests were carried out to determine fluid discharge characteristics of unthickened and Poly-Trol 200-thickened water. This was accomplished by using coloured tracer balls to identify the bottom and top of the load. The distribution of coloured balls at ground level was compared with contour drop distributions. Deductions concerning changes in the distribution of viscous and non-viscous fluids were based on the rheological properties of unthickened and thickened water.

RÉSUMÉ

Des essais de largage ont été effectués à l'aide d'un avion-citerne Dromader M-18 pour déterminer les caractéristiques de dispersion de l'eau épaissie ou non avec du Poly-Trol 200. Des billes de couleur ont été utilisées pour identifier le dessus et le dessous du chargement. La distribution des billes au sol a été comparée aux lignes de contour de la distribution du chargement. Les déductions concernant les changements dans la distribution des fluides visqueux et non visqueux ont été fondées sur les propriétés rhéologiques de l'eau épaissie et non épaissie.

DROMADER M-18 AIR TANKER LOAD TRANSPOSITION

INTRODUCTION

Several studies have been carried out on air tanker load discharge rates and the relationship of these rates to the resultant distribution of fluid at ground level. Most of the tests were conducted under static conditions i.e. using mock-up tanks or stationary air tankers. The in-flight measurements taken were carried out with float-type mechanisms which only identified the fluid level along a vertical chord at one particular place within the tank. There were no means to measure fluid circulation within the tank while the fluid was exiting. A new approach was required to study fluid flow patterns within the tank following opening of the drop-door.

The Dromader M-18 air tanker specifications state that the entire contents (2497 litres) can leave the hopper in 2¼ seconds through the 40 cm x 104 cm door opening. The gravitational force on the fluid causes it to exit the tank when the door-locking mechanism is unlatched and the mass forces the front-hinged door to drop. The fluid is redirected rearward by the angled door, the inner surface of which acts as a deflector for the fluid and the outer surface as a deflector for the air streaming past the aircraft's fuselage. The hopper is subdivided into compartments by vertical metal anti-slosh baffles with flow-through openings in the baffle walls. This arrangement favours accelerated discharge of the compartment immediately above the door opening relative to the peripheral compartments. A knowledge of the load's exit characteristics was required to facilitate prediction of dispersal characteristics of those suppressants and retardants used for forest fire suppression. Measurements of the load's distribution at ground level were previously determined and documented but the load's movement within the tank during exit and the effect of this circulation on the ground pattern was not known. To identify the load's exit characteristics when viscous and nonviscous fluids were released, drop trials were conducted in 1984 with ordinary water and with Poly-Trol 200-thickened water. The aim was to distinguish fluid lying at the bottom of the hopper from that at the top and to determine their resting places on the ground relative to the balance of the load.

METHOD

The need to identify the fluid at the two extreme levels within the hopper led to the use of 500 floating (specific gravity 0.93) and 500 sinking (specific gravity 1.07) coloured tracer balls. The use of perforated plastic practice golf balls permitted the fluid to enter and exit the balls at will; therefore, the trajectory of the balls was much the same as that of water. The balls were manually loaded into the hopper from the top once the required amount of liquid had been pumped into the tank.

The drops were made over a grassy field at an air speed of 160 km/h and at drop heights of 35 m for water and 38 m for Poly-Trol 200. The drop pattern centreline was established after each drop and the position of each ball was determined by measurement from this reference line. The location of each coloured ball was plotted on graph paper by colour code.

RESULTS

The air tanker made the water drop directly into the wind which, at 5.8 km/h, had sufficient velocity to restrain the water from spreading laterally. The net result was an uniform drop pattern with well defined edges (Figure 1) and no visible separation between balls and water during the load's descent. This was not the case for the Poly-Trol 200 drop which was released under a 3.4 km/h cross-wind. The drop site was unidirectional and the air tanker's flight path could not be altered. Even though this load had a viscosity of 460 mPa.s, wind-drift effect was prominent as evidenced on the lee side of the drop (Figure 2). The cohesiveness of the Poly-Trol 200-thickened water retarded the exit of fluid from within the balls. This meant that as the free-falling fluid was losing its forward momentum, the Poly-Trol 200-laden balls were behaving like projectiles and maintaining forward momentum. Their trajectory was such that they landed up to 4 m farther down the field than the fluid that initially enveloped them during their descent. The fluid lost much of its forward momentum when the base of the load was still approximately 3 m above ground. However, as the free fluid began to settle vertically, balls emerged from below the base of the fluid mass and continued their forward angular flight path, reaching the ground when the accompanying fluid was still approximately 1 m above ground level.

