Rev. 7/9/80

APPLICABILITY CRITERIA FOR GENERAL PERMITS FOR NONCONTACT COOLING WATER

Recommendation for Streams

1. For streams with a $Q_{7,10}$ equal to or less than 0.1 cfs, the effluent temperature shall not exceed 120°F.

2. For streams with a $Q_{7,10}$ greater than 0.1 cfs, the following applies:

   a. If $\frac{Q_{effluent}}{Q_{stream}}$ is greater than 0.05, the maximum temperature should not exceed 60°F.

   b. If $\frac{Q_{effluent}}{Q_{stream}}$ is less than 0.05, but greater than 0.03, the maximum temperature should not exceed 80°.

   c. If $\frac{Q_{effluent}}{Q_{stream}}$ is less than 0.03, but greater than 0.015, the maximum temperature should not exceed 100°F.

   d. If $\frac{Q_{effluent}}{Q_{stream}}$ is less than 0.015, the maximum temperature should not exceed 120°F.

Rationale

The first recommendation cited above was based on the assumption that temperature is not a significant factor in the pollution of non-continuous streams. However, such waters should be protected for public rights uses and the temperature should not be harmful to those coming into contact with those waters. Therefore, all discharges to such waters will meet the applicability criteria as long as their temperature is less than 120°F. In addition, perhaps a maximum effluent volume should be placed on these discharges to prevent a power plant from falling under this criteria. (An arbitrary volume of 250,000 gallons per day is perhaps a reasonable number.)

The second recommendation was developed using a simple temperature balance for critical summer and winter periods assuming an allowable temperature rise of 5°F in 25 percent of the low flow. The equation is:

$$Q_e T_e + 1/4\, Q_s T_s = (Q_e + 1/4\, Q_s)(T_s + 5)$$

Where:
- Q_e = Effluent Flow.
- T_e = Effluent Temperature.
- Q_s = Stream Flow = $Q_{7,10}$.
- T_s = Ambient Stream Temperature.

By re-arranging terms and assuming that the winter value for T_s is 40^oF and the summer value is 80^oF, the equation takes the following form:

$$\text{Winter:} \quad \frac{Q_e}{Q_s} = \frac{5}{4(T_e-45)}$$

$$\text{Summer:} \quad \frac{Q_e}{Q_s} = \frac{5}{4(T_e-85)}$$

Applying these equations to various effluent temperature values yields the graph shown as Figure 1. The values used in this figure are shown in Table 1. It is noted that the winter condition controls the amount of dilution required for a given volume of discharge. The recommendation is based upon this critical winter temperature condition. A knowledge of the effluent flow, the $Q_{7,10}$ and the effluent temperature is all that is needed, therefore, to determine if a particular cooling water meets the applicability criterion.

Recommendation for Lakes

That effluent combinations above and to the right of the line shown on Figure 3 not fall under the applicability criteria of a general permit.

Rationale

A recommendation for lakes is somewhat more difficult because one does not have a very good background condition to work with. However, with a few assumptions and references, reasonable applicability criteria can be developed. The primary reference for this criterion is:

> Federal Water Pollution Control Administration, "Industrial Waste Guide on Thermal Pollution." Corvallis, Oregon, September 1968.

The primary assumptions used in this analysis are that an effluent disperses outward uniformly from a shoreline discharge, that the equilibrium temperature at that time is 85^oF, and that the mixing zone area acts as a cooling pond. On page 102 of the cited reference an equation for the temperature through a pond is provided. That equation is:

$$T_4 = (T_3 - E)\, e^{-\alpha} + E$$

Where:
- T_4 = Temperature at the end of the pond.
- T_3 = Temperature going into the pond.
- E = Equilibrium temperature.
- $e^{-\alpha}$ = An empirical factor.

The quantity α is calculated by the following equation:

$$\alpha = \frac{KA}{PC_p\, Q_3}$$

Where:
- K = Energy exchange coefficient
  = $15.7 + (0.26 + B)\,(bW)$
- B = A coefficient which depends on the equlibrium temperature.

= 0.99 for E between 80° and 90°F.
b = Experimental evaporation coefficient = 15
W = Wind speed = 10 mph.
A = Area in square feet.
P = Density of water.
C_p = 1.
Q_3 = Discharge volume in ft^3 per day.

