APPENDIX 28-a

Subsurface drains are not generally designed to flow under pressure and the hydraulic gradient is parallel with the grade line. Consequently, the flow is considered to be open channel and Manning's Equation can be used. The metric conversion of this appendix has been delayed until standardized metric nomographs and charts are readily available. Typical metric conversions are listed where applicable. The required drain size can be determined by the following procedure:

1. Determine the flow the drain must carry.

2. Determine the gradient of the drain

3. From Table 28-3, determine "n" for the type of drain pipe to be used. Choose the correct Table (28-4 through 28-6) for the "n" just determined.

4. Enter the appropriate plate with the gradient of the pipe and the flow in the pipe. The intersection of the two lines must be to the right of the line for 1.4 ft/sec. If it is not, increase the gradient or flow capacity or both.

Example 1 -

Given:

A random subsurface drain is to be installed on a 1.0% grade, 700 feet in length, and using corrugated plastic pipe.

Calculate: The required size of the drain pipe.

Solution:

From the BMP, the required capacity of the pipe is:

$$1.5\ ft^3/sec/1000\ ft$$

$$Capacity = \frac{700 ft.}{1000 ft.} \times 1.5 ft.^3/sec = 1.05 ft^3/sec$$

From Table 28-3, n = 0.015 for corrugated plastic pipe.

From Table 28-5, choose a 8-inch pipe (200 millimeter).

Example 2 -

Given:

A relief drain installed in a gridiron pattern of 8 laterals, 500 feet long, 0.5% grade, and 50 feet on centers. A main 400 feet in length on a 0.5% grade will connect to the laterals. Use bitumenized fiber pipe for the main and laterals.

Calculate: The required size of the drain pipe.

Solution:

The drainage area for each lateral is 25 feet on either side of the pipe times the length. Therefore:

$$\frac{50\,ft \times 500\,ft}{43{,}560\,\frac{ft^2}{acre}} = 0.57\,acre$$

From the BMP, the drains must remove a minimum of 1 inch of groundwater in 24 hours or 0.042 cfs/acre.

0.042 cfs/acre x 0.57 acre = 0.02 cfs

From Table 28-3, n = 0.013 for bituminized fiber pipe.

From Table 28-5, a 4-inch pipe (100 millimeter) must be used for the laterals.

The first 25 feet of the main will drain 25 feet on either side of the pipe. The remaining 375 feet will drain only 25 feet on the side opposite from the laterals. In addition, the main will drain the laterals.

Drainage from main:

$$\frac{25ft \times 50ft}{43,560ft^2/acre} + \frac{375ft \times 25ft.}{43,560ft^2/acre} = 0.24acre$$

Drainage from laterals:

8 x 0.57 acre = 4.56 acre

Total = 0.24 + 4.56 = 4.8 acre

Required capacity:

0.042 ft./sec./acre x 4.8 acre = 0.20 cfs

From Table 28-4, choose a 5-inch pipe (125 millimeter) for the main.

TABLE 28-3
"n" VALUES FOR SUBSURFACE DRAIN PIPES

Composition of Pipe or Tubing	"n" Value
Asbestos Cement	0.013
Bitumenized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

Spacing of Relief Drains

If the necessary information is known, the following equation can be used to calculate drain spacing in lieu of the recommended standard:

$$S = \sqrt{\frac{4k(M^2 + 2AM)}{q}}$$

Where,

S = drain spacing, feet

k = average hydraulic conductivity, inches per hour (for practical purposes, hydraulic conductivity is equal to permeability).

M = vertical distance, after drawdown, of water table above drain at mid-point between lines, feet.

A = depth of barrier below drain, feet.

q = drainage coefficient, rate of water removal, inches/hour (in/hr).

Spacing of Interceptor Drains -

If one interceptor drain is not sufficient, the spacing of multiple drains can be calculated by the following equation:

$$Le = \frac{ki}{q}(de - dw + W_2)$$

Where,

Le = the distance downslope from the drain to the point where the water table is at the desired depth after drainage, feet. The second drain should be located at this point.

k = the average hydraulic conductivity of the subsurface profile to the depth of the drain, in./hr.

q = drainage coefficient, rate of water removal, in./hr.