DISCUSSION

The pronounced V configuration in the pattern (Figure 3) was formed by the parcel of bulk water which carried through as a projectile along the centreline of the descending load. The three segments of the pattern identified as bottom, middle, and top in Figure 3 corresponded to the initial location of water in the air tanker hopper. The clear separation between floating and weighted balls confirmed that anti-slosh dividers did not impede the crossflow of the water as it left the hopper.

The distribution of the floating and the weighted balls (Figure 4) in the Poly-Trol 200-thickened water was indicative of the change in discharge characteristics. The clear break between the fluid that originated from the bottom of the hopper and that at the top for unthickened water was nonexistent in the Poly-Trol 200 drop. Areas of concentration of either floating or weighted balls were identified in parts of the pattern but most of the coverage zone depicted an intermingling of balls. From this distribution, it appeared that the anti- slosh dividers played an important role in controlling the load's exit. A large portion of the contents of the compartment located immediately above the door emptied before the cohesive fluid located in peripheral compartments was able to fill the void above the door. This explained the early emergence of a few floating balls that landed in the fore of the pattern and the late discharge of weighted balls and their deposition in the aft of the pattern. The mix of floating and weighted balls in the central portion of the pattern confirmed the intermingling of fluid from various sections of the hopper rather than the expected uniform bottom to top orderly discharge. By zoning the density distribution of the two types of balls, the bottom, middle, and top portions of the load could still be defined along the centreline of the pattern (Figure 4). The proclaimed benefit of using Poly-Trol 200 as a water thickener was its ability to alter the dispersion characteristics of the descending load. However, the effect of fluid cohesion on its flow characteristics during exit was ignored. The superimposition of pattern contours (Figure 5) confirmed that the flow rate was more consistent, thereby creating a three island distribution rather than the single island so commonly obtained using water (Figure 6).

The usefulness of tracer balls to evaluate new product drop dispersion is dependent on the evaluator's knowledge of the particular air tanker's footprints for other fluids under varied drop conditions and payload dispersal characteristics. Because the trajectory of dispersed water is considerably less than that of bulk water, the bulk water portion of the load tends to create an island of high deposition in the trailing edge of the drop pattern. This load distribution was confirmed when contours were superimposed on the tracer ball distribution The relative distribution of water along the pattern centreline could be predicted by comparing the proportions of the distances (along the centreline) where weighted balls predominated, where very few of either type occurred, and where floating balls predominated. Using Figure 6 as an example, the proportions of these three lengths, each representing one third tank of water, were 5:1.5:1.5 (60%:20%:20%) and the respective range of application depths in each zone were 0 to 0.20 cm, 0.20 to 0.35^{+} cm, and 0 to 0.35^{+} cm.

CONCLUSION

The release of the Dromader air tanker load of water containing tracer balls resulted in a distribution that was relatively consistent with previously determined drop pattern configurations. That is, the bulk of the water landed in the latter half of the pattern. The use of tracer balls afforded a method of determining the origin of this mass of water ie. its position within the hopper, and also an understanding of the water's discharge and descent characteristics.

The addition of Poly-Trol 200 changed the rheological characteristics of the water to a degree whereby the cohesive forces acting within the fluid compounded the impedance of anti-slosh dividers on the free lateral movement of this viscous fluid, and resulted in a confused type of tracer ball distribution. This distribution was not an anomaly but a confirmation that fluids of different viscosities and rheological properties have different flow and dispersal characteristics. Fluid cohesion altered the discharge rate, the flow pattern within the tank, and the dispersion pattern as it exited the tank, to the extent that a more uniform distribution was attained.