At an equilibrium temperature of 85°F, the value of K from the above equation is 203. From the first equation, with a temperature at the edge of the mixing zone (T_4) equal to 88°F, the following results:

$$e^{-\alpha} = \frac{3}{T_3 - 85}$$

For various values of T_3, α can be calculated as shown below:

T_3	α
90°F	.51
100°F	1.61
110°F	2.12

The area of the mixing zone is, as noted earlier, dispersed from a shoreline outfall in all directions and is, therefore, a semi-circle. Assuming that 100 feet is a reasonable mixing zone distance, the area is about 15,700 square feet. Applying this value and the other values noted above to the remaining equation, a discharge volume (Q_3) can be computed for each of the effluent temperatures.

T_3	Q_3
90°F	100,150 ft^3/d(750,000 gpd)
100°F	31,720 ft^3/d(237,000 gpd)
110°F	24,090 ft^3/d(180,000 gpd)

A graph of these values is shown in Figure 2. All combinations below and to the left of the line meet the criteria set forth while those to the right and above do not.

A similar exercise can be done to evaluate the winter condition. In this case, the equilibrium temperature is selected as 40°F. Values of α for various effluent temperatures are:

T_3	α
55°F	1.61
65°F	2.12
80°F	2.58

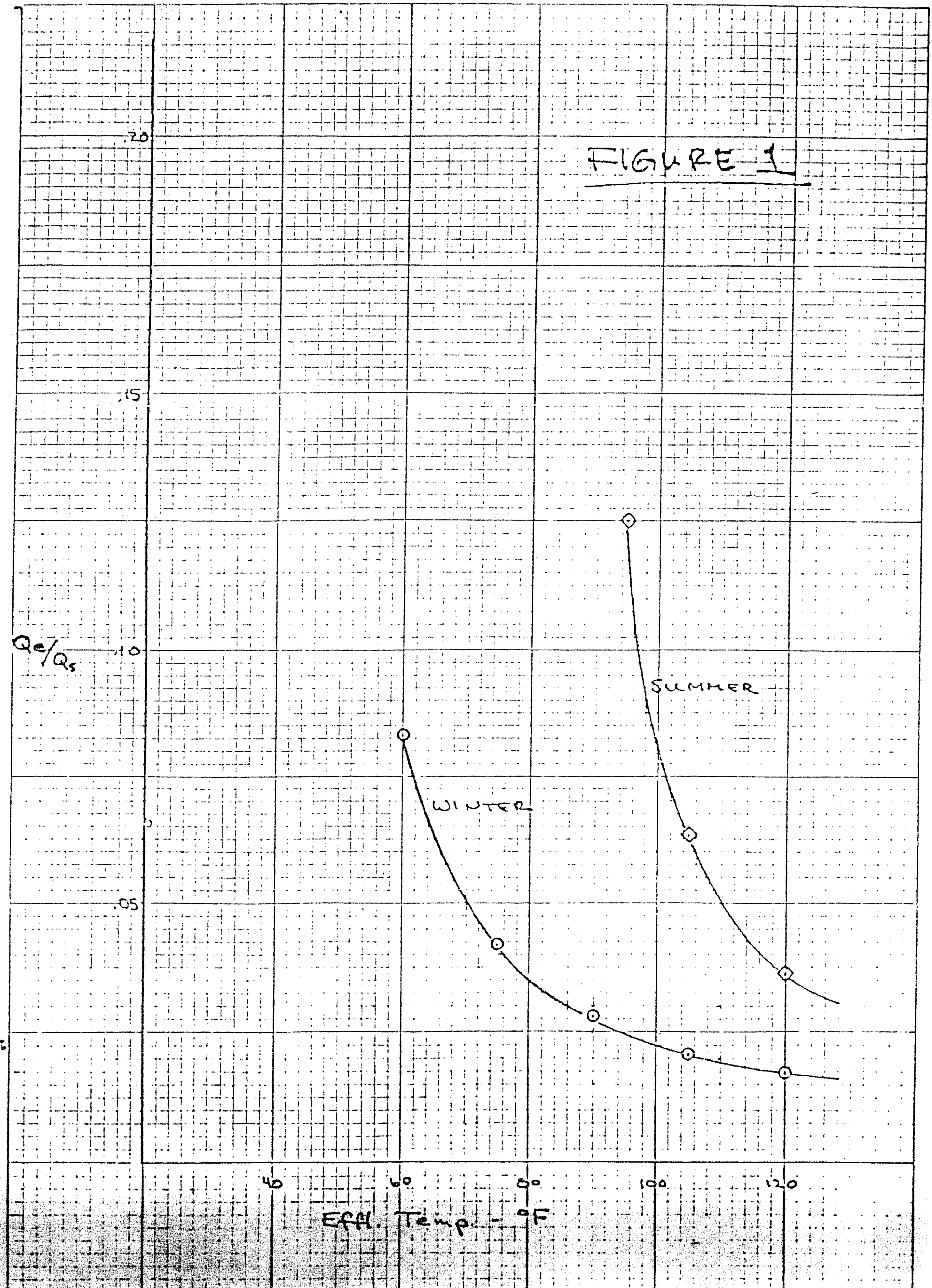
Effluent volumes for these various temperatures during the winter condition are:

