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# SIMPLIFIED METHOD FOR DETERMINING FLOODWATER RETARDING STORAGE

The procedure is an approximation for determining the minimum required floodwater retarding storage for single-stage principal spillway structures. It will apply where there is reasonable assurance that a single-stage is more economical than an equally effective two-stage principal spillway. The method is based on use of the principal spillway mass curves (PSMC) included in Chapter 21 of SCS National Engineering Handbook, Section 4, Hydrology, issued in August 1972. The method is useful for estimating the minimum storage requirement for floodwater retarding structures in which the release rate and 10-day runoff are within the limits of the accompanying graphs (Figures 1 through 8) and the structure complies with the following provisions:

a. The structure has a single-stage principal spillway;

b. That on (shallow) reservoirs with gently sloping topography, where storage increases greatly with small increases in stage, this procedure may underestimate the required retarding storage volume. In this situation the PSMC should be routed;

c. That the release rate and 10-day runoff ($Q_{10}$) to be used with the graphs are based on the procedure in Chapter 21, NEH 4 (accounting for quick return flow, snowmelt and channel losses);

d. That the release in Figures 1 through 8 is further considered as a new rate, excluding the release from upstream structures in series.

The attached curves eliminate the necessity of plotting the PSMC. The runoff volumes at 1 day ($Q_1$) and at 10 days ($Q_{10}$) are determined and the ratio of $Q_1/Q_{10}$ is computed. This ratio and a selected average release rate through the principal spillway are used with Figures 1 through 8 to determine the minimum retarding storage requirements.

This simplified procedure is illustrated by its application to Examples 21.1 and 21.2 in Chapter 21.

Example 21.1 (page 21.12 of Chapter 21). In this situation, the climatic index is less than 1.00 and channel losses are considered.

1. Estimate the direct runoff for 1 and 10 days. This was determined to be $Q_1$ = 4.37 and $Q_{10}$ = 6.34 inches.

2. Compute the climatic index. In the example Ci = 0.603.

3. Estimate the net runoff. For the climatic index and drainage area size, the reduction factor is 0.75. Multiply $Q_1$ and $Q_{10}$ of step 1 by this factor to get net runoffs of 3.28 and 4.76 inches respectively.

4. Compute the $Q_1/Q_{10}$ ratio. From step 3, $Q_1/Q_{10}$ = 3.28/4.76 = 0.69.

5. Select an average release rate through the principal spillway. The maximum release rate through the principal spillway is 150 cfs which represents 10 csm for the 15 square mile drainage area. The average release rate for a single-stage structure was estimated to be 70 percent of this rate, or 7 csm.

6. Determine minimum floodwater retarding storage. Use Figure 6, attached, for the closest $Q_1/Q_{10}$ ratio of 0.70 and the applicable $T_c$ value of 7.1 hours. Note that Figure 6 covers a range in $T_c$ from 0.1 to 9.0 hours. With a $Q_{10}$ runoff of 4.76 inches and an average release rate of 7 csm, the floodwater retarding storage is 3.15 inches.

Example 21.2 (page 21.13 of Chapter 21). In this situation, the climatic index is greater than 1.00, and the addition of quick return flow is to be considered.

1. Estimate the direct runoff for 1 and 10 days. This was determined to be $Q_1$ = 2.94 and $Q_{10}$ = 6.68 inches.

2. Compute the $Q_1/Q_{10}$ ratio. From step 1 this is 2.94/6.68 = 0.44.

3. Determine the minimum quick return flow. Use the Ci value of 1.08 as determined and table 21.4 to obtain the quick return flow value of 1.20 csm.

4. Determine the new average discharge through the principal spillway. The maximum release rate for this situation has been assumed to be 10 csm, and the average release rate is estimated to be 70 percent of the maximum, or 7 csm. To get the net release rate, subtract the quick return flow inflow of 1.2 csm from the 7 csm, giving a net discharge of 5.8 csm through the principal spillway.

5. Determine minimum floodwater retarding storage. Enter Figure 3 with a ratio of $Q_1/Q_{10}$ = 0.40 which is the closest ratio to that determined in step 2, a $T_c$ of 2.0 hours, and $Q_{10}$ of 6.68 inches. Note that Figure 3 covers a range in $T_c$ from 0.1 to 9.0 hours. Figure 3 gives a value of 4.60 inches of retarding storage for a

net release of 5.8 csm. Then enter Figure 4 with the ratio of $Q_1/Q_{10}$ = 0.50 and find the value of 4.50 inches of storage. By interpolation for a $Q_1/Q_{10}$ = 0.44 the minimum retarding storage would be 4.54 inches.

Figures 1 to 8, inclusive, were developed for $T_c$'s of 9 hours or less. When a greater $T_c$ is to be used, it is suggested that the PSMC be routed.

