The following memorandum is transmitted with the Compliments of the Under Secretary of State. Home Office (Fire Brigades Division) Cleland House, Page Street, S.W.1.

F.B. GEN. 100/20 26th August, 1940

MEMORANDUM

Use of Supplementary Water Supplies.

F.B. Circular No. 118/1940

1. These notes are intended primarily to assist fire brigade Officers to make the best use of supplementary water supplies if the quantity of water available from the mains should prove insufficient, or should fail completely, owing to the occurrence of a large number of simultaneous fires or the mains being fractured or pumping stations put out of action.

2. Every fire brigade should keep readily available full information as to the position and capacity of the supplementary supplies of water which could be used to best advantage if required to deal with a fire on any premises constituting a major fire risk. If the principal local risks have not already been surveyed from this point of view, the work should be undertaken as soon as possible; and schemes should be worked out in advance and personnel trained, so that the measures for obtaining supplementary water could be carried out smoothly and expeditiously in case of need. The schemes should include particulars and details of the hose lines and the number of pumps which would be required to deliver say 400/500 gallons a minute, or such other quantity as may be practicable, from each available source, subject, of course, to the availability of equipment.

3. The fixed 5000 gallon dams which have been installed in many places near the principal fire risks could be usefully incorporated in these schemes as the reservoir dams at the end of the relaying line or lines; and in some areas it may be possible to make use of these dams in series. Thus while water from one dam was being used for fighting a fire, it might be possible to replenish it by pumping from another dam and so on, until a dam was reached which could be replenished from the supplementary supply itself.

4. By using these dams as "water depots" it should be practicable to devise efficient schemes to cover most high risk areas. Where such measures are likely to be required in respect of serious fire risks, pumps with the necessary crew and sufficient hose to reach to the next nearest dam should be allocated to each dam, so that when they are called on they can proceed to their pre-arranged position and supply water as required.

5. For this kind of work frequent and careful drilling is essential; the slightest mistake in getting a water relaying scheme into operation may cause considerable delay and interfere seriously with its efficiency; and, it must be remembered that in all such operations a small quantity of water brought into use during the early stages of a fire may be of considerably more value than a much larger quantity made available at a later stage. It is also desirable, where sufficient personnel and equipment are available, that some of the regular and auxiliary firemen should have special training in the provision of water from a distance, and that "water squads" provided with pumps, hose-laying lorries or trailers and mobile dams should be formed and specially allocated to this class of work, without prejudice, however, to their being employed on normal fire fighting if they are not required for water relaying.

6. The first essential step for the officer in charge at a fire who is faced with a shortage of water is to decide the specific manner in which he requires the provision of supplementary water to be carried out, and this is dependant upon:-

(1) the quantity of water required at the schee of the outbreak;
(2) the number and capacity of the appliances available;
(3) the distance to the nearest suitable source of supply.

7. There are two principal methods of providing supplementary water for use at fires, viz:-

(a) by the use of 500 gallon or 1000 gallon dams mounted on lorries,
(b) by means of long lines of hose with pumps interposed and working in series for the purpose of boosting up the supply and overcoming the resistance due to friction in the hose. It should be noted that where the necessary equipment is available both these methods can be used simultaneously and in conjunction with each other; thus it may often be possible to get an initial supply of water at a fire more quickly by the first method than by means of a long line of hose, especially if no hose laying lorry is available, and to augment the supply when lines of hose can be brought into operation. In several of the larger fires which have so far been caused by enemy action this has been amply illustrated when mains have been fractured.

Mobile Water Supplies.

8. Special attention is directed to F.B. Circular No.11/1940 which was issued on the 16th February last, in which full information is given regarding the use of 500 gallon and 1000 gallon dams mounted on lorries. This method of providing supplementary water at fires has proved to be of considerable value, and should be employed when quantities of water up to, say, 300 gallons per minute are required.

9. The following result of a test shows the practicability of the mobile dam system. Water was conveyed by means of seven 1000 gallon dams over a distance of 1½ miles. Two large trailer pumps were used for filling the dams, each pump supplying two lines of hose led directly into the mobile dams by means of "goose-necks". The average time taken to fill a dam was under one minute. The water from the mobile dams was emptied into a dam of the "Sportapool" type, so positioned as to allow three mobile dams to discharge their contents into it simultaneously. The actual quantity of water delivered over the 1½ miles was about 390 gallons per minute, which should be sufficient for six ¾" streams.

Relaying Through Lines of Hose (Series Pumping).

10. The more familiar method of conveying water from a distance for fire fighting is by means of long lines of hose with pumps interposed in series. This method of providing supplementary water takes time to get into operation and a considerable quantity of material is required, it interferes with traffic and the long lines of hose are vulnerable to damage; but when a large quantity of water is required and it is necessary to maintain the supply for a considerable period, this is the only practicable course.

