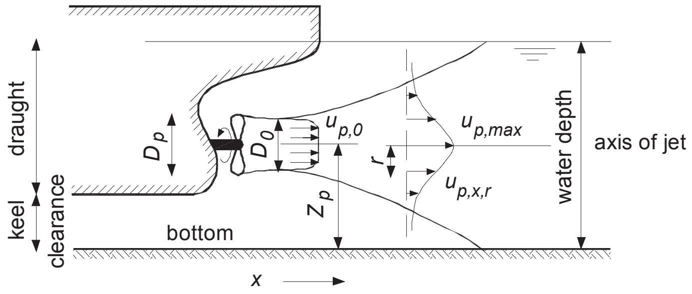

Figure 4.86 *Water movements due to a main propeller*

Equations 4.187 to 4.190 can be used to estimate the time-averaged current velocities in propeller jets caused by main propellers (see Figure 4.86, for ship speed V_s = 0 or otherwise relative to the ship when underway) or caused by bow or stern thrusters.

Velocity behind propeller (see Equation 4.187):

$$u_{p,0} = 1.15\left(P/\rho_w D_0^2\right)^{1/3} \quad (4.187)$$

Velocity along jet axis (see Equation 4.188):

$$u_{p,axis}(x) = a\, u_{p,0}\left(D_0/x\right)^m \quad (4.188)$$

Velocity distribution (see Equation 4.189):

$$u_p(x,r) = u_{p,axis}(x) \cdot \exp\left[-br^2/x^2\right] \quad (4.189)$$

Maximum bed velocity along horizontal bed (see Equation 4.190):

$$u_{p,\max bed} = c\, u_{p,0}\left(D_0/z_p\right)^n \quad (4.190)$$

where P = applied power (W), D_0 = effective diameter of propeller, D_0 = 0.7 (for free propellers without nozzle) to 1 (for propellers and thrusters in a nozzle) times the real diameter D_p (m), z_p = distance between the propeller axis and the bed (m).

A wide range of values for the empirical coefficients a, b, c, m and n in Equations 4.188 to 4.190 is available because different researchers have taken into account different influences such as the influence of a quay wall and the influence of a rudder. In addition to the approach presented below, reference is made to Fuehrer *et al* (1987), Römish (1993) and EAU (1996, 2004) where alternative values are presented. For more information, reference is also made to a special publication of the PIANC Working Group 48 (PIANC, in preparation).

In the Netherlands these coefficients are generally used for design, neglecting the influence of rudders and confinements with the following values: $m = n = 1$, $a = 2.8$ and $b = 15.4$, which results in $c = 0.3$ (Blaauw and Van der Kaa, 1978). In this approach the influence of lateral confinement by a quay wall in some cases is taken into account by increasing the velocity according to Equation 4.190 by 10–40 per cent. Blokland and Smedes (1996) measured a 40 per cent higher bottom velocity in the case of a jet that displays an angle of 16° with the quay wall.

In the case of a propeller jet perpendicular or oblique against a sloping embankment, the velocities above the embankment can be estimated using Equation 4.189. In fact, the velocities in the jet are influenced by the presence of the embankment. In PIANC (1997) this influence is neglected for practical purposes. Hamill *et al* (1996) found that the velocities above the embankment are delayed.