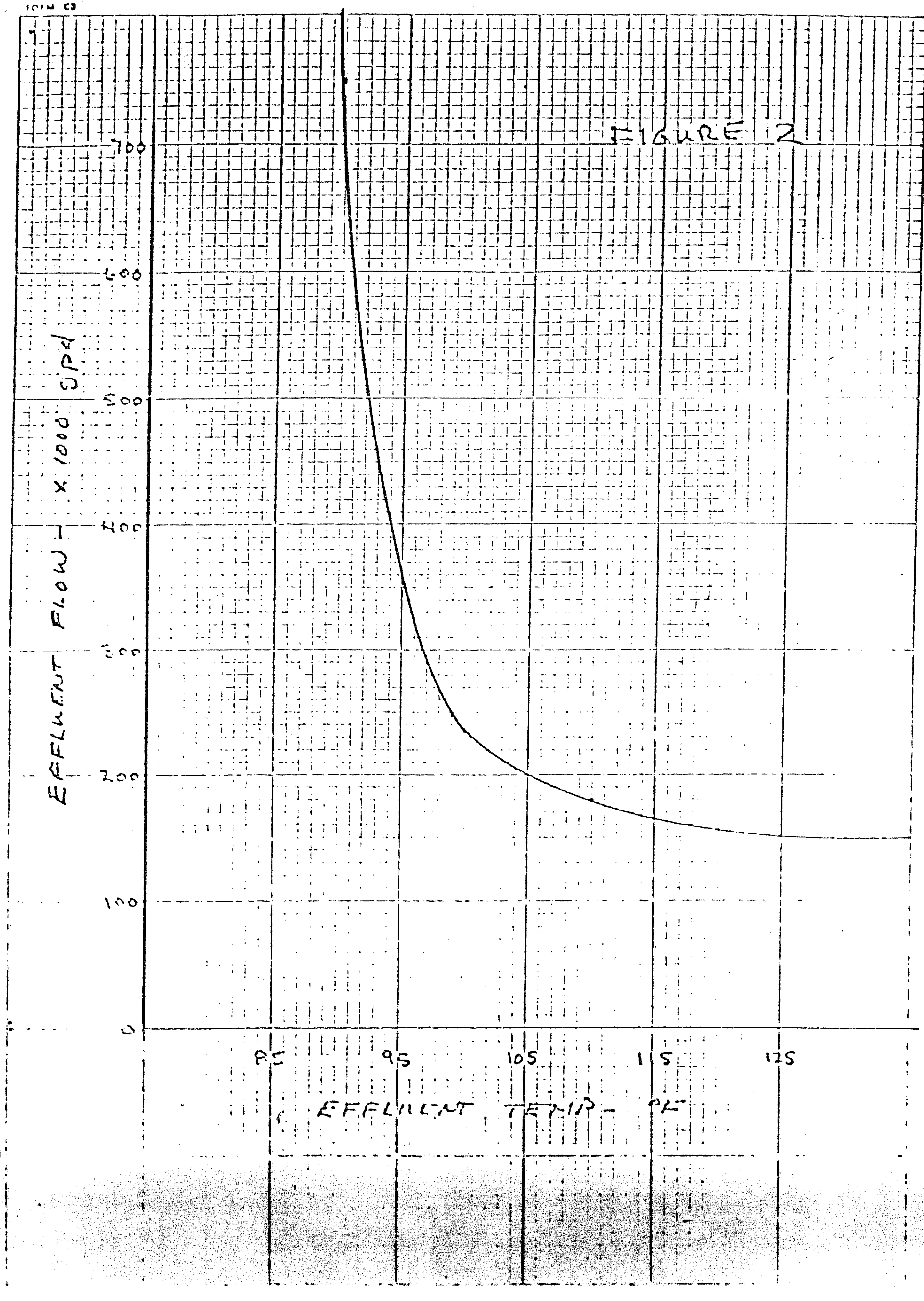
T_3	Q_3
55°F	116,500 gpd
65°F	88,500 gpd
80°F	72,700 gpd