Storage requirements for various release rates that should be considered in conjunction with various downstream channel and flood plain situations can be quickly estimated by this method.

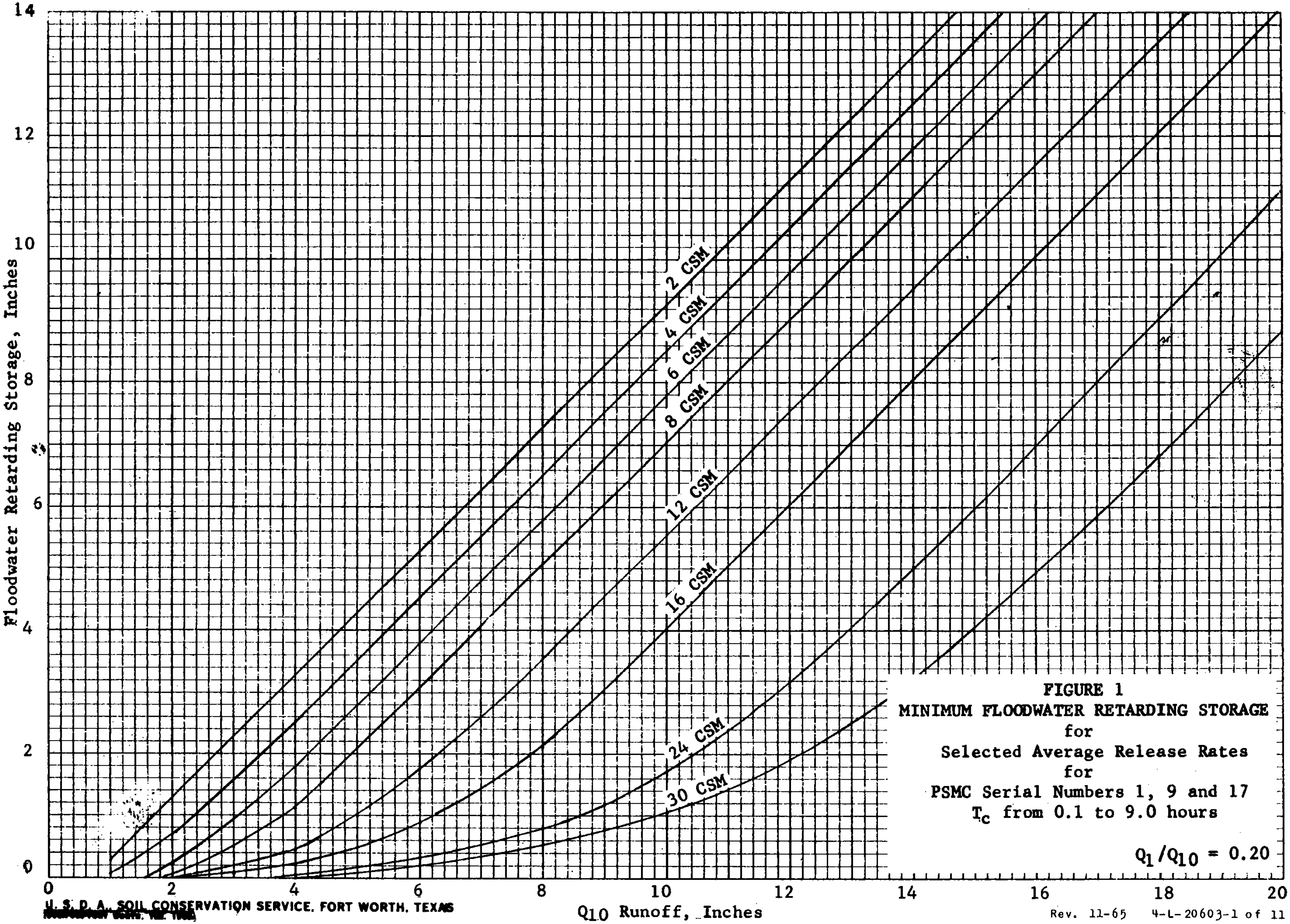



**FIGURE 1**
**MINIMUM FLOODWATER RETARDING STORAGE**
for
Selected Average Release Rates
for
PSMC Serial Numbers 1, 9 and 17
$T_c$ from 0.1 to 9.0 hours

