Picture the flow in the annulus as a series of nested tubes. Velocity varies as if these tubes were sliding past one another while moving in the same direction. Flow near the wall and near the drill string is at a slower rate than near the center. Cuttings near the center can be vigorously lifted while cuttings near the wall and drill string actually slip in a net fall. Rotation of the drill string changes the flow pattern near the drill string and materially enhances particle lift.

For example, if you use a 3 1/2-inch ID and 4-inch outside diameter (OD) pipe to drill a 9-inch hole and pump 200 GPM, the velocity of the ID pipe is 400 feet per minute (fpm) and the velocity of the OD pipe is 75 fpm. To test cumulation at these rates (bit is 300 feet deep), pump down a marker (strew or oats). The majority of the material should take 4 minutes and 45 seconds to return (300 feet at 400 fpm takes 45 seconds and 300 feet at 75 fpm takes 4 minutes). To clean all the cuttings from a 300-foot depth with an average up-hole mud velocity of 75 fpm will require more than four minutes of pumping. Consider this concept regarding sampling cuttings from the return mud.

If cuttings remain in the annular space between the drill rod and borehole wall when circulation is stopped, they will produce a denser fluid than the clean drilling mud inside the drill rods. The denser mud in the annular space will then flow down the hole and force the clean drilling mud up the drill rods. This causes a *geyser effect*, and the drilling mud may shoot several feet into the air until the mud columns equalize. (Some drillers mistake this for a *caving hole.)* If this situation happens when adding drill rods, the circulation time should be increased after drilling down the next rod. Use the following formula to calculate the annular space volume

$$V = \frac{(D^2 - d^2)(5.5)(L)}{1,000}$$

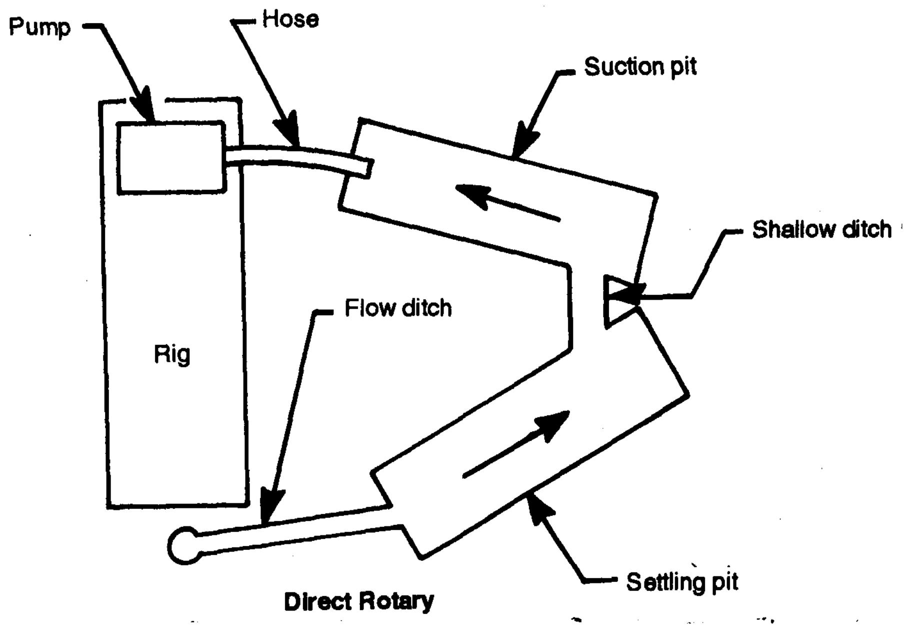
where—

V = annular space volume, in cubic feet.
D = hole diameter or bit size, in inches (Figure 5-4, page 5-8)
d = drill hole or drill steel collar diameter, in inches (Figure 5-4, page 5-8)
L = hole length, in feet (Figure 5-4, page 5-8)

(9) Mud Pits. Rotary chilling preparation is the design and excavation of an in-ground mud pit or installation of a portable mud pit and the mixing of the drilling fluid. For standard drilling operations that use well-completion kits, well depths could range from 600 to 1,500 feet. For wells up to 600 feet using the 600-foot WDS, use portable mud pits. For wells over 600 feet, use dug mud pits. In either case, you will have to clean cuttings from the pits as drilling progresses. Design considerations include the anticipated depth and diameter of the drill hole, since the material cuttings from the hole will be deposited in the mud pits.

The volume of the pits must equal the volume of the completed hole. Therefore, during drilling, you will have to clean the cuttings from the pits frequently. If you have a backhoe to dig and clean the pits, size and depth of the pits are not critical. If you must dig and clean the pits with shovels, width and depth are important. Drilled cuttings should drop out of suspension in the mud pit. Therefore, long, narrow pits are better. Figure 5-8 shows a mud-pit layout and a chart depicting mud pit capacities and dimensions.

NOTE: Portable mud pits will require constant cleaning.



A. Rectangular mud pit

Volume (gal) = length (ft) x width (ft) x depth (ft) x 7.5

B. Pit with sloping sides

Volume (gal) = length (ft) x average width (ft) x depth (ft) x 7.5

$$\text{Average width} = \frac{\textit{width at top} + \textit{width at bottom}}{2}$$

C. Ideal dimensions for two basic pits

In general, the pit should be three times the volume of the finished borehole. Each mud pit should have a settling section and a suction section. The dimensions of the settling pit can be determined by using a basic equation to establish the width. Once the width is known, the length and depth can be calculated.

$$\text{Width} = \sqrt[3]{\frac{\textit{hole volume (gal)} \times 2}{2.125 \times 7.5}}$$

Length = 2.5 x width
Depth = 0.85 x width
For the suction pit, the length is 1.25 x width and the depth is 0.85 x width.

Figure 5-8. Mud-pit layout with pit capacities and dimensions

Mud pits are part of the circulating system for mixing and storing drilling fluid and for settling cuttings. The ground slope will affect site layout. Pit design can enhance pit performance. Most drillers agree&t using multiple pits is best when dropping drill cuttings from the fluid. The volume of the pit should be one and one-half to three times the volume of the hole. This will provide fluid to fill the hole and an excess volume to allow stilling and settlement or processing before returning to the drill string. A volume of three times the hole volume will minimize drilling-fluid and mud-pit maintenance. Figure 5-9 (page 5-20) shows a mud pit that is prepared on-site. Figure 5-10 (page 5-20) shows a portable mud pit.