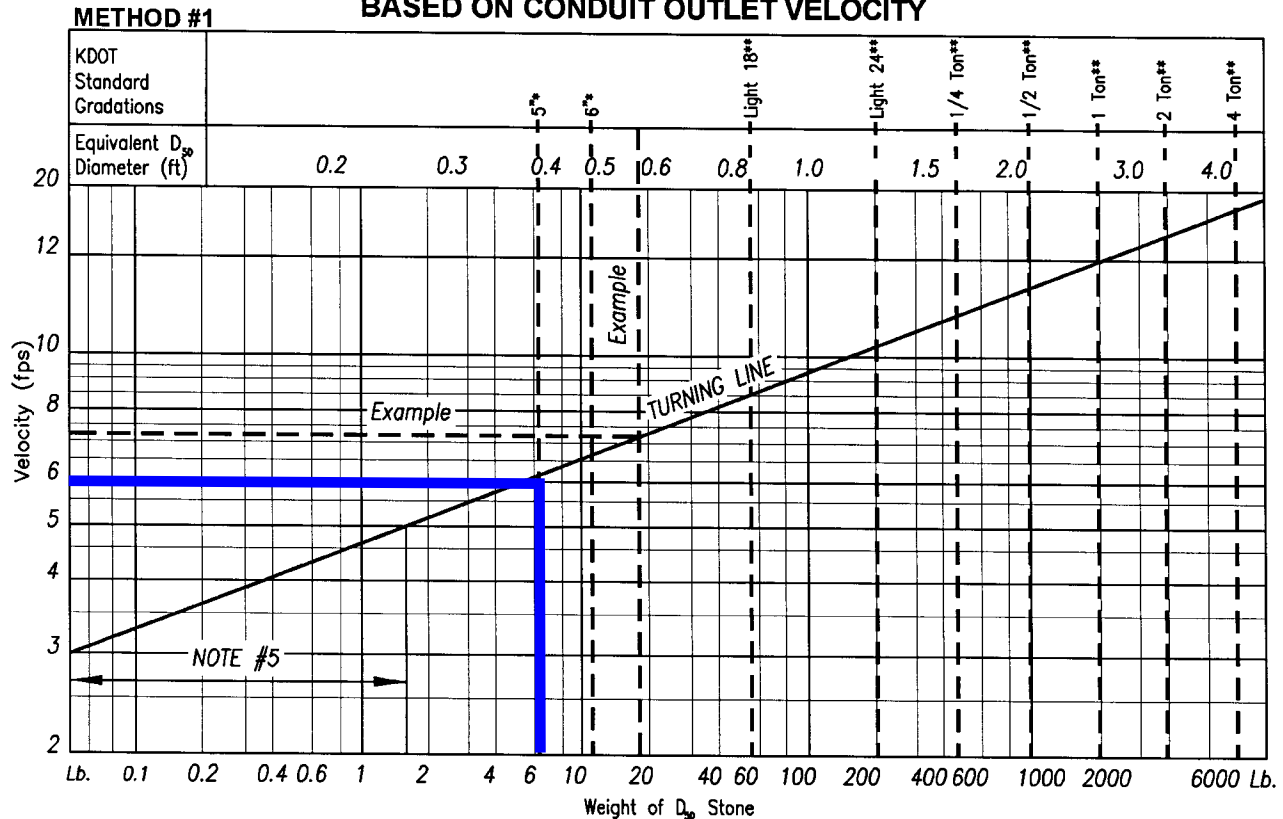


**APPROXIMATE SIZE OF RIPRAP REQUIRED TO RESIST MOVEMENT  
BASED ON CONDUIT OUTLET VELOCITY**



Example: A 15" pipe has an exit velocity of 7.2 fps with a tail water depth of 30" and channel slope of 2%. Acceptable Riprap Size:  $D_{50}$  = 0.58', W = 19lbs., KDOT Gradation = Light 18", Max. Stress =  $(62.4)(2.5)(.02) = 3.2$  psf < 5 psf O.K.

How to use this nomograph:

**Method #1**

1. Find the exit velocity at the outlet.
2. Intersect with Turning Line.
3. Read top and bottom scales to determine approximate weight and size of stone.
4. Read top scale to determine KDOT gradation of stone.
5. Compare to see if design sizes meet or exceed the sizes calculated by method 2 on this sheet.

**Method #2**

1. Calculate Maximum Shear Stress (Using Table).
2. Compare Maximum Shear Stress to Allowable Shear Stress from Table. Maximum shear stress must be equal or less than allowable stress or larger stone is required.

**General Notes:**

1. This nomograph allows the user to approximate the  $D_{50}$  stone size of riprap for conduit outlet protection based on the exit velocity of the conduit.
2. This nomograph is based on Figure 2.3.12-6a, "Guide for Estimating Stability of Channels and Large Rocks", KDOT Design Manual, Volume III, Bridge Section.
3. Conduit velocity as calculated by Manning's Equation.
4. Estimations based on this nomograph are only valid for velocities between 5 fps and 15 fps. Outlets with higher velocities should be investigated further.
5. Riprap is not normally required for velocity below 5 f.p.s. Consider grass lining materials.

**METHOD #2 - MAX. SHEAR STRESS**

$$\tau_c = \gamma ds$$

$$\gamma = 62.4 \text{ pcf}$$

$$d = \text{depth\_of\_tailwater\_ (ft)}$$

$$s = \text{slope\_at\_exit\_ (ft / ft)}$$

**Allowable Shear Stress for KDOT Standard Gradations**

**Heavy Series**

4 Ton	27 psf
2 Ton	21 psf
1 Ton	16 psf
1/2 Ton	13 psf
1/4 Ton	10 psf

**Light Series**

Light 24"	6 psf
Light 18"	5 psf

**Stone for Ditch Lining**

6"	3 psf
5"	2 psf

KDOT Gradations are based on the stone specifications from the KDOT Standard Specifications for State Road and Bridge Construction (1990) – \* Table 12b Stone for Aggregate Ditch Lining, and \*\* Table 11 Stone for Riprap.