$Q_1/Q_{10} = 0.20$

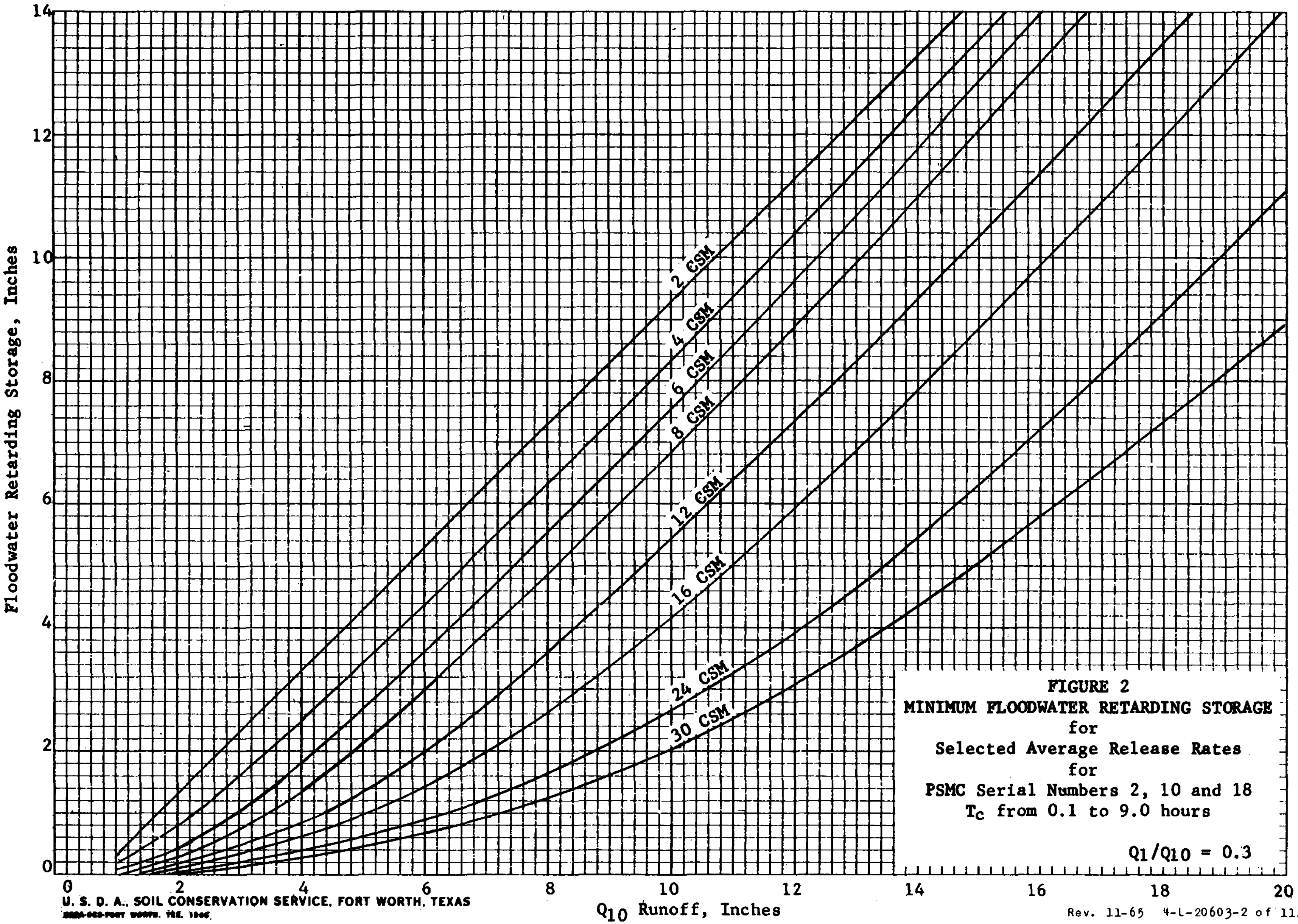



**FIGURE 2**
**MINIMUM FLOODWATER RETARDING STORAGE**
**for**
**Selected Average Release Rates**
**for**
**PSMC Serial Numbers 2, 10 and 18**
**$T_c$ from 0.1 to 9.0 hours**

