Example Problem: Drawing Profiles

SPEAKER Rick Huizinga: Here's an example of a problem for lesson 13. What you have in front of you is a regular rectangular channel. It has a constant cross-sectional area, but it changes in slope as you see. It goes from a mild slope to a steep slope, and back to a mild slope. Well, what are some things that we know about this? Well, in the mild slope, we know that the normal depth has to be greater than the critical depth and that the downstream end of that reach will control. On the steep slope, the critical depth is greater than the normal depth and the upstream end of the reach will control. And then, once again on the mild slope, the normal depth is greater than the critical depth and the downstream controls.

So let's draw our critical depth lines and our normal depth lines in relationship to one another. The critical depth line, because it's a constant cross-section, will only change--umm, it's not dependent upon the slope. The critical depth will stay the same for all three sections. However, the normal depth will change whether it's the mild slope or the steep slope. On the mild slope, the normal depth is above the critical depth line. On the steep slope, the normal depth is below the critical depth line. And let's go ahead and put the three zones as well. We have zone 1, zone 2 and zone 3: zone 1 being above both normal and critical depth; zone 2 being between critical and normal depth; and zone 3 being below both. For the upstream most section, the downstream end controls, and so our point of control for the first reach is right at the brink.

The sort of profile that we will see then will be the M2 profile because flow wants to return to normal depth, moving in an upstream direction from that point of downstream control. In the middle section, because it's a steep slope, we know that the upstream end controls things, which means at the point of control for the upstream reach is the same as the point of control for the middle reach. It is now the point of control for both the first and second reaches. Therefore, the flow line will follow the S2 profile because flow is forced to be at critical depth at that point of control and wants to approach normal in a downstream fashion.

In the downstream most cross-section, we have once again downstream control because it's a mild slope.

Therefore, the point of control is at the very end of the image, and it will want to flow at normal depth in an upstream direction because of the downstream control of that section. Now, what

about the area of transition between the steep slope and the mild slope? Well, if the steep slope portion has more control, then it will follow an M3 profile with a hydraulic jump, such as shown on your graph. However, if the mild slope portion has more control, then it will follow an S1 curve with the submerged jump. And in actuality, it can occur anywhere between these two points, but it will follow one of those two lines to get from the one normal depth on the steep slope to the normal depth on the mild slope.

And so, let me review again for you the steps for sketching a water surface profile so that as you work through the problems, you can refer to this list. You want to compute the normal and critical depths, D sub-n and D sub-c. You want to draw the normal depth and critical depth in proper position with respect to the bed and with respect to one another, and you will then establish the proper point of control for the given flow regime, whether it's the upstream end or the downstream end, whether it's supercritical or subcritical, and then consider what happens to the depth if the water surface is forced to be in any of the three zones. Draw the appropriate water surface shape for the appropriate zone that the flow was found to be in, and then follow the basic rules of thumb that flow approaches normal depth asymptotically and it approaches critical depth perpendicularly.