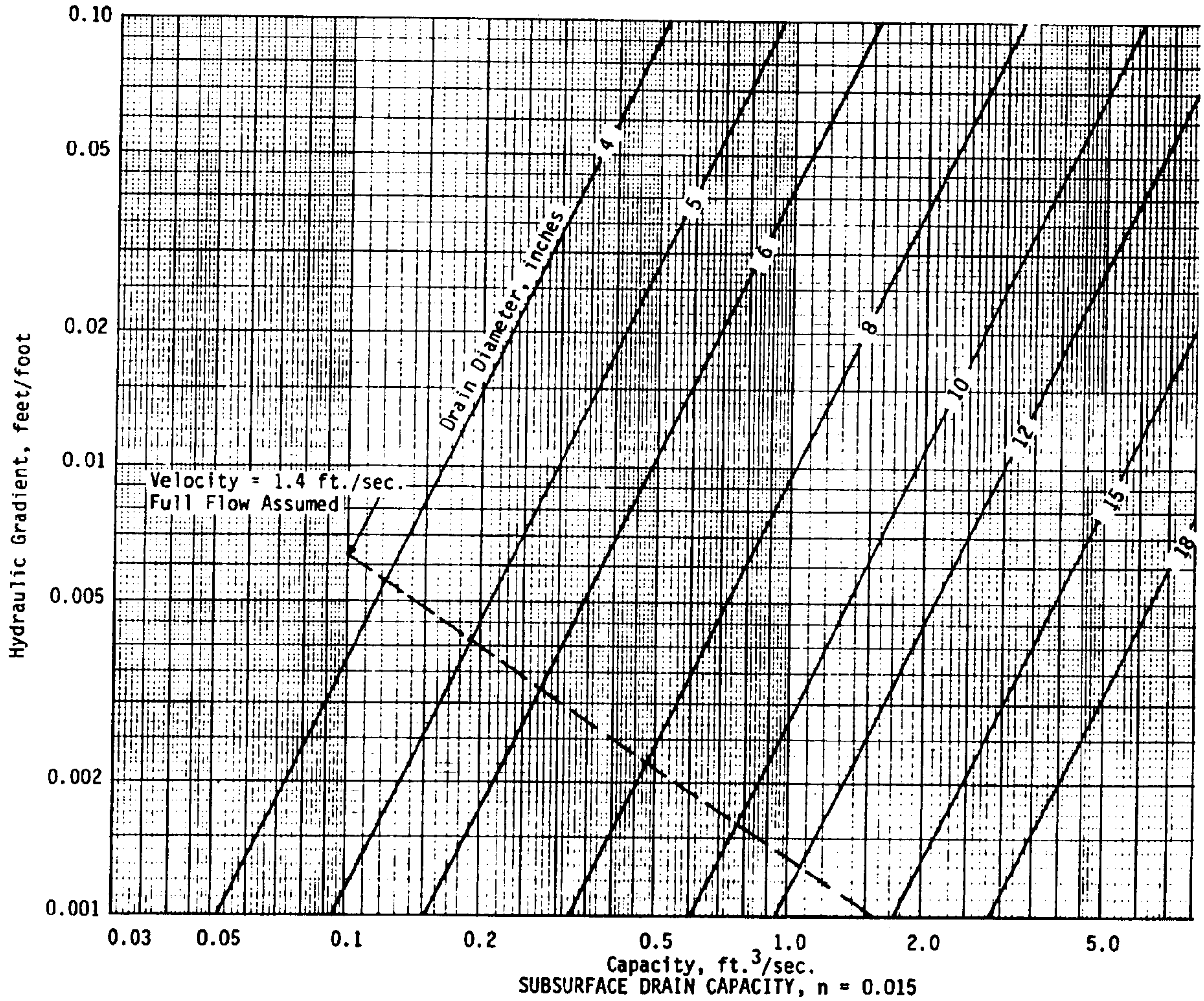
i = the hydraulic gradient of the water table before drainage, feet/foot.

de = the effective depth of the drain, feet.

dw = the desired minimum depth to water table after drainage, feet.