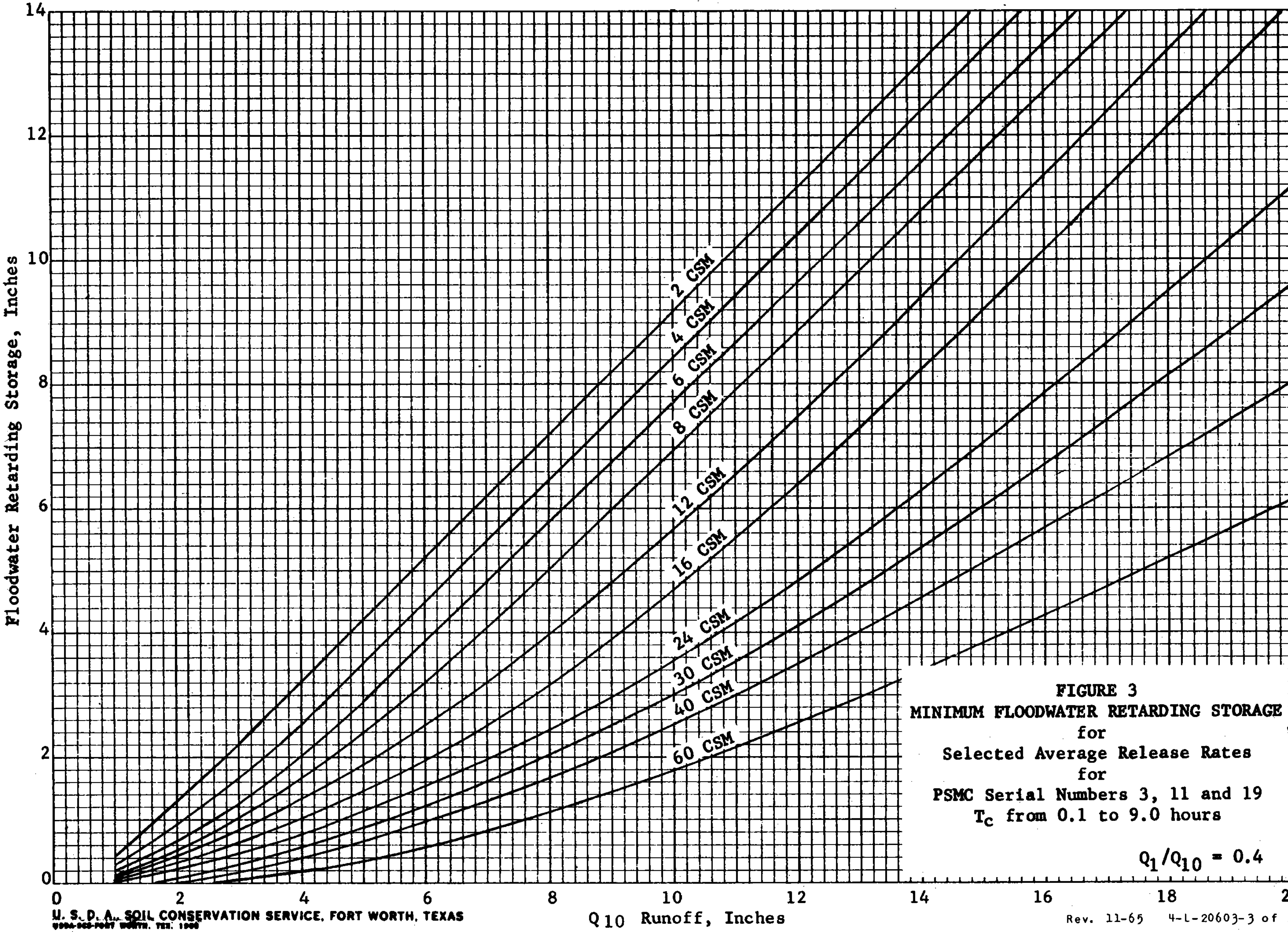



**FIGURE 3**
**MINIMUM FLOODWATER RETARDING STORAGE**
**for**
**Selected Average Release Rates**
**for**
**PSMC Serial Numbers 3, 11 and 19**
**$T_c$ from 0.1 to 9.0 hours**

