



FIGURE 2.—Combinations of mean bottom water velocity (V) and passage length (L) that spawning and nonspawning brown trout did and did not pass through. The nonlinear regression lines are fits to the strenuous passage combinations indicated by the open squares. Each passage symbol indicates at least one fish successfully completed passage.

lengths is that some groups did not face as strenuous passage conditions as spawning rainbow trout and not because these groups have less swimming ability.

In other studies, the swimming abilities of rainbow trout and Arctic grayling increased with total body length when the fish were tested in culverts (MacPhee and Watts 1976) and swimming stamina devices (Fry and Cox 1970; Jones et al. 1974). Because we found trout of different lengths passing through similar hydraulic conditions, there appears to be no relation between total length of trout and passage ability for the lengths of fish studied here. This lack of relation may have been the result of smaller fish being able to use lower-velocity zones near the bottom or sides of the culverts more efficiently than larger fish.

We used equation (1) to convert the relation of

strenuous passage for spawning rainbow trout in Figure 1 to 0.6-depth velocities for comparisons with results from other studies (Table 2). The maximum velocities we found are similar to those recommended previously for nonanadromous salmonids for passage lengths of 30 m or less and greater than those values recommended earlier for passage lengths greater than 30 m. In contrast, our maximum velocities for nonanadromous salmonids are about one-half the velocities recommended by Kay and Lewis (1970) for anadromous salmonids throughout the range of passage lengths we studied. This ratio has been previously implied in the recommendations made by Gebhards and Fisher (1972) and Lauman (1976) for maximum allowable velocities in culverts.

After a passage length of about 10 m, our study indicates that the slope of the strenuous-passage