The use of tracer balls was a novel method of determining how the load was transposed from within the hopper to its final resting place at ground level. Their use in identifying depth of application was minimal, for their spatial arrangement afforded only an estimate of relative rather than quantitative fluid distribution. During the preliminary evaluations of tank and gating system modifications, this technique circumvents the need to utilize the laborious catch-cup grid method of drop pattern determination until the optimum tank and gating configuration has been identified.

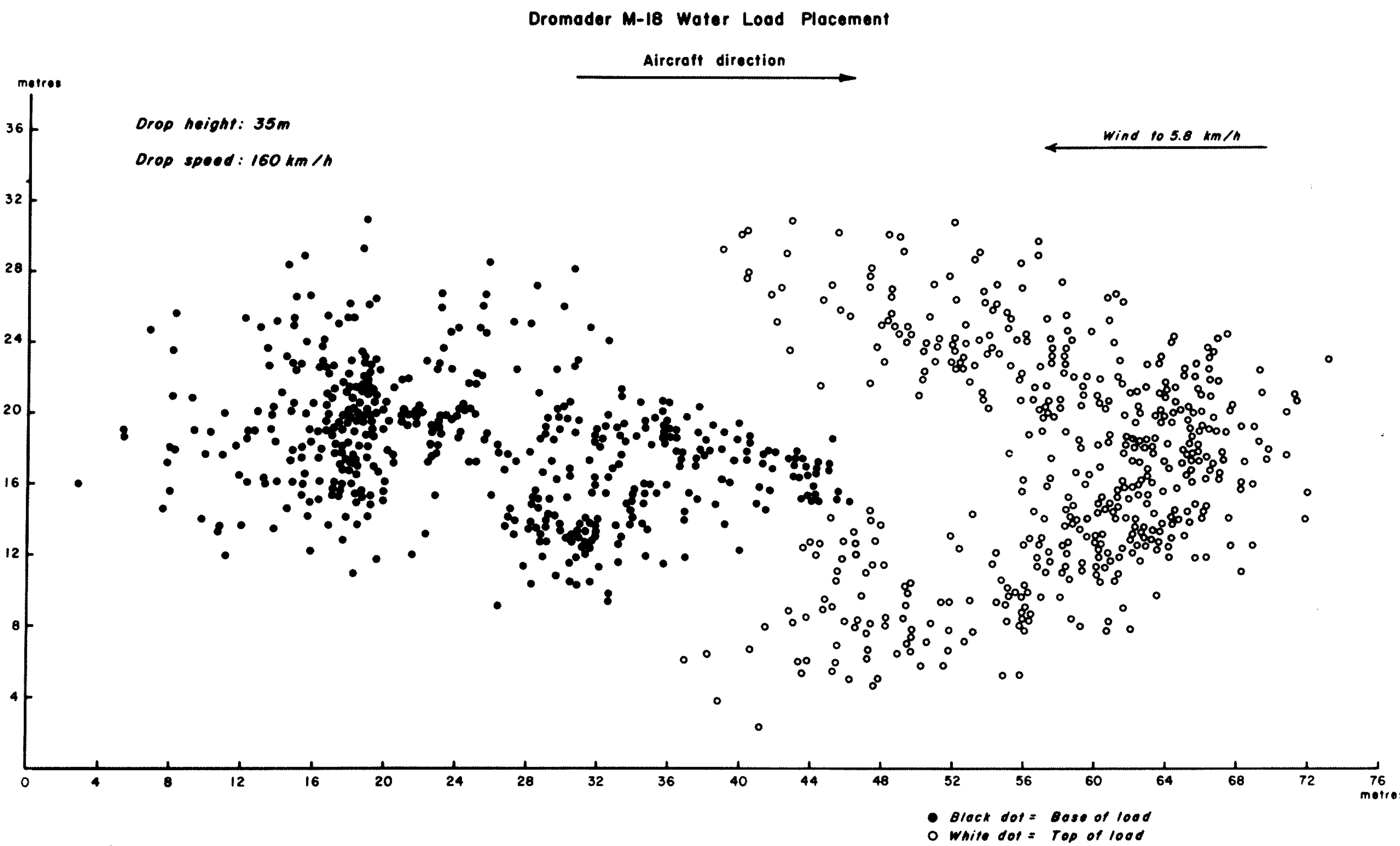


Figure 1. Tracer-ball distribution at ground level reflecting the load exit sequence for unthinned water.