**$Q_1/Q_{10}$ = 0.4**

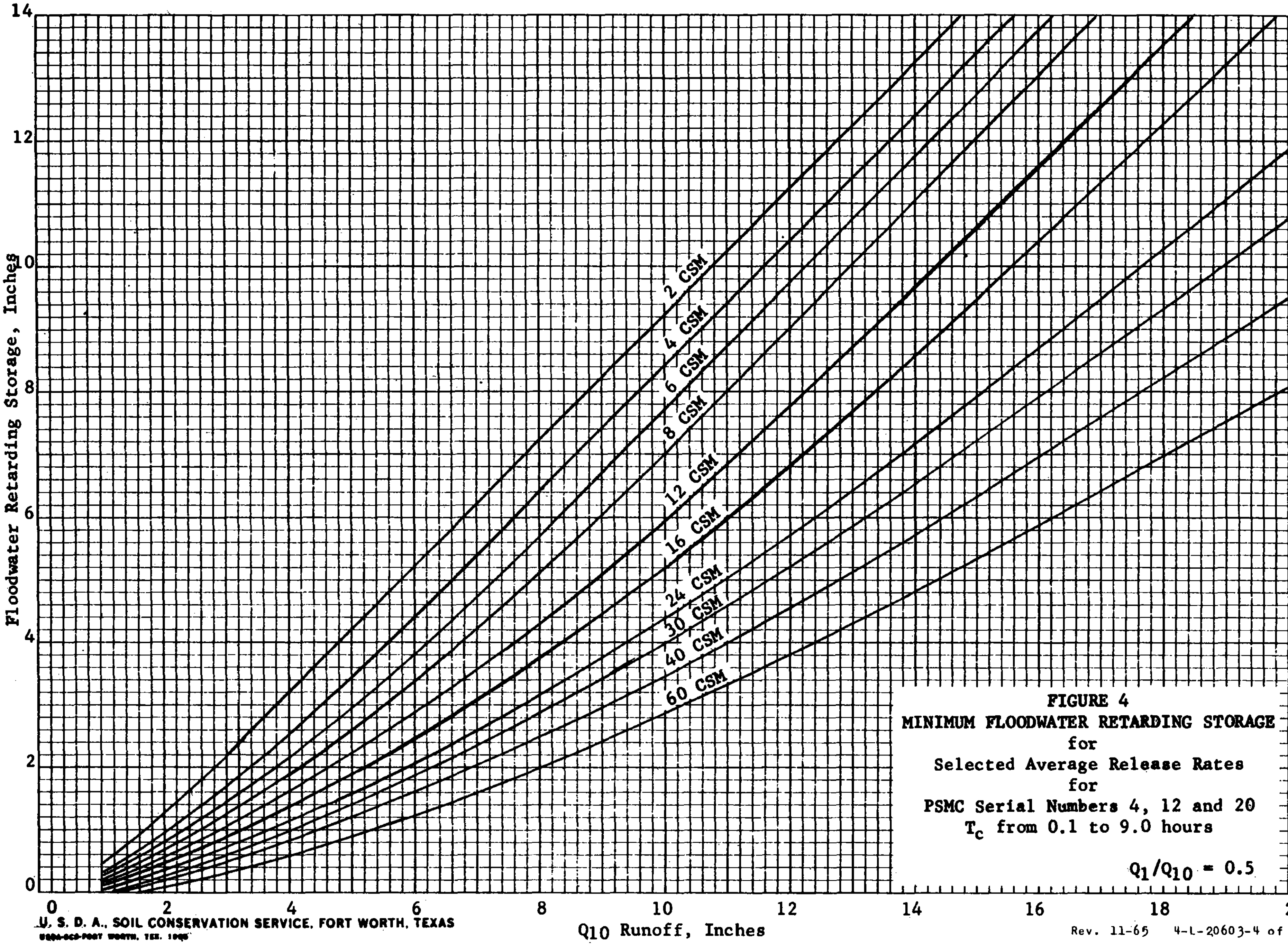


FIGURE 4
MINIMUM FLOODWATER RETARDING STORAGE
for
Selected Average Release Rates
for
PSMC Serial Numbers 4, 12 and 20
$T_c$ from 0.1 to 9.0 hours
$Q_1/Q_{10} = 0.5$
2 CSM
4 CSM
6 CSM
8 CSM
12 CSM
16 CSM
24 CSM
30 CSM
40 CSM
60 CSM
Floodwater Retarding Storage, Inches
$Q_{10}$ Runoff, Inches
0
2
4
6
8
10
12
14
16
18
20