11. Frictional resistance in the hose is the most important factor to consider when pre-arranging relaying schemes and getting them into actual operation. It should be remembered that frictional resistance varies as the square of the velocity of the water in the hose, so that it is essential to reduce this velocity as much as possible by using hose of a large diameter, or, alternatively, by using twin or multiple lines. When water is being delivered through twin lines of hose the velocity in the water is halved as compared with a similar delivery through a single line of the same type of hose. By using twin lines, it is therefore possible, with a given pump pressure, to obtain delivery of a given quantity of water over approximately four times the distance obtainable with a single line. For instance, a single line of 2½ inch rubber-lined hose will deliver 210 gallons per minute over a distance of about 800 feet at about 110 lbs. pump pressure, but with twin lines the same quantity at the same pump pressure will be delivered over a distance of about approximately 3200 feet. For the same reason a given quantity of water can be delivered, with 3½ inch unlined hose over nearly three times the distance obtainable with 2¾ inch unlined hose. Thus a single line of 2¾ inch unlined hose will deliver about 150 gallons a minute over 1000 feet, at about 110 lbs. pressure, but the same delivery is obtainable over a distance of about 2700 feet with 3½ inch unlined hose. When using unlined canvas hose allowance has to be made for percolation, but the same general rule is applicable.

12. The following table gives approximately the relative discharge values of the types of hose in general use in terms of lengths of line, assuming a pump pressure of about 110 lbs. per square inch.

Type of hose	Distance over which specified discharges are attainable			
	150 g.p.m.	250 g.p.m.	350 g.p.m.	450 g.p.m.
	ft.	ft.	ft.	ft.
3½" rubber lined	5300	2100	1100	700
3½" unlined	2650	1100	500	-
2¾" rubber lined	1850	670	-	-
2½" rubber lined	1500	550	-	-
2¾" unlined	1000	400	-	-

To obtain double the quantities, twin lines of hose must be used under the same conditions, and the pump used must of course be capable of working to the required capacity. (For practical relaying purposes it can be assumed that rubber lined hose will deliver approximately 30 per cent. more water than unlined hose of the same diameter.)

13. For relaying work, 110 lbs. per square inch is a good working pressure, which will not involve risk of unduly straining the hose. The extra quantities obtainable by increasing this pressure by, say, 25 lbs. working through 1000 feet of hose are:-

3½" rubber lined hose	...	50	gallons	per	minute
3½" unlined hose	...	33	"	"	"
2¾" rubber lined house	...	25	"	"	"
2½" " " "	...	13	"	"	"
2¾" unlined hose	...	12	"	"	"

From these figures it will be seen that the increased outputs are relatively small except in the case of 3½" rubber lined hose, and it is not advisable to work at much higher pressure than 110 lbs. per square inch.

14. Further particulars are given in the accompanying table and graphs,* which show the approximate outputs through various types of hose with working pressures of 75 lbs., 100 lbs. 125 lbs., and 150 lbs. per square inch at the pump delivery outlet, working over distances from 500 feet to one mile.

15. It is essential to bear in mind that in the operation of a relaying line the reduction in the flow over any section of the line necessarily reduces the quantity of water which can be maintained in the line as a whole. Consequently, it is essential to ensure that every "link" is so planned that it can maintain the quantity required. The principal problem facing the Chief Officer of a Fire Brigade in planning a relaying operation is to decide how to use the available hose and pumps to the best advantage and so secure the maximum available supply at the fire. If, for instance, the object be to deliver 450 - 500 gallons per minute over a given distance, it can be seen from the particulars which have been given in the accompanying tables and graphs that the object could be secured by making up the line in sections by any of the following methods, subject, of course, to any allowances which have to be made for variation in ground levels:-

Twin lines	3½" unlined	hose	1000 ft.	in length.
" "	2½" rubber-lined	"	500 "	" "
Triple lines	2½" " "	"	1200 "	" "
" "	2¾" unlined	"	800 "	" "
Twin lines 1 - 3½" unlined 1 - 2½" rubber-lined		"	800 "	" "

It would not, however, be easy for the Chief Officer of a Fire Brigade to carry through such calculations on the occasion of a fire, and it is for this reason that Brigades are advised to organise teams, well practised in relaying work, who know the capacity of their units when operating over various distances and with different hose lines or combinations of lines.

16. A further point is that it is desirable to have a reservoir of water at the delivery end of the relaying system, to overcome any interruption in the supply which may occur, for example, if a line of hose should burst or a pump fail to develop its required capacity. The best course is to work to a fixed dam, as already suggested, if there is one sufficiently near to the fire, or to set up a dam to receive the discharge from the relaying hose in a position near the fire where the pumps can approach to draw their water. The use of dams in series in the lines of hose is not recommended, as more water can be delivered by directly connecting the delivery lines of hose to the suction inlets of the pumps, thereby gaining the benefit of the positive pressure on the suction side of a pump. If a length of hose should burst when working with twin or multiple lines, the damaged length should be replaced, without completely interrupting the supply, by isolating the line affected between the pumps.

Simultaneous laying of hose between pumps.

