

**R2D\_Ice**

**Ice Topography File Editor**

**User's Manual**

**by**

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## **1.0 INTRODUCTION TO R2D\_Ice**

### **1.1 Background**

R2D\_Ice is a program designed for use with the River2D river modelling system. R2D\_Ice is an interactive and graphical program intended for defining and editing ice topography files for use in the River2D program. The normal development of an ice topography file involves creating a preliminary file from field data using a text editor, then editing and refining it using R2D\_Ice. The resulting ice topography file can be used (although it is not necessary) in conjunction with the corresponding bed topography file to develop a computational discretization in R2D\_Mesh. The ice topography and the discretization are then used in River2D to solve for the ice affected water depths and velocities.

R2D\_Ice is almost identical, visually and functionally, to the bed topography file editor, R2D\_Bed. For this reason, this document is only intended as a supplement to the information provided in the User's Manual for R2D\_Bed. Its purpose is to identify and discuss the differences between the two programs and provide the user with specific direction on using R2D\_Ice to develop an ice topography file.

### **1.2 Features Overview**

#### **1.2.1 Ice Properties**

The relevant physical properties of the ice cover necessary for modelling flow in an ice-covered reach are the ice thickness, ice roughness height, and the specific gravity of the ice. R2D\_Ice allows the user to edit thickness and roughness values either on an individual point basis, over irregular polygonal regions, or throughout the entire domain. The user can also edit the specific gravity of the ice but this on a global basis.

An ice cover can be defined as partial or continuous. In the case of a partial ice cover, holes in the ice are acceptable but pieces of

floating ice are not. The hydrodynamic solution in the River2D program will assume that any ice in the domain is fixed in space.

### 1.2.2 Interpolation of Ice Properties

In the River2D suite of programs, the Triangulated Irregular Network methodology is used to define digital surfaces where nodal parameters are linearly interpolated between nodes. When a domain is only partially covered with ice, the value of ice thickness can change significantly (from some positive value to zero or vice versa) across the boundary separating open water and ice-covered areas. Due to this discontinuous nature of ice covers, spatial interpolation of ice thickness and ice roughness values is as follows in the River2D suite. Ice parameter values are only linearly interpolated within 'ice-covered' elements, that is, elements where all of the defining nodes have ice thickness values of greater than zero. If any node in a given element has an ice thickness of zero, then the element is considered to be 'ice-free' and ice parameters are not interpolated within this element. Interpolation of ice parameters is done in this manner so that the transition between ice cover and open water is unambiguous: it is at the edges of triangles. If linear interpolation were employed in all elements of partially ice-covered domains, the edges of the ice cover would be smeared across the area of an element.

The distinction between ice-covered and ice-free elements is of importance in R2D\_Ice as it allows the user to accurately specify ice edges in partially ice-covered domains. Breaklines are a useful tool for enforcing the location of ice edges in ice topography.

The interpolation convention is of more significance in the River2D program than in R2D\_Ice. Ice topography is used in River2D to interpolate ice parameters at the nodes in the computational mesh. If a computational node falls within an 'ice-covered' element in the ice topography TIN, then ice parameters are interpolated for this node. If the node falls within an 'ice-free' element then its ice parameters are set to 0. If breaks in ice topography, due to ice edges, are not taken into consideration

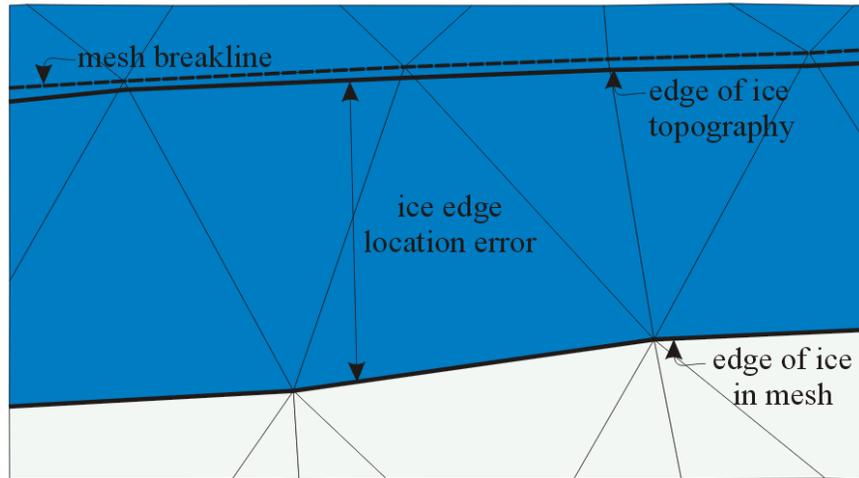
during the mesh generation process, then there is no guarantee that they will be well represented in the model.