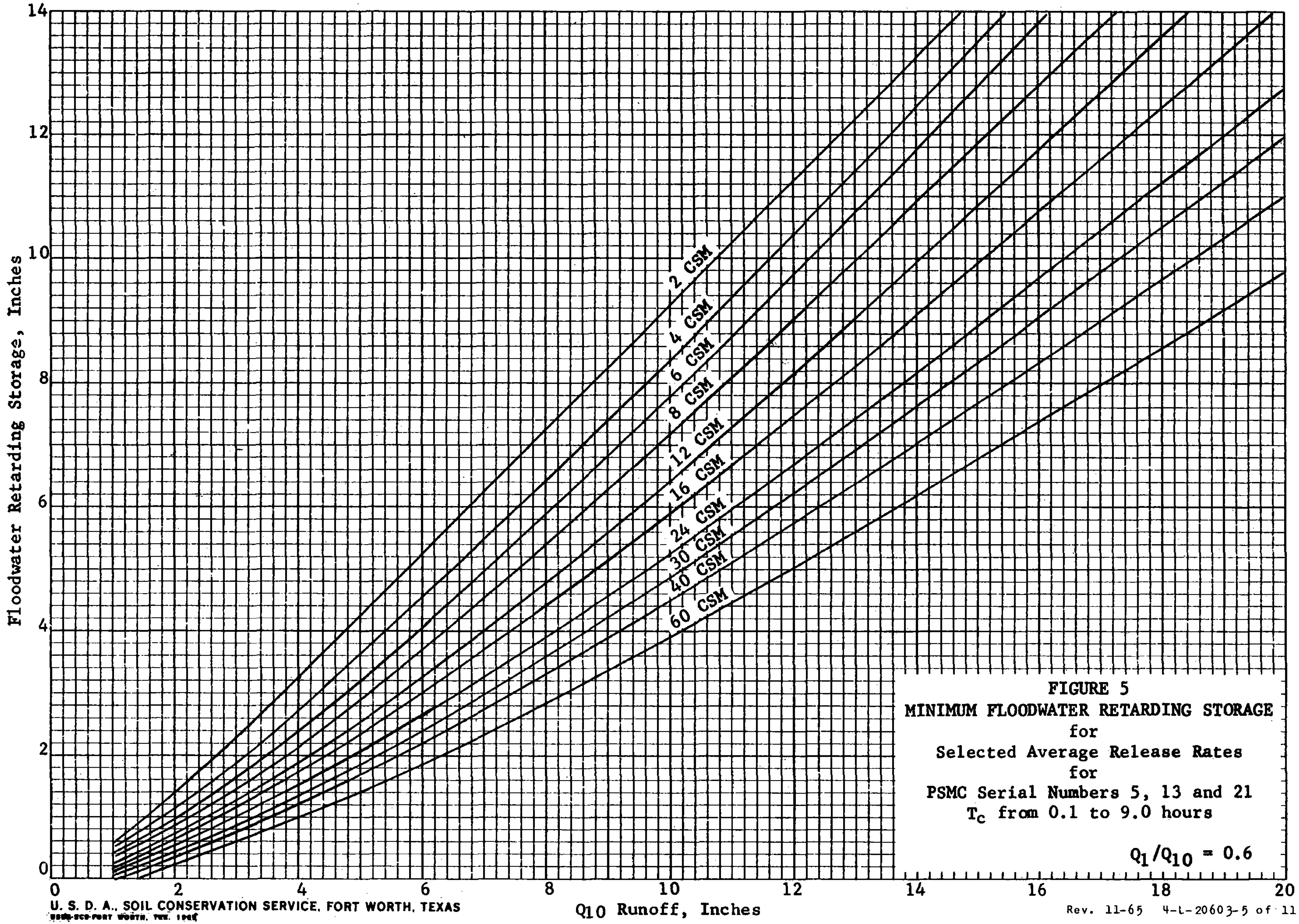



FIGURE 5
MINIMUM FLOODWATER RETARDING STORAGE
for
Selected Average Release Rates
for
PSMC Serial Numbers 5, 13 and 21
$T_c$ from 0.1 to 9.0 hours