These values are shown on Figure 3. Again, a discharge condition which falls to the right and above the line does not meet the assumed criterion while those to the left and below do.

It is obvious that the winter condition always controls. Therefore, Figure 3 should be used for the applicability criteria for discharges to lakes or impoundments.

FIGURE 1




700
600
500
400
300
200
100
0
EFFLUENT FLOW - X 1000 gpd
85
95
105
115
125
EFFLUENT TEMP - °F
FIGURE 2

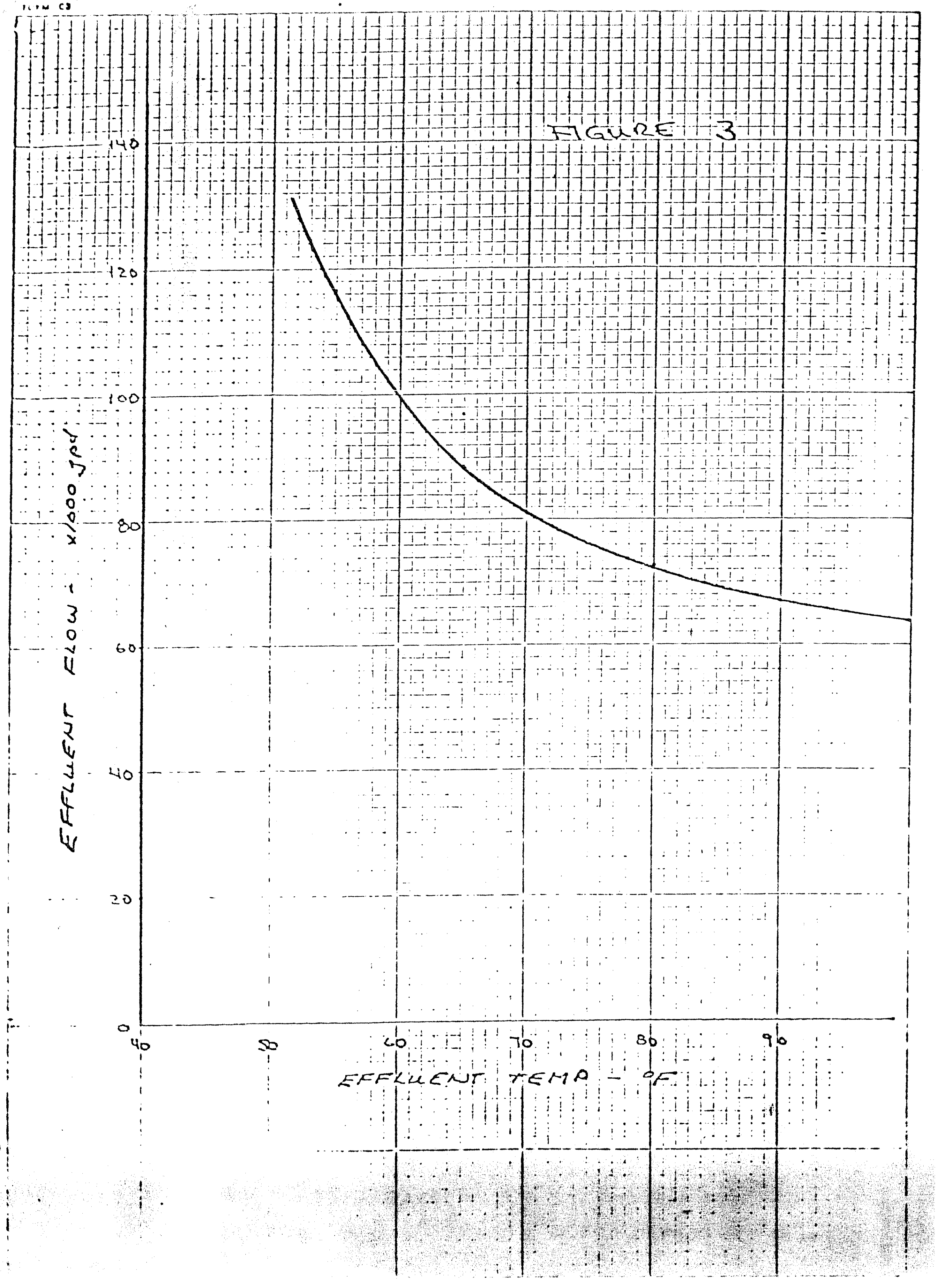
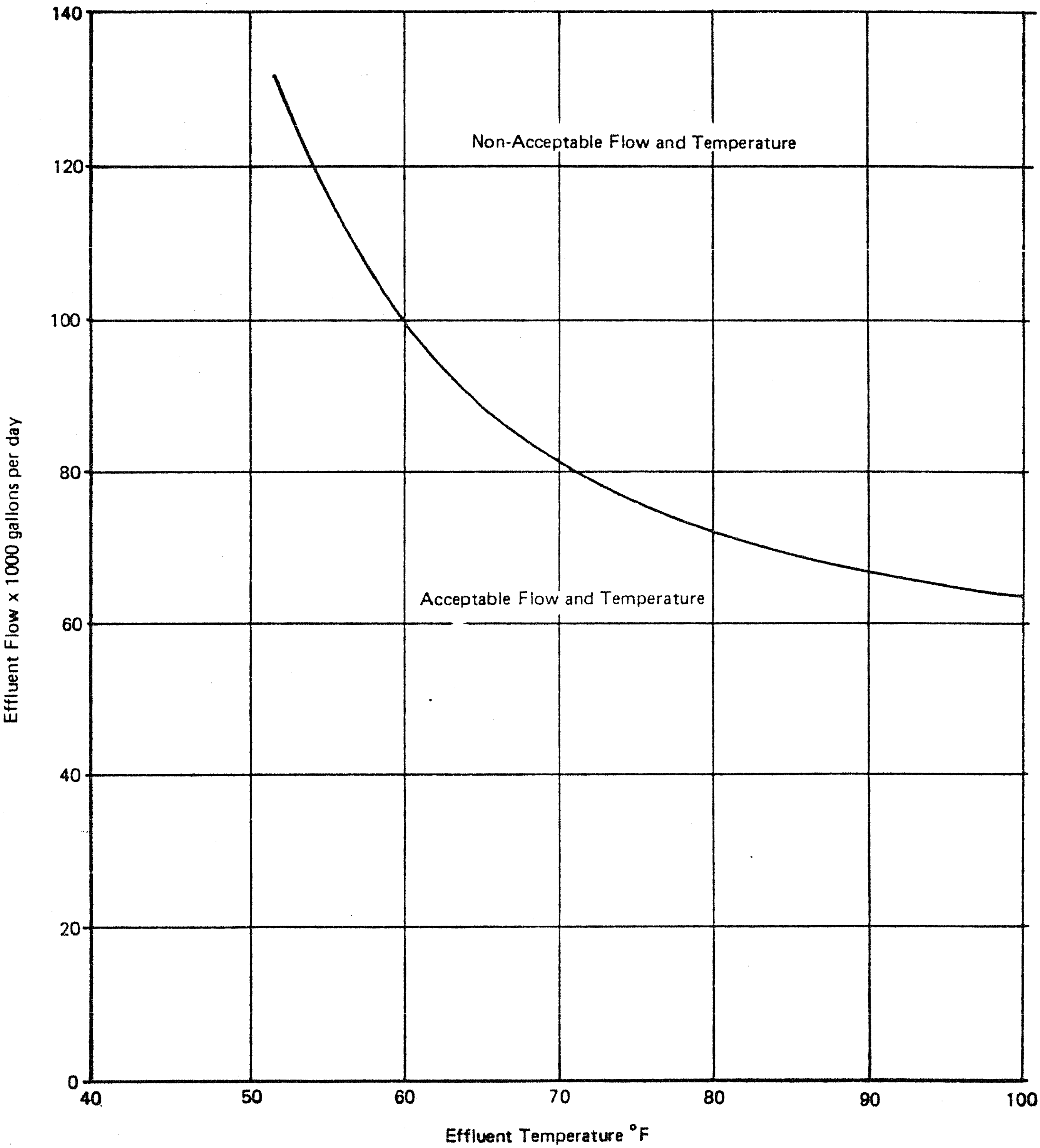