### 1.2.3 Breaklines

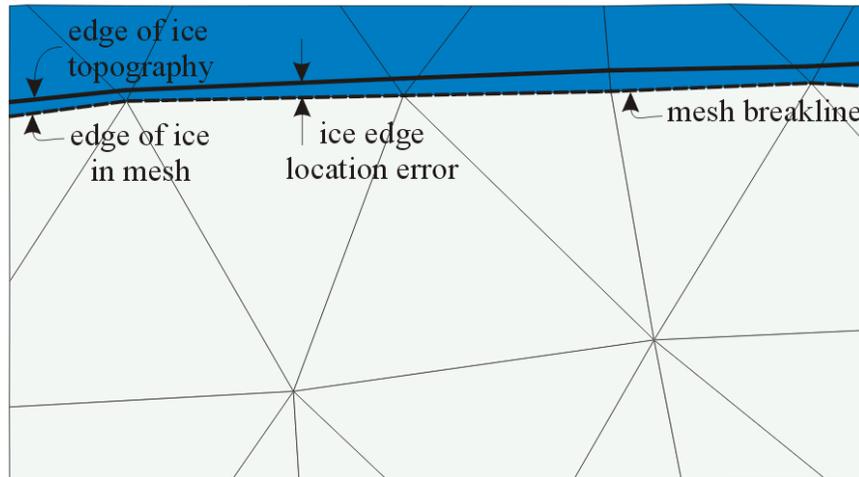
During the mesh generation process, the placement of breaklines in the mesh is typically coincident with the location of breaklines in the bed topography. Due to the ice parameter interpolation convention, it is advised, when inserting breaklines into the mesh to define any breaks in ice topography, that they be placed just slightly to the ‘ice side’ of any ice edges in the ice topography. This is to ensure proper location of ice edges in the mesh once ice parameters are interpolated. If the exact location of ice edges in the computational mesh is imperative, one might consider accounting for this compensation when locating ice edges in the ice topography. Figure 1 illustrates the effects breakline placement has on the location of an ice edge in the computational domain.

**Figure 1: Ice edge location error.**

a) Placing mesh breaklines on the ‘water side’ of ice edge



b) Placing mesh breaklines on the ‘ice side’ of ice edge



#### 1.2.4 Boundaries

In R2D\_Bed, boundaries can be defined and/or edited. If they are present in the bed topography file, then they are automatically used to define the boundaries in the computational discretization in R2D\_Mesh. Ice topography information is only used as a visual supplement during the mesh design process. Therefore, the definition of boundaries in ice topography is not necessary. However, the location of computational boundaries can be useful in defining the areal extent of an ice cover. For this reason, an ice

topography file can contain boundaries, which will be displayed in the R2D\_Ice environment. However, boundaries cannot be modified within the R2D\_Ice environment and must therefore be defined and/or removed using a text editor.

### **1.3 Program Status**

Version 0.01 of R2D\_Ice has not been extensively tested as yet. While each function works correctly on its own, not all possible combinations and sequences of commands have been tried. In addition, only a few data files have been considered. Further still, no undo features are available. It is advisable to save often, as modifications are made.

## 2.0 ICE TOPOGRAPHY FILE DESCRIPTION

### 2.1 General

Input to, and output from, the R2D\_Ice model is in the form of ice topography files, usually indicated with a .ice filename extension. These files can also be loaded into the R2D\_Mesh finite element mesh generator program.

The format of ice topography files is almost identical to that of bed topography files. The main differences are that nodal parameters are ice thickness and ice roughness height rather than bed elevation and bed roughness height. The similarity is intended to allow the user to create an ice topography file from an existing bed file and then refine the ice using R2D\_Ice. For this reason, R2D\_Ice can read both implicit and explicit format (including comments), but like R2D\_Bed, it will only write the explicit format.

#### 2.1.1 Node Specification

In an .ice file, each node (whether it is defined separately or as part of an implicit boundary or breakline) is represented by one line and consists of a point number (integer), x-coordinate (floating point number), y-coordinate (floating point number), ice thickness (floating point number), and ice roughness height (floating point number), all separated by any number of spaces or tabs. Both ice thickness and roughness are to be specified in meters. As with R2D\_Bed, the end of the list of data points should be indicated with a period (which may be part of a comment, such as "end of data points.>").

| n   | x    | y    | t   | k   |
|-----|------|------|-----|-----|
| 101 | 1000 | 1000 | 0.8 | 0.1 |
| 102 | 1450 | 1000 | 0.6 | 0.1 |
| 103 | 1000 | 1200 | 0.5 | 0.1 |
| 104 | 1250 | 1300 | 0.6 | 0.1 |
| 105 | 1450 | 1300 | 0.8 | 0.1 |