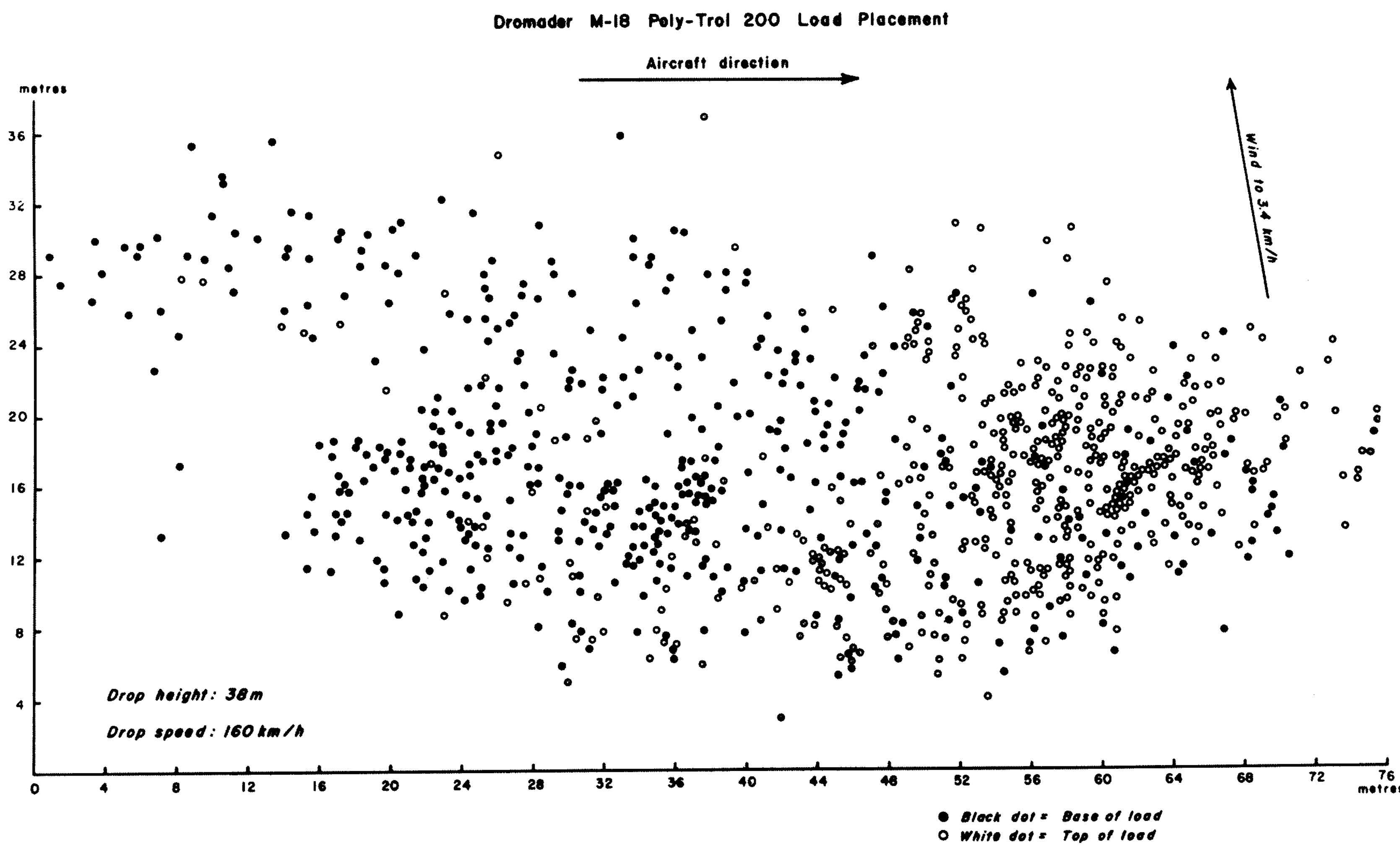


Figure 2. Tracer-ball distribution at ground level reflecting the load exit sequence for Poly-Trol 200 thickened water having a viscosity of 460 mPa·s.