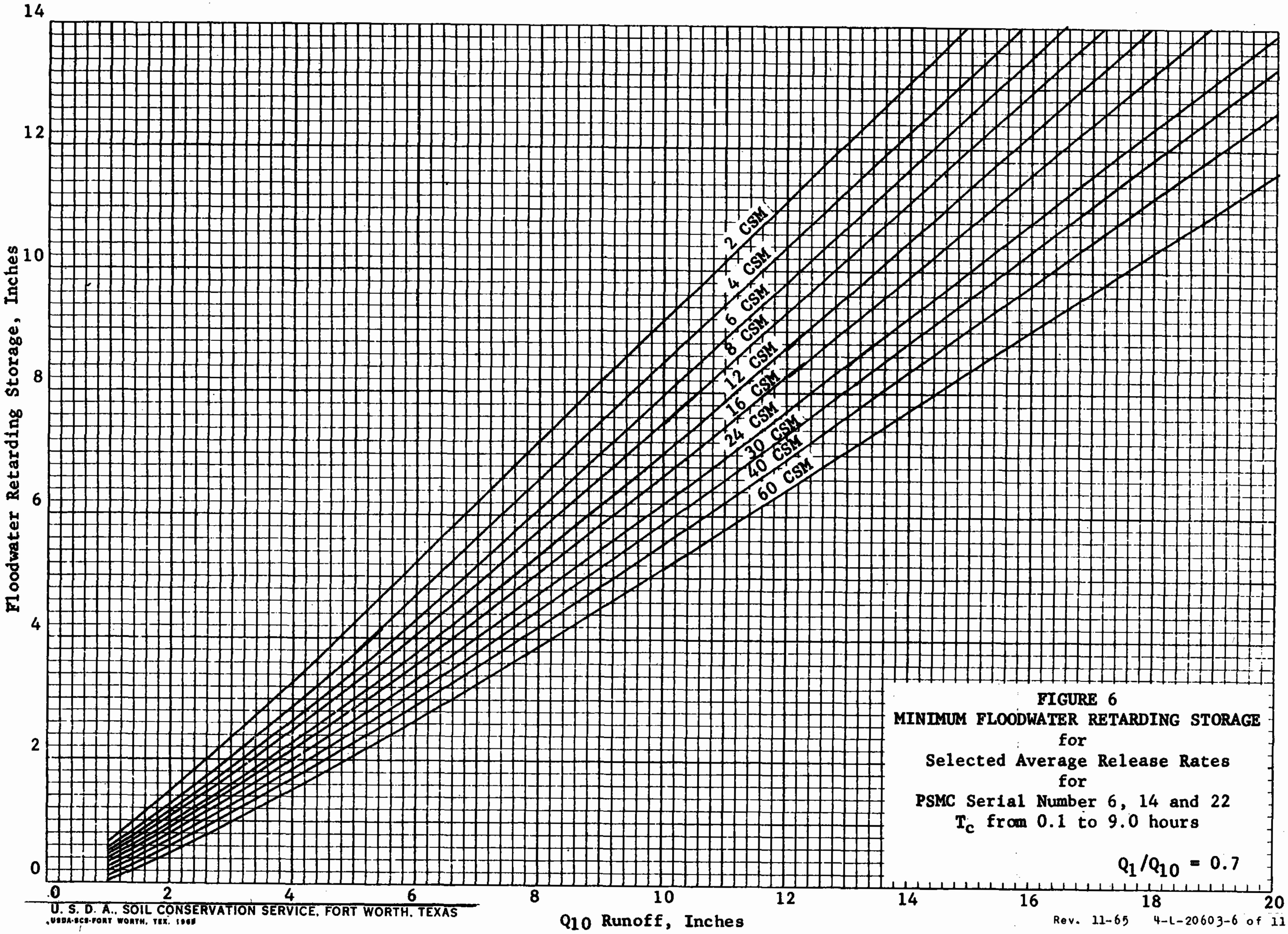
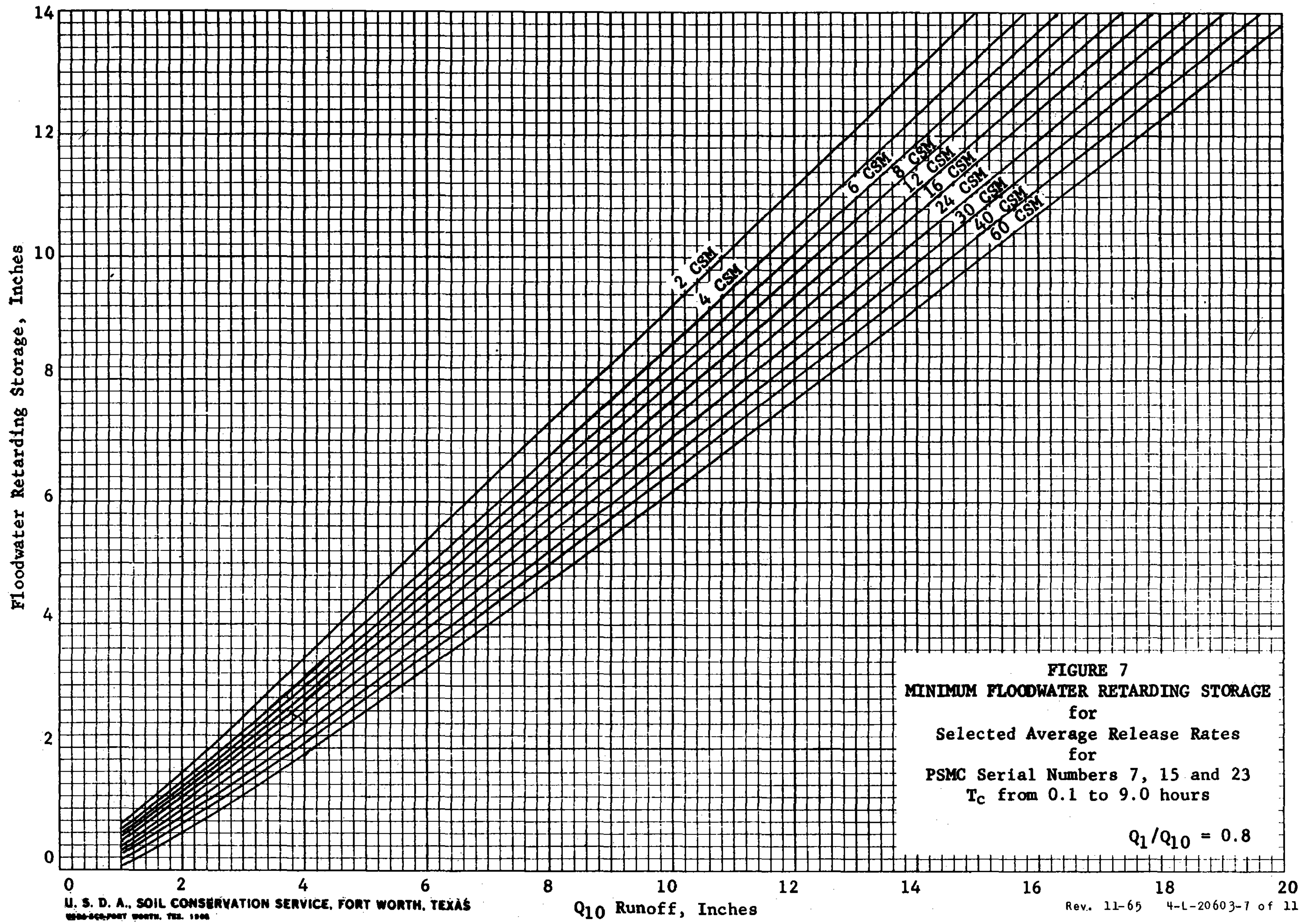



