HYDRAULIC MODEL OF "RIVICE"

BY

P.KO
SNC LAVALIN
1100, RENE-LEVESQUE BLVD
MONTREAL, QUEBEC, H3B 2G4

G.HOLDER
0250, ST. PATRICK
LASALLE, QUEBEC,H8R 1R8

AND

M.SYDOR
ENVIRONMENT CANADA
INLAND WATERS DIRECTORATE
WATER PLANNING AND MANAGEMENT BRANCH
OTTAWA, CANADA, K1A 0H3

ABSTRACT

The steady state hydraulic module of RIVICE was developed at the Lasalle Consulting Group specifically for the RIVICE program. It is a pseudo two dimensional, standard step backwater routine that calculates the water surface profile and panel velocities cross-section by cross-section.

Key Words: Pseudo, 2D, Steady-state, BKWTR5

INTRODUCTION

The hydraulic model of RIVICE is composed of two parts: steady state backwater profile calculations; and transient computations. The steady state backwater profile calculations will be discussed in this part of the paper.

The steady state routine includes the distribution of the mean values of the hydraulic characteristics at the cross sections along the transversal direction thereby making the module PSEUDO-2D as shown in figure 1. The main objective of this distribution is to have the capability of having a transversal distribution of ice characteristics such as the growth of "Border Ice" as illustrated in figure 1.

MODULE REQUIREMENTS

The backwater routine requires the following input:

- the cross-section co-ordinates obtained from the COORD1X routine;
- the main channel discharge;
- the tributary inflows of water and corresponding temperature;
- the tributary ice discharges;
- the water level at the most downstream cross section which is interpolated from the user specified rating curve;
- the manning coefficient;
- the ice cover conditions; and
- the river system characteristics.

Having the information available to the routine, computations can then proceed from downstream to upstream to calculate the steady state hydraulic conditions, taking into account the ice covered conditions.

GENERAL COMPUTATIONAL PROCEDURE

At first the tributary flow status is interrogated, which gives the discharge to be used in the calculation by adding up all the tributaries upstream. As the calculation proceeds upstream, and passes a section where a tributary enters, the discharge at the next upstream section will be smaller by the amount of the tributary.

The BKWTR routine is then called, and its first step is to calculate the critical depth at the first cross-section. To do this, it must call the subroutine XCRIT and start with a finite set of parameters taken from the introductory main program. A flow depth equal to 0.01 m is first selected, and calculations are done to test for critical flow. If the test is negative, the program adds 1 m to the depth and redoes the calculations. This loop is continued until a depth greater than critical is found. The depth at that point is less than one metre greater than critical, so the program takes off one metre, and adds 0.1 m and redoes the check.

Using the same looping procedure at 0.1 m intervals, the first depth greater than critical is found. Again, 0.1 m is subtracted, and the looping procedure is done using 0.01 m intervals until the depth just less than 1 cm greater than critical is found. The fourth and limiting iteration in this procedure gives the critical depth to 1 mm accuracy.

Then, the water level information at the downstream limit of the study reach is obtained from the rating curve. For the test case, a depth is imposed, and the next step is to compare this with the critical depth. If the imposed depth is equal to or less than critical, a rapids, a falls or at least a critical flow section is assumed, and the program continues the calculation further upstream starting from the critical level at Section 1. If the imposed depth is greater than critical, the calculations continue upstream starting from the imposed depth at Section 1.

Information at the first cross-section which is necessary to continue the calculations of the complete river flow characteristics is furnished by the subroutine XSECI. This routine calculates the flow distribution across the cross-section by using up to 40 sets of lateral coordinates, which divide the river into 39 subsections or panels. Definition of the number of lateral coordinates selected is established by the user based on the degree of bathymetric detail on each cross-section. Each subsection is dimensioned in terms of width by the distance between succeeding lateral coordinates.

Figure 2 provides a definition of the lateral subsection. The symbol DIST gives the lateral measurement to the coordinate, and the difference between two succeeding coordinates, or the width of the subsection, is DDIST. Later in the program reference will be made to the ice cover, and the shore ice width that will be brought in from that module. Once defined for the whole river width, the amount of ice cover in the individual sub-sections is given by DDISTC - see Figure 2.