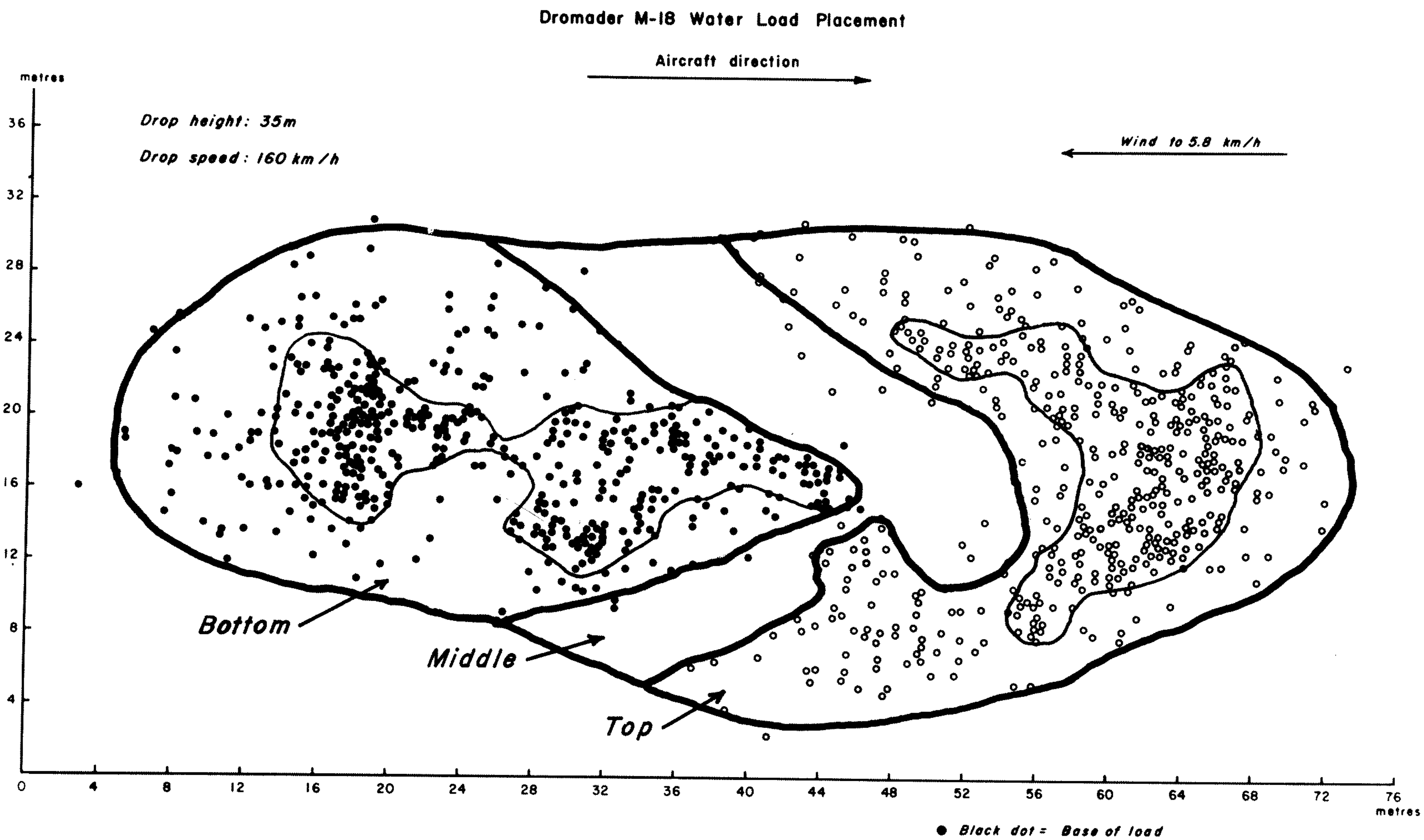


Figure 3. Zone demarkation and density distribution of the floating and weighted tracer-balls for unthickened water drop at ground level.