FIGURE 3
EFFLUENT FLOW - x1000 gpd
140
120
100
80
60
40
20
0
40
50
60
70
80
90
EFFLUENT TEMP - °F

Figure 1. Applicability Criteria for Discharge to Lakes



CORRESPONDENCE/MEMORANDUM — STATE OF WISCONSIN

Date: August 27, 1980 — File Ref: 3450

To: Joan Karnauskas

From: Duane Schuettpelz/Mike Gappa MJG

Subject: General Permits for Discharges to Storm Sewers

As a sequel to our earlier memo, it has also been brought to our attention that thermal discharges to storm sewers may not contribute as much heat to a receiving system as a direct discharge. In consideration of this fact, we have proposed the following changes: If an industry has a termal discharge to a storm sewer whose ultimate discharge is to a stream with a flow ($Q_{7,10}$) greater than 0.1 cfs, the volume discharged or the maximum allowable discharge temperature may be increased appropriately, depending on the distance the industry is from the receiving water. These changes are distance dependent and are illustrated by Figure A.

If an industry's point of discharge to a stream as described above is less than 1000 feet, then the proposed limits described in my memo of July 9, 1980 stand. If the point of discharge is greater than 1000 feet, but less than 5000 feet, the maximum allowable limits are essentially doubled. The limits are tripled if the industry is greater than 5000 feet from the receiving system.

The distance criterion suggested is, of course, difficult to determine in those situations where one does not know the route of the storm sewer system. In light of that, we suggest using a conservative estimate as the straight line distance between the discharge site and the receiving system. In this case, the receiving system being the nearest stream with a flow greater than 0.1 cfs.

In the case of Milwaukee County streams tributary to the Milwaukee River, we suggest the waters listed below be included as "receiving systems". All other surface streams (e.g. Underwood Creek, Lincoln Creek, Honey Creek, etc.) should not be regarded as such.

<u>Streams to be Used for Determing Distances from Outfalls in Milwaukee County</u>

Milwaukee River - all
Menomonee River - all
Little Menomonee River - all
Kinnickinnic River - downstream from 43rd Street

Based on this, the recommendation for streams expressed similarly to the earlier document, are as follows:

1. **Discharge location less than 1,000 feet from the nearest receiving stream: same as for direct discharge to stream.**

2. Discharge location greater than 1,000 feet but less than 5,000 feet from the nearest receiving stream:

   a. If Qeffluent/Qstream is greater than 0.10, the maximum temperature should not exceed 60°F.

   b. If Qeffluent/Qstream is less than 0.10, but greater than 0.05, the maximum temperature should not exceed 80°F.

   c. If Qeffluent/Qstream is less than 0.05, but greater than 0.03, the maximum temperature should not exceed 100°F.

   d. If Qeffluent/Qstream is less than 0.03, the maximum temperature should not exceed 120°F.

3. Discharge location greater than 5,000 feet from the nearest receiving stream:

   a. If Qeffluent/Qstream is greater than 0.15, the maximum temperature should not exceed 60°F.

   b. If Qeffluent/Qstream is less than 0.15, but greater than 0.10, the maximum temperature should not exceed 80°F.

   c. If Qeffluent/Qstream is less than 0.10, but greater than 0.05, the maximum temperature should not exceed 100°F.

   d. If Qeffluent/Qstream is less than 0.05, the maximum temperature should not exceed 120°F.

Lakes may be evaluated similarly to the stream situation. Figure B shows the criteria for use in discharges to lakes. As with streams, all discharges within a straight line distance of 1,000 feet to a lake should be evaluated as if there were a direct discharge. For a distance of 1,000 feet to 5,000 feet the effluent volume is doubled and if the distance is greater than 5,000 feet the volume is tripled.