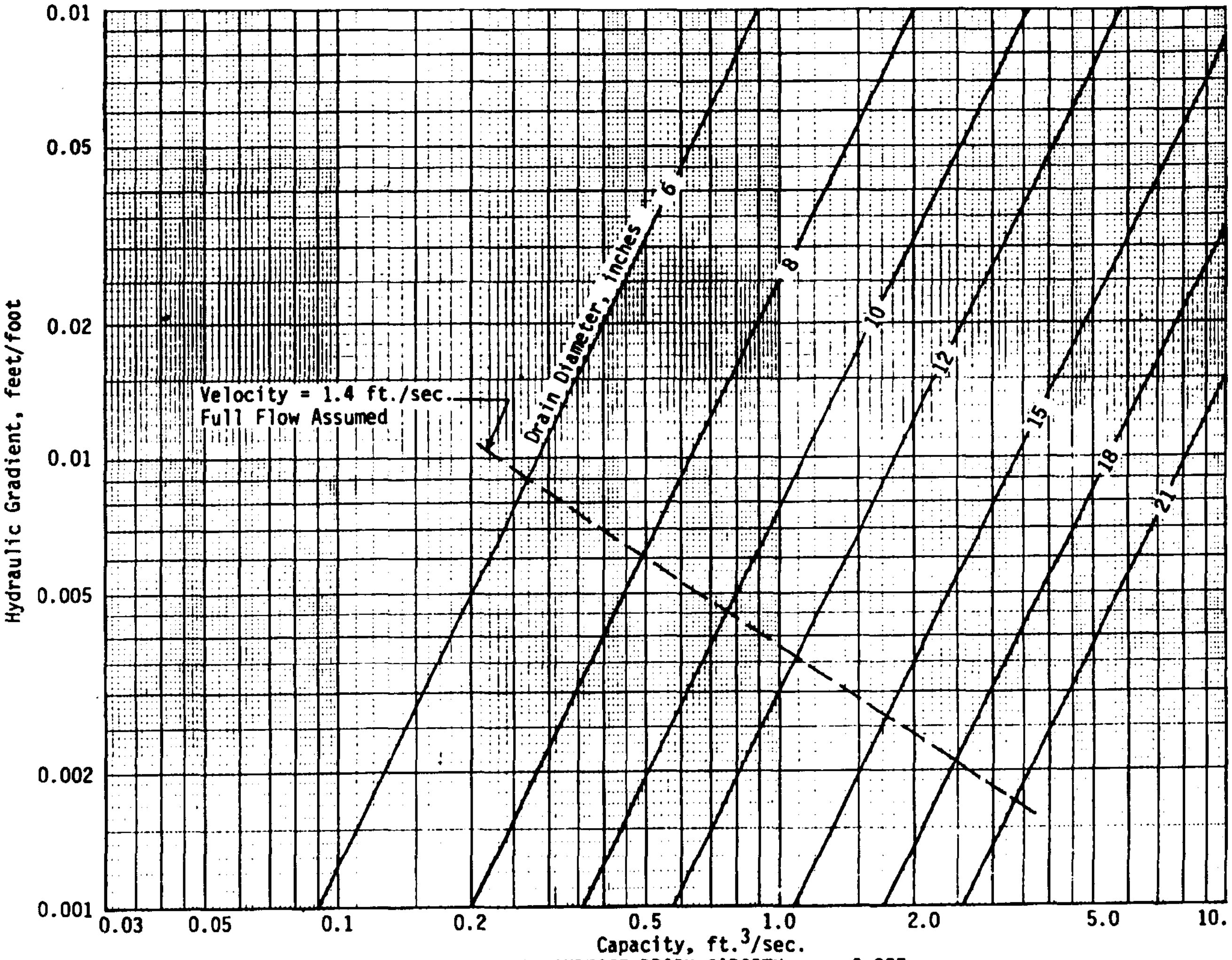
W_2 = the distance from the ground surface to the water table, before drainage, at the distance (Le) downslope from the drain, feet.

TABLE 28-5: SUBSURFACE DRAIN CAPACITY, n = 0.015



Typical Metric Conversions:
Cubic meters per second = cubic feet per second x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4

TABLE 28-6: SUBSURFACE DRAIN CAPACITY, n = 0.025



SUBSURFACE DRAIN CAPCITY, n = 0.025

Typical Metric Conversions:
Cubic meters per second = cubic feet per second x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4