CHAPTER 7
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A numerical model that predicts the geometry and stress distribution of a channel supporting sediment transport along its bed while maintaining stable banks has been developed. This model significantly differs from previous stable channel models in that it consistently accounts for the momentum-diffusion phenomenon. It was shown that consideration of the momentum-diffusion phenomenon in conjunction with a 'curved bank, flat bed' channel geometry, is necessary to reproduce the 'stable bank, mobile bed' condition that is representative of natural channels.

The model specifically predicts an optimal stable channel, whose curved banks are composed of particles that are in a state of incipient motion, and whose flat-bed region supports sediment transport. This differs from a threshold channel, whose entire boundary is continuously curving, and made up of particles that are all on the verge of motion; no sediment transport occurs in a threshold channel. Moreover, optimal stable channels exist over a range of d_{cr}^{*} values for a given value of μ, whereas threshold channels exist only at one value of d_{cr}^{*} for a given μ value; the lower limit for the corresponding valid d_{cr}^{*} range.

In developing the model, the boundary condition at the junction point used by Parker (1978) was reexamined. It is suggested that the lateral momentum flux, rather than the stress gradient, should be continuous at that point. This condition, which is more physically appropriate and consistent with similar phenomena, is adopted in the present model. Furthermore, a modified Dirac delta function is used in the vicinity of the junction point to account for the discontinuity in curvature there. This is yet another difference between optimal stable and threshold channels. Because a threshold channel's junction point lies along its axis of symmetry, there is no discontinuity at that point. For such channels, therefore, there is no need for a Dirac delta function.

For a known range of critical stress-depth values at the junction point, the bank shape and flat-bed width adjust. At a certain critical stress-depth value, the bank shape ceases to change, while flat-bed width continues to vary, depending on the water and sediment discharge the channel has to convey.

The model confirms that sediment transport is possible only at bankful or near bankful conditions for equilibrium channels. It also demonstrates that for sufficiently wide channels, the effect of the banks extends only to a certain distance along the flat-bed. For extremely wide channels, therefore, this effect becomes negligible.

The bank profile generated by the model plots reasonably well against experimental data. When compared with previously proposed bank profiles, the model profile best conformed to experimental data with the exception of the region in the vicinity of the bank toe. More investigations must be performed to ascertain whether or not this is due to the experimental channel's not being in complete equilibrium, or if local secondary currents are important in this region.

To assess the model's predictive ability, results generated by the model were compared with six available sets of experimental and field data. The model calculated values of center depth

D_c that were in good agreement with the corresponding observed values. Comparison of the predicted and observed values of top channel width B shows that the model predictions for B are also good.

To provide the design engineer with a practical means of generating the model results, without actually having to run the numerical model itself, equations and plots based on simulations using the model were developed. These equations and plots can be combined in a graphical solution which is easy to implement and quickly yields the dimensions of a stable channel. The design values yielded by the graphical solution are in close agreement with the corresponding values provided by the model. This means the graphical method has a predictive capability that is just as good as that of the numerical model, and yet is more straightforward to use.

It should be reiterated that the model was developed on the assumptions that the channel is straight, secondary currents are ignored, and bank material is noncohesive. In addition, bedforms are not considered in the formulation. The justification is that gravel streams tend to have weakly formed bedforms that do not contribute to the overall channel resistance in a significant way (Parker and Peterson, 1980), and that these bedforms tend to be washed away during bankful conditions (formative discharge).

Although the formulation used to build this model appears to properly represent the dominant phenomena occurring in stable channel flow, it is recommended that the formulation be examined thoroughly to see if slight modifications can be made, so that the singularities encountered in the present model can be eliminated. Future investigators are encouraged to try other numerical methods with the present formulation, to see if they can better handle these problems. This may be a little difficult, since the governing equations have been too unwieldy for several alternative methods that have already been tried.

A formulation that accounts for suspended load as well as bed load over the flat-bed region has also been proposed. This formulation should serve as a good starting point in the development of a more generally applicable numerical model for stable channel flow. Again, a search for other numerical techniques which will better handle or sidestep the problems experienced by the present numerical model is recommended.