## 3.0 COMMAND REFERENCE

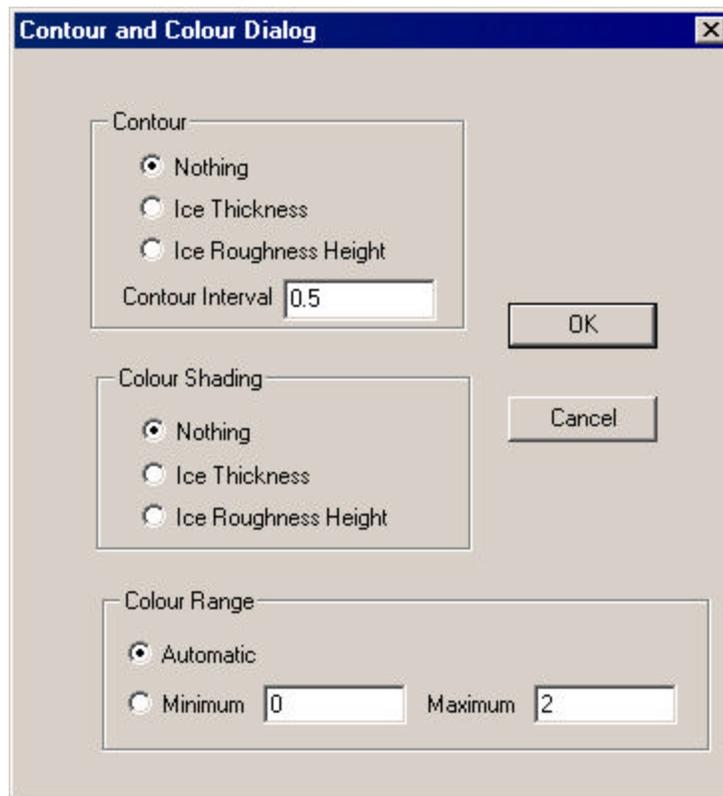
### 3.1 General

The operation of R2D\_Ice is very similar to that of R2D\_Bed. Therefore, for the sake of brevity, only differences between the program commands will be mentioned here.

### 3.2 Display Menu commands

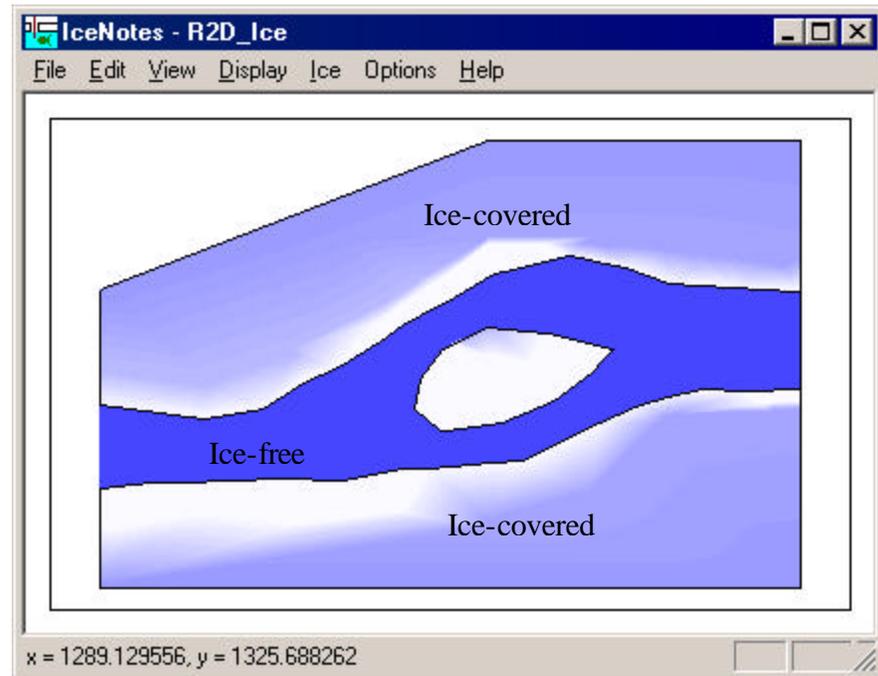
Of the commands in the display menu, all are the same as those in R2D\_Bed except for “Contours/Colour” command. In R2D\_Ice, the Contour and Colour dialog, shown in Figure 2, allows the user to display ice thickness and ice roughness rather than bed elevation and bed roughness.

**Figure 2: The Contour and Colour Dialog**



If a colour map is selected, shades of blue are used to create the map rather than a colour spectrum. The shades of blue (white is highest (thickest), blue is lowest (thinnest)) are scaled to parameter values for ice-covered elements only. This is true when mapping ice thickness or ice roughness height. Ice-free elements are coloured a darker blue to indicate the lack of ice (open water) at that particular element in the TIN. A black line is used to define the edges of the ice. If the Colour Range is set to Automatic, the lower limit for the range is set as the lowest non-zero value for selected display parameter. Figure 3 shows ice thickness displayed using a colour map.