This information together with the previous suggestions should provide some direction for consistent application of general permits for noncontact cooling water. Although there is little empirical data to support the assumptions made, we feel it is a reasonable attempt to screen these discharges. If you have any questions, please contact either of us.

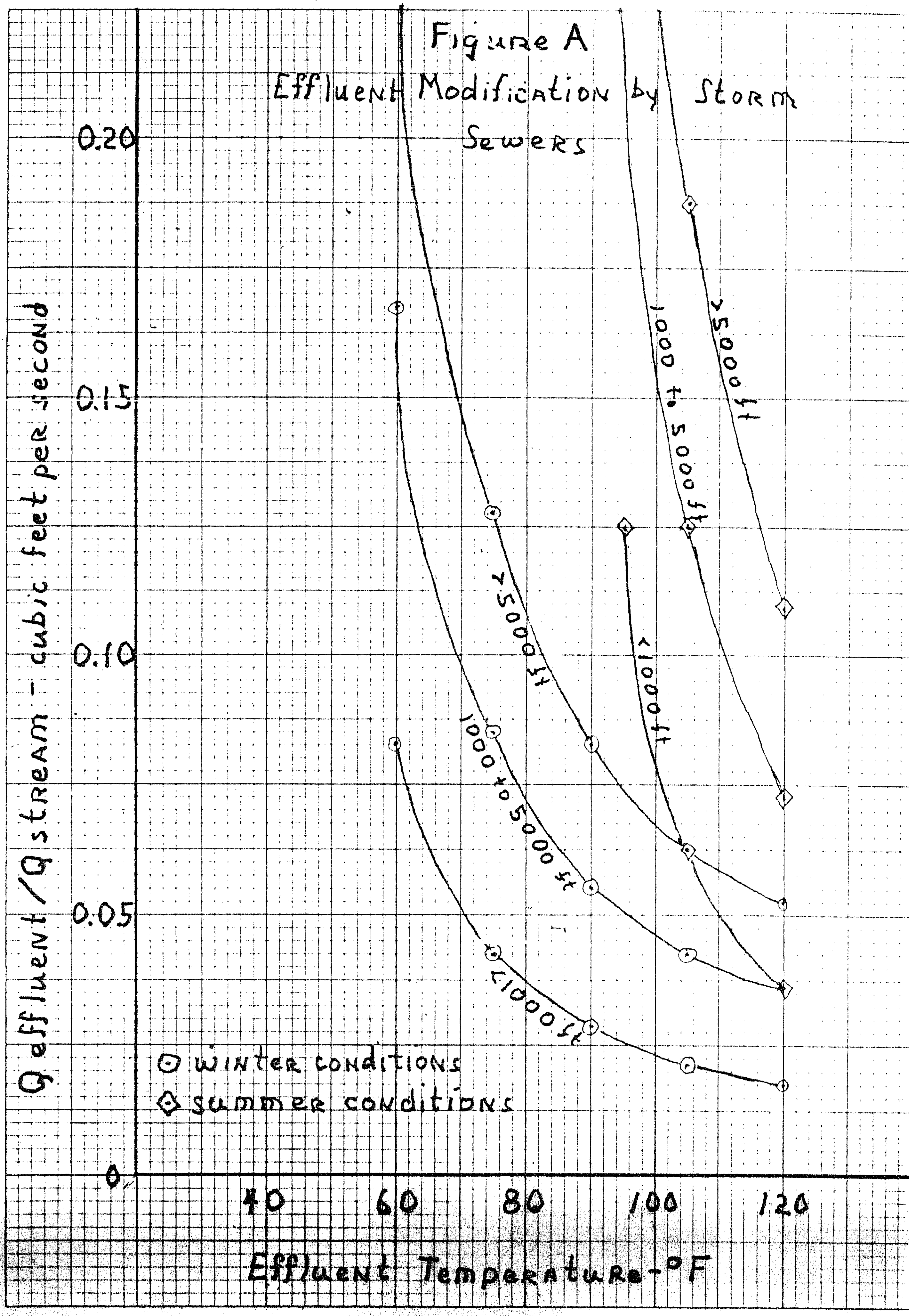


Figure A
Effluent Modification by Storm Sewers
Q effluent / Q stream - cubic feet per second
0.20
0.15
0.10
0.05
0
40
60
80
100
120
Effluent Temperature - °F
>5000 ft
1000 to 5000 ft
<1000 ft
winter conditions
summer conditions