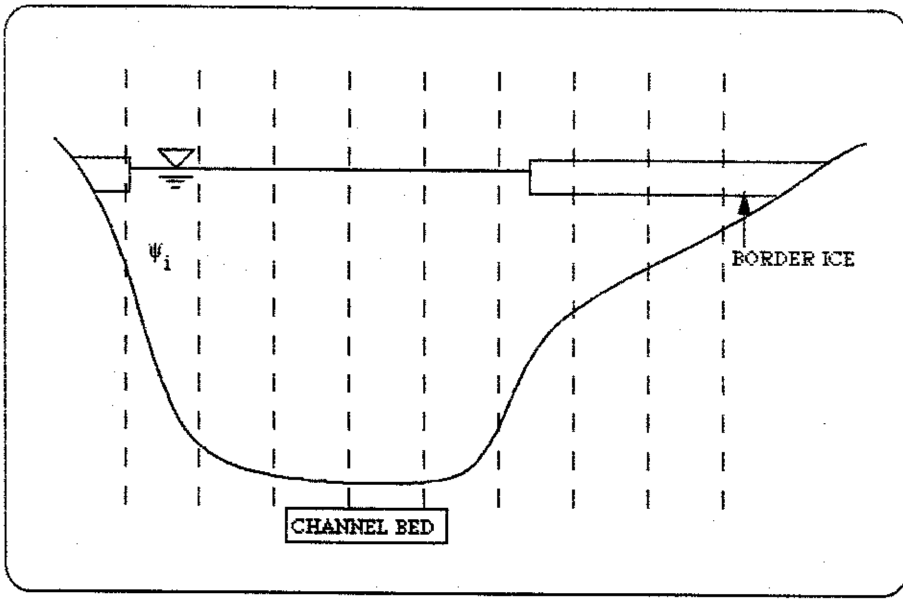
Within XSECI, two small routines calculate the triangular geometry of the subsections at either shore if the further shoreward coordinates place the channel bottom at water level or above it. Another calculates the more general case away from the shores, where there is a finite depth of water at each side of the subsection, resulting normally in a trapezoidal shape. The representative velocity for the subsection is then calculated, without a coefficient for the slope, since it is common for all subsections across the cross-section. The representative velocity is squared and multiplied by the area of the subsection, thereby providing the weighting factor with respect to each subsection. The sum of these weighted parameters is divided by the total cross-section area, multiplied by the slope and divided by 2g to give the weighted cumulative velocity head for the cross-section.

The procedure at the second section starts the same as the first, that is, it first calculates the critical conditions, including depth, head slope and total critical energy. The mean slope is found between the present and previous sections, and the headloss line is projected from the previous total energy level to the present cross-section, given a local total headloss energy. Flow charts 5 and 6 show the steps starting with a comparison between the headloss energy level and the critical level. If the critical level is higher than the headloss level, there must be a falls or rapids between the two sections, so the critical condition is retained at the present section to continue the calculation upstream.

If the headloss energy level is higher, a four stage loop algorithm, similar to that described in the critical depth calculation, is used to find the correct headloss energy level and flow depth. The XSECI subroutine is called to calculate the characteristics for the subsections then the cross-section as described above.

CONCLUSION

The RIVICE modules which control the steady state backwater profile computations has been linked with the driver of RIVICE and executed for a simple four reach channel system (test case 1). Preliminary results are presented in "Examples of Simulated Ice Conditions With RIVICE", which will be presented in session A article A-5 of this workshop.



NOTE:

in the term ψi, the ψ represents the following hydraulic characteristics: area of flow, velocity, discharge, water depth, wetted perimeter, top width and manning 'n'. The i represents the panel number that goes from 1 to the number of panels.

Figure 1. Cross Section Distribution of Hydraulic Characteristics

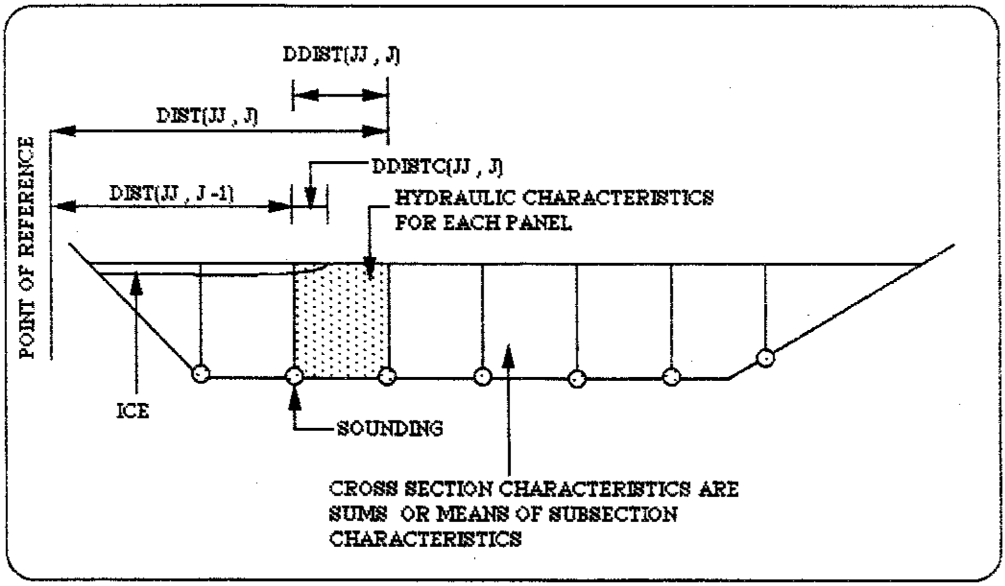


Figure 2. Definition of Lateral Subsection