Step 5: Determine the angle of repose for the riprap size determined above.

It should be noted that all VDOT standard riprap sizes are assumed to have angles of repose of 42°.

Step 6: Determine the ratio of maximum side shear to maximum bottom shear (K_1) using Appendix 7E-7.

Step 7: Determine tractive force ratio (K_2) from Appendix 7E-8.

Step 8: Calculate required D_{50} for side slopes ($D_{50\ side}$)

$$D_{50\ side} = \frac{K_1}{K_2} D_{50\ bottom}$$

From a practical standpoint, whatever riprap size is indicated for the ditch side slope should be used on the bottom as well.

7.5.5.2.1 *Channel Stability Sample Problem - Tractive Force Calculation*

Check the stability of channel's native material using tractive force calculation. Note that the "RIPRAP" computer program referenced in section 7.4.6.4.4 could be employed to perform this computation.*

Given: A natural channel with a bed and banks of native materials composed of cobbles and pebbles. Mean diameter is 1.25 inches for the D_{75} size stone. The channel bottom width (B) is 10 ft. The longitudinal slope is 0.008 ft./ft. Its side slope is 2(h):1(v). The flow (Q) is 150 cfs at a depth (d) of 2 ft.

Determine whether the channel is stable for the indicated condition.

Solution:

Step 1: Determine the permissible shear stress (τ_p)

From Appendix 7E-2, for a D_{75} particle diameter of 1.25 inches, read a permissible tractive force (τ_p) on the channel bottom of 0.5 lbs/ft^2.

Step 2: For a side slope ratio of 2:1, the sine of the slope angle (θ = 26.6°) is 0.5

Step 3: From Appendix 7E-1, for a particle diameter of 1.25 inches, read an angle of repose (ϕ) of 40°

The sine of 40° = 0.643

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* Rev 9/09

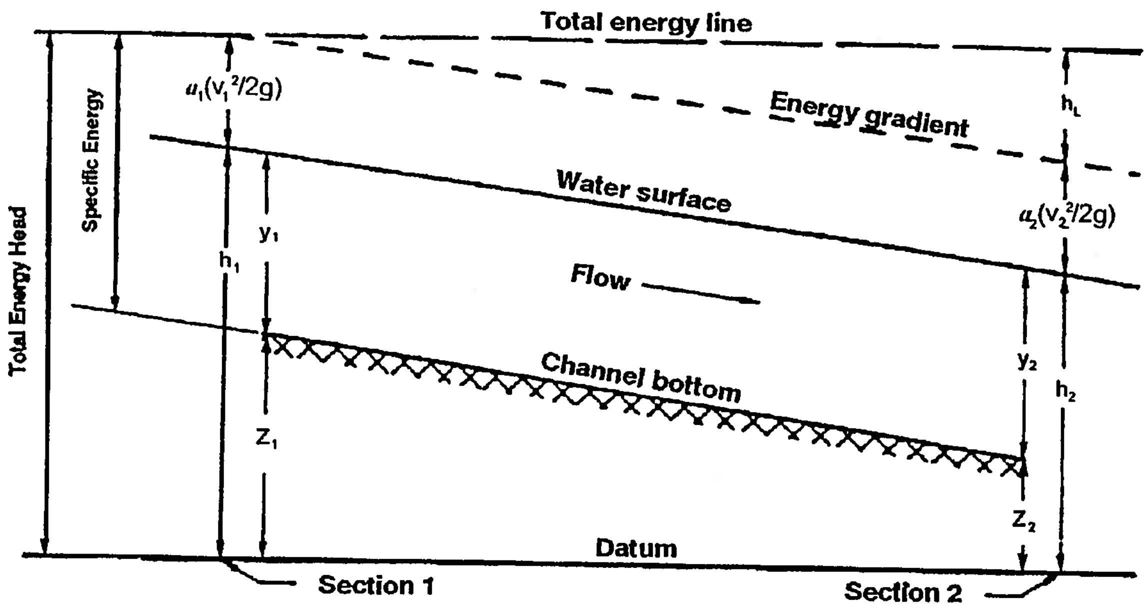

Figure 7-3. Terms in the Energy Equation

7.4.4.3 Hydraulic Representation of Channels

The following sections describe the data needed to apply Manning's equation to the analysis of open channels.

7.4.4.3.1 *Cross Sections*

The cross-sectional geometry of streams is defined by coordinates of lateral distance and ground elevation, which locate individual ground points. Individual cross sections are taken normal to the flow direction along a single straight line where possible, but in wide floodplains or bends it may be necessary to use intersecting straight lines to form a section; i.e., a "dog-leg" section. It is especially important to make a plot of the cross section to reveal any inconsistencies or errors.

Cross sections should be located to be representative of the sub-reaches between them. Stream locations with major breaks in bed profile, abrupt changes in roughness or shape, control sections such as free overfalls, bends and contractions, or other abrupt changes in channel slope or conveyance will require cross sections taken at shorter intervals in order to better model the changes in conveyance.

Cross sections should be subdivided with vertical boundaries where there are abrupt lateral changes in geometry and/or roughness as in the case of overbank flows. The conveyances of each subsection are computed separately to determine the flow