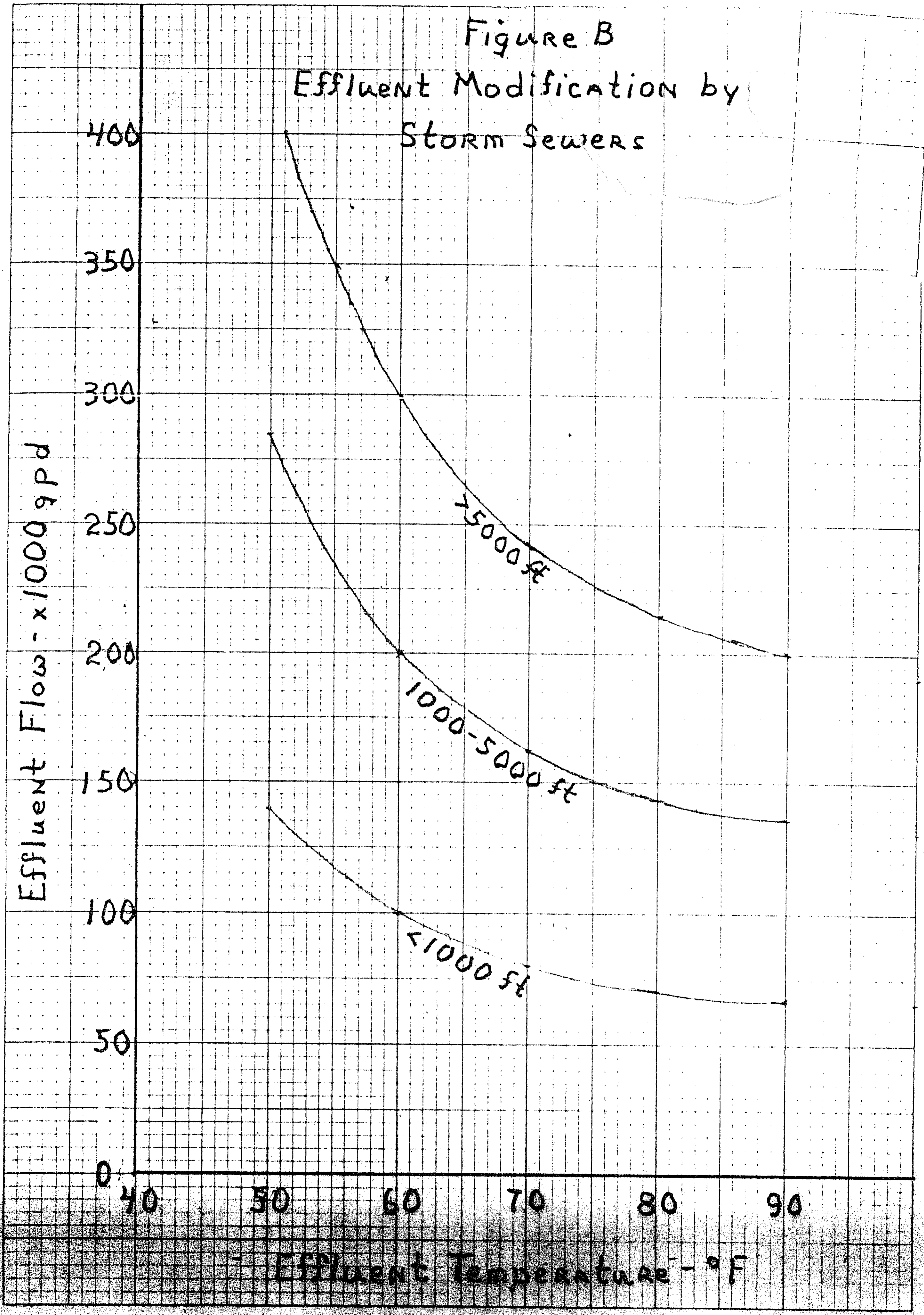


Figure B
Effluent Modification by
Storm Sewers
400
350
300
250
200
150
100
50
0
Effluent Flow - x1000 gpd
>5000 ft
1000-5000 ft
<1000 ft
40
50
60
70
80
90
Effluent Temperature - °F