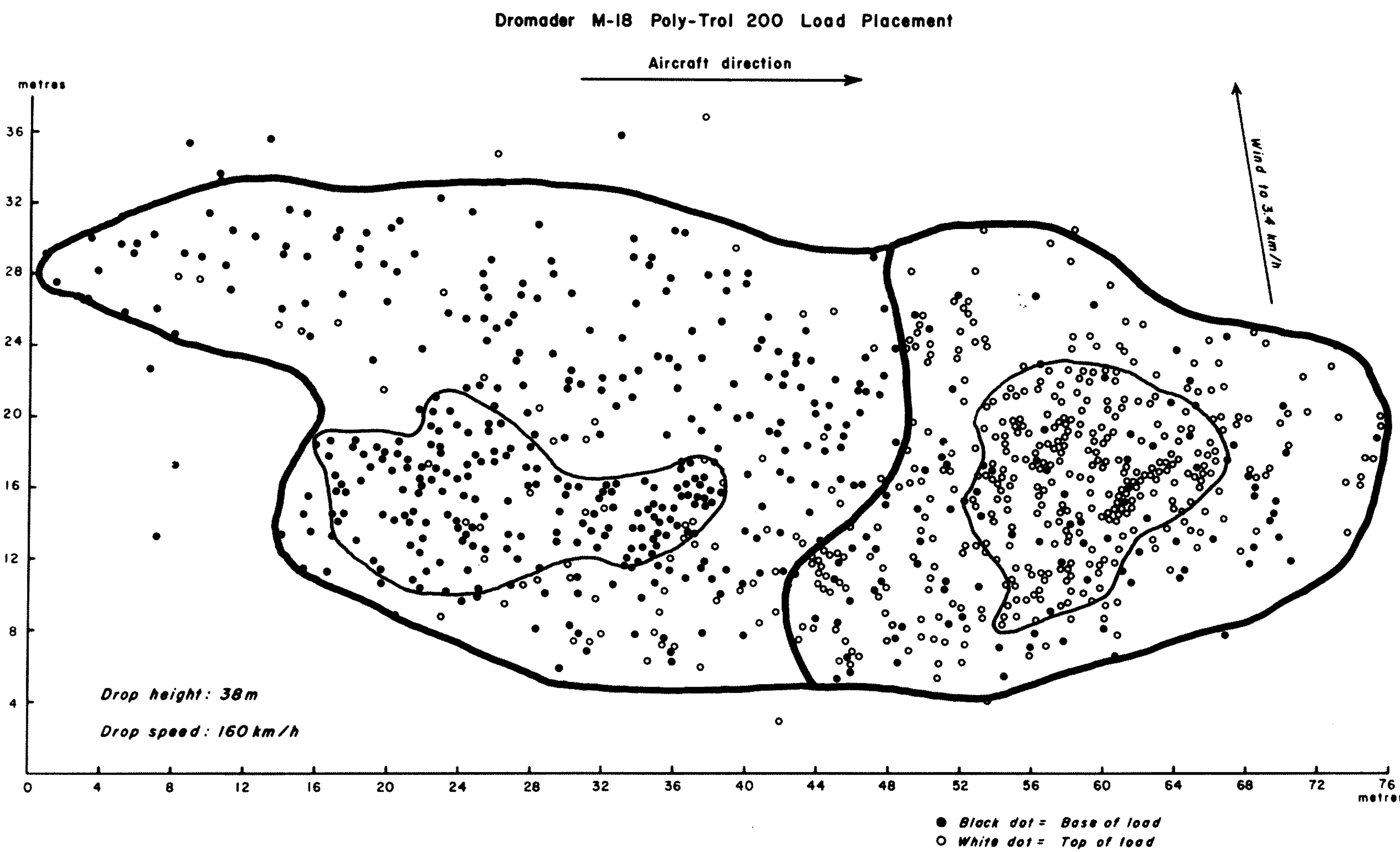


Figure 4. Zone demarkation and density distribution of the floating and weighted tracer-balls for Poly-Trol 200 thickened water drop at ground level.