**Figure 3: A sample ice thickness colour map.**



### 3.3 Ice Menu Commands

The commands available under the Ice Menu, shown in Figure 4, allow the user to edit to ice topography data. Most of the commands in this menu are identical those found in the Bed Menu in R2D\_Bed. The only differences are that there are commands for setting ice thickness and ice roughness (rather than bed roughness)

and that there are no commands for defining or removing boundaries (as they are not needed).

**Figure 4: The R2D\_Ice Ice Menu**

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### 3.3.1 Set Ice Roughness/Thickness by Region

Similar to the “Set Roughness by Region” command in R2D\_Bed, these two commands allow the user to specify either the ice roughness or thickness for a group of nodes within a user defined polygon. The key to using this command is that points must be selected using the mouse in a **counter-clockwise** direction around the desired polygon region. Once the polygon is defined, a dialog box will open requesting a new value of ice roughness or thickness for the nodes within the polygon region.

### 3.3.2 Set Ice Roughness/Thickness Everywhere

The Set Ice Roughness/Thickness Everywhere command works the same as “Set Roughness Everywhere” in R2D\_Bed. Selecting this option will bring up a dialog box asking for a global value of ice roughness or thickness for the entire domain. This option is useful for setting a default or background roughness. Then local modifications using the region setting can be made.

### 3.3.3 Roughness Converter...

This command works identically to the Roughness Converter in R2D\_Bed. It is discussed here because the input is different when

considering ice-covered domains. In open water conditions, the hydraulic radius is approximately equal to the depth of flow to the free surface. That is,

$$R = \frac{A}{P} \cong H \quad (1)$$

where  $A$  is the cross sectional area of the channel and  $P$  is the wetted perimeter of  $A$ . This approximation does not apply for ice-covered channels. When ice is present, the hydraulic radius becomes

$$R = \frac{A}{P} \cong \frac{D}{2} \quad (2)$$

where  $D$  is the depth of flow under the ice cover. To understand this relationship, consider a rectangular prismatic channel of width  $B$ . When covered in ice, the hydraulic radius for this channel is

$$R = \frac{A}{P} = \frac{DB}{2B} = \frac{D}{2} \quad (3)$$

This relationship applies when converting composite roughness values (Manning's  $n$  to  $k$  and vice versa). This is not the case when converting ice roughness values. The composite roughness value applies to the entire depth,  $D$ , where as, ice roughness acts only on the depth between the bottom of the ice and the point of maximum velocity. Consider the ice-affected portion of the same rectangular channel. The hydraulic radius of this portion is given by

$$R = \frac{A}{P} = \frac{D_i B}{B} = D_i \quad (4)$$

where

$$D_i = \alpha D \quad (5)$$

If the ice and bed roughness values are the same, then the point of maximum velocity will be at the middle of the flow depth. Therefore  $\alpha = 1/2$  and the hydraulic radius becomes

$$R = \frac{D}{2} \quad (6)$$

In most cases, bed and ice roughness values will not be equal and  $\alpha$  must therefore be estimated. If the roughness converter is being used to obtain ‘ball park’ values of ice roughness height that will eventually be modified during calibration, then a value of  $\alpha = 1/2$  should give reasonable first estimates.

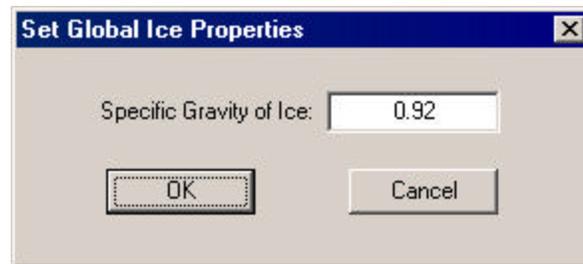
### 3.4 Options Menu Commands

#### 3.4.1 Set Global Ice Properties

This command opens the ‘Set Global Ice Properties’ dialog box as shown in Figure 5.

**Figure 5: The Set Global Ice Properties dialog.**

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Eventually this dialog will be used to set a number of ice properties but at the moment it is only used for setting the specific gravity of ice in the domain. Once an ice file has been saved using R2D\_Ice, the value of the specific gravity will be located at the end of the file as shown below.

Global ice properties

Specific gravity of ice = 0.920

If a value is not specified, then a default value of 0.92 will be written to the file. River2D is capable of reading an ice file where the specific gravity is not specified; however, in this eventuality, the hydrodynamic solution will assume a value of 0.92.