**FIGURE 6**
**MINIMUM FLOODWATER RETARDING STORAGE**
**for**
**Selected Average Release Rates**
**for**
**PSMC Serial Number 6, 14 and 22**
**$T_c$ from 0.1 to 9.0 hours**

$Q_1/Q_{10} = 0.7$




U. S. D. A., SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS

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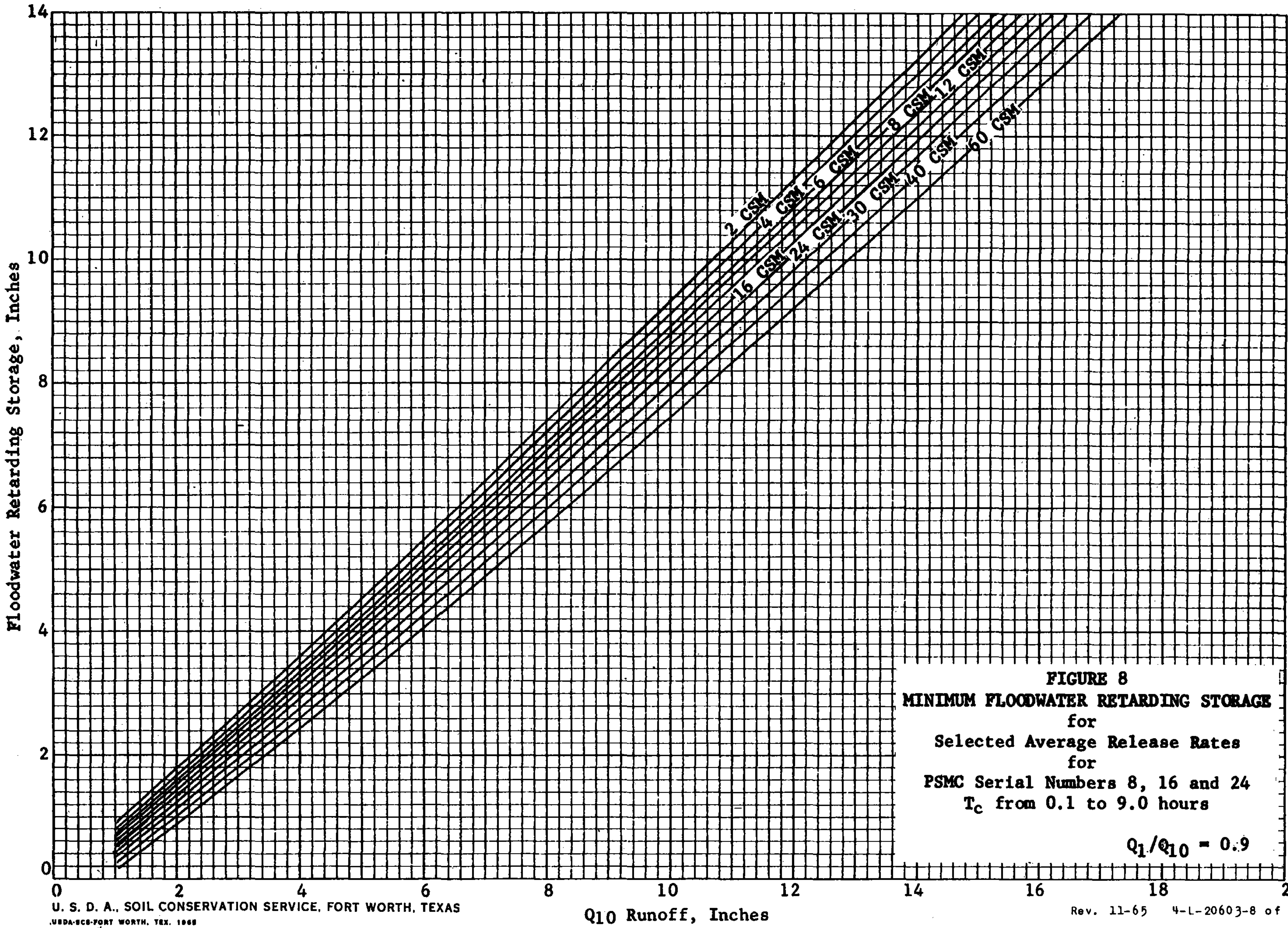


**FIGURE 8**
**MINIMUM FLOODWATER RETARDING STORAGE**
**for**
**Selected Average Release Rates**
**for**
**PSMC Serial Numbers 8, 16 and 24**
**$T_c$ from 0.1 to 9.0 hours**

$Q_1/Q_{10} = 0.9$