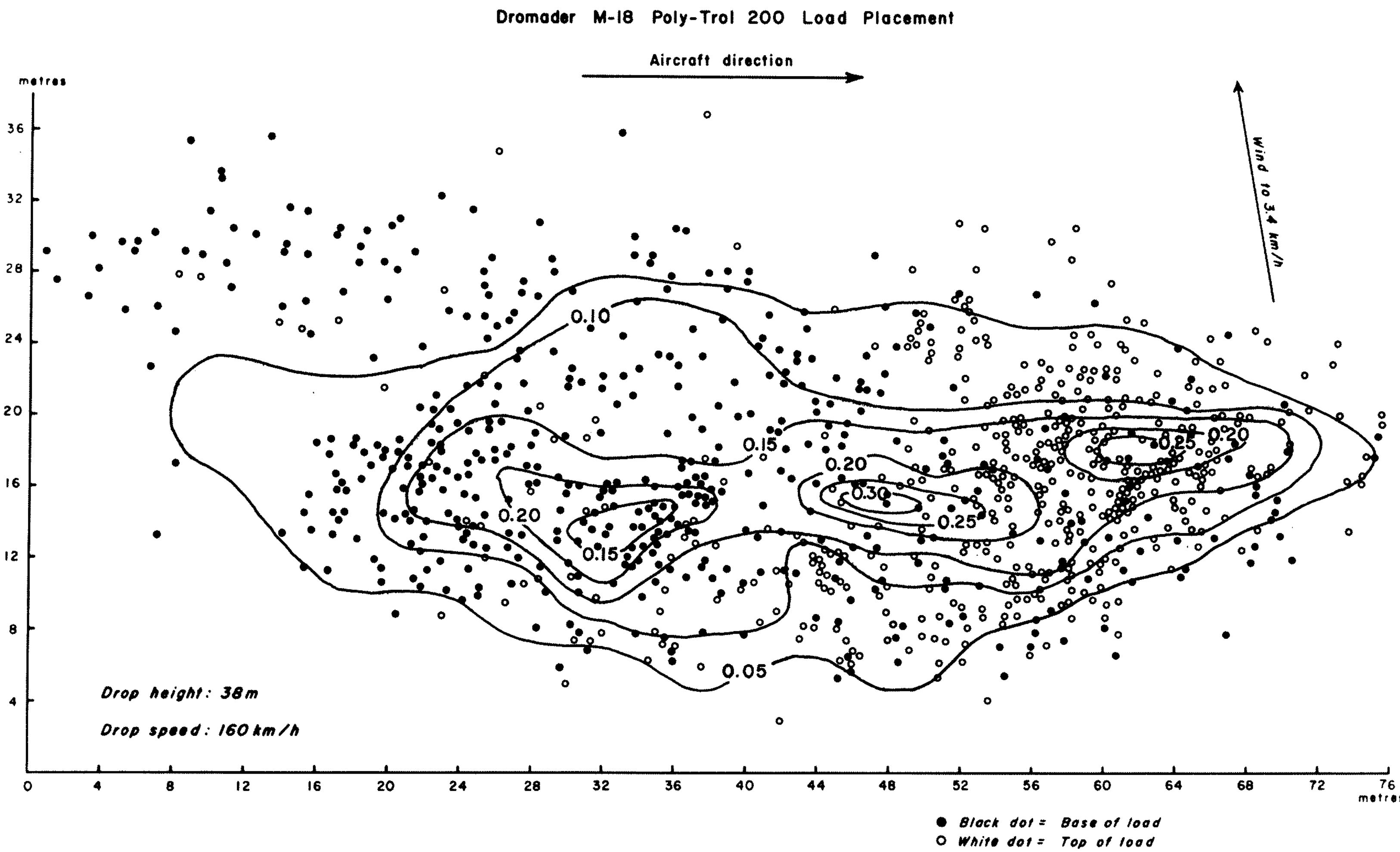


Figure 5. Contour lines from comparable Poly-Trol 200 drop superimposed on tracer-ball distribution.