17. Where it is possible to do so, the location of the pumps to be used in relaying schemes to cover the principal risks should be pre-determined, so that the hose lines from all pumps employed in the series can be laid simultaneously. But it will often be necessary to relay water over a distance where it has not been possible to pre-arrange any scheme, and in such cases the Officer in charge of the relaying operation should step out the required distances according to the length of line which can be operated by each unit to give the required capacity, and indicate the points at which the interposed pumps should be placed and get to work. This will render it unnecessary for the crews of the interposed pumps to wait until the hose lines have been completed up to them before commencing to lay their hose lines to the following pump, and will greatly facilitate getting the whole line into operation.

18. When relaying lines are laid in the manner indicated in the foregoing paragraph arrangements can be made for the water to follow up to each pump immediately the necessary hose lines are completed, by means of signalling between pumps. If water should reach a pump before the hose line to the next pump has been completed, the water arriving at the receiving pump should be allowed to run to waste through an open delivery outlet until the signal is given that the hose line has been completed to the following pump, when the water should be directed into the hose line.

19. When hose has to be laid by hand it is preferable to complete one line of hose between pumps before duplicate or triplicate lines are laid, and then, as time permits, to lay the extra lines for the purpose of increasing the volume of water supplied.

20. In laying hose for relaying purposes, as on other occasions, great care must be taken to avoid dragging the hose, especially if there is glass or other debris on the road surface.

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* For reasons of economy Graphs have been supplied only to Chief Officers of Fire Brigades.

SIGNALS

21. It is essential to embody a system of signalling in every water relaying scheme to provide rapid and accurate means of communication between pump operators and so ensure a steady flow of water and avoid excessive pressures being built up, with risk of damage to hose or suction collecting heads. Whistles are of little use as they cannot be heard close to a pump at work. For visual signalling, flags by day and lights at night can be used, but cyclist messengers are recommended. The following is a simple code of visual signals which will serve for many purposes:-

FLAG SIGNALS

"Open up water" - Right arm raised over head to full extent and lowered smartly to side.

"Close down water" - Right arm extended to right, swung across to left and back again.

"Increase pressure"- As "open up water" repeated several times.

"Reduce pressure" - Right arm extended horizontally from shoulder and left arm vertical.

LAMP SIGNALS

Open up water - Lamp raised and lowered in front of body.

"Close down water" - Lamp passed in front of body from left to right and back again.

"Increase pressure"- As "open up water" repeated.

"Reduce pressure" - As flag signal, with lamps.

For further signals see Fire Services Information Bulletin No. 4, paragraph 48.

22. Points to be observed when relaying water through long lines of hose:

(a) Every effort should be made to avoid obstructing traffic. Lines of hose should be laid close to the curb and ramps must be placed in position where it is necessary to cross a road. All pumps should be on the pavement or, if this is not possible, at the side of the road.

(b) Sharp bends in the hose should be avoided. If intermediate pumps are coupled into the line of hose they should be placed at right angles to the hose line, so that both the inlet and the outlet hose will have no more than a right angled bend. Sufficient slack hose should be allowed to make these bends as easy as possible.

(c) If the hose is laid from a lorry or trailer it should be secured before the lorry or trailer moves off, otherwise it is apt to be dragged away from the pump and a very sharp bend caused at the pump outlet, or it may be necessary to insert an extra length.

(d) Careful attention must be paid to the gauges of all interposed pumps to see that the correct pressure is maintained. The compound gauge reading should show a slight positive pressure.

(e) Care must be taken to see that the water cooling system is functioning properly. This is liable to be overlooked.

(f) Where only one line of hose is feeding a pump, connection should be made by means of the suction adaptor, not through the suction collecting head, which should be used only with multiple lines of hose. The internal strainers in the suction inlets of pumps cause some restriction to the flow of water, and in relaying they are unnecessary and should be removed, as all pumps will be adequately protected by the basket strainer on the supply pump.

TABLE SHOWING DISCHARGE IN GALLONS PER MINUTE THROUGH DELIVERY HOSE WITH OPEN ENDS

Size	Pressure lbs. per sq." at pump outlet	Distance						
		500' g.p.m.	1000' g.p.m.	¼ mile g.p.m.	2000' g.p.m.	½ mile g.p.m.	¾ mile g.p.m.	1 mile g.p.m.
2¾" Unlined Canvas Hose	75	175	130	115	90	80	60	50
	100	205	150	130	105	90	70	60
	125	230	160	140	115	100	80	70
	150	250	177	150	125	106	84	70
2½" Rubber Lined Hose	75	215	163	144	115	97	76	60
	100	255	185	160	130	120	85	67
	125	285	200	175	145	130	100	80
	150	300	220	190	157	136	107	93
3½" Unlined Canvas Hose	75	300	220	190	147	126	96	77
	100	345	265	230	183	150	115	90
	125	385	295	255	205	170	135	100
	150	423	330	290	230	190	143	115
3½" Rubber Lined Hose	75	425	320	280	225	190	150	120
	100	500	380	325	255	220	175	150
	125	575	425	365	287	245	195	170
	150	615	450	390	315	277	230	200

Note. All the above Hose is fitted with 2½" instantaneous couplings.