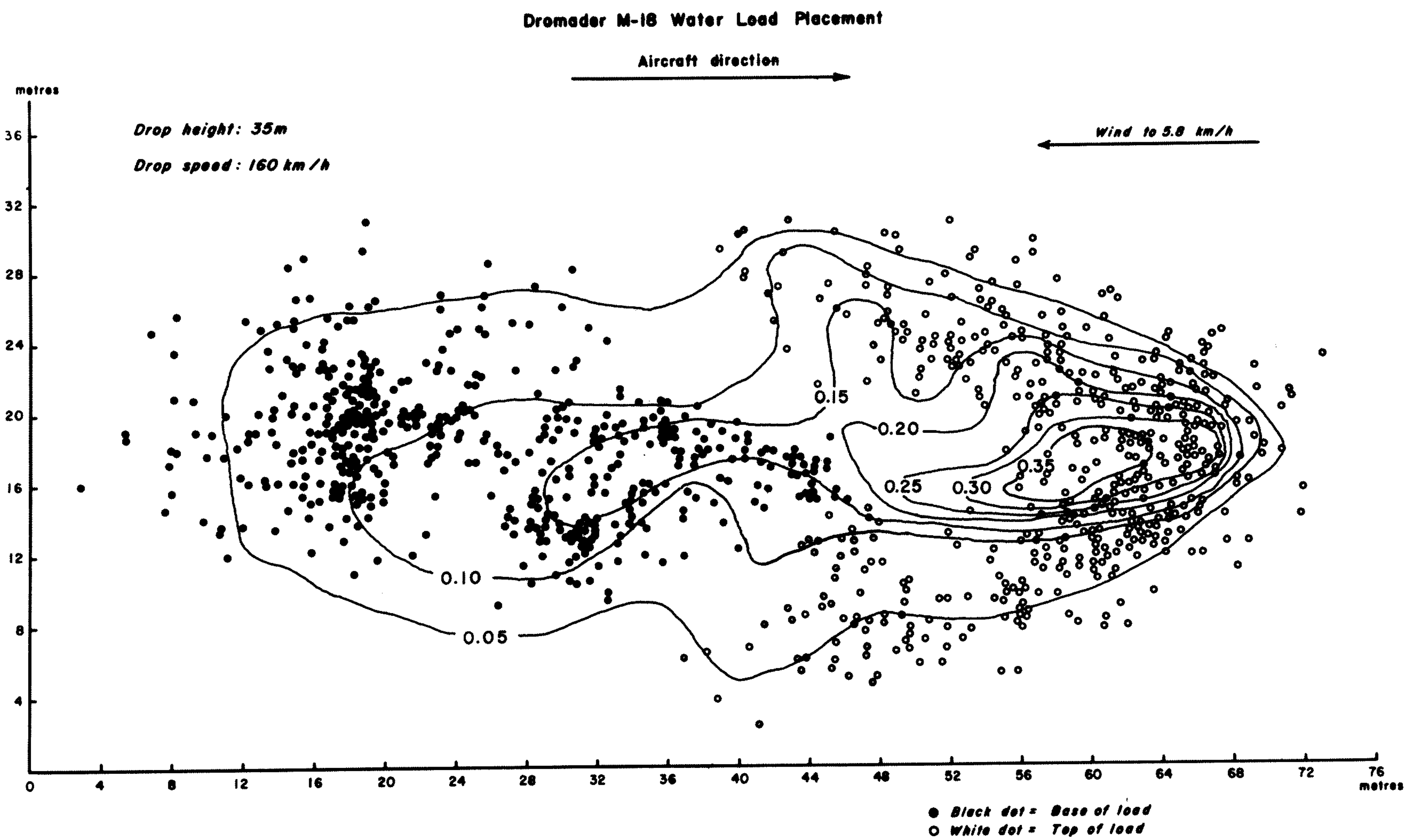


Figure 6. Contour lines from comparable water drop superimposed on tracer-ball distribution.