

Hydrologic Risk

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1 Introduction

1.1 Hydrologic Risk

HYDROLOGIC RISK

This program proposes the construction of a model of a hydrologic basin and its diverse characteristics, such as to enable the user to evaluate the conditions that may lead to overflow and flooding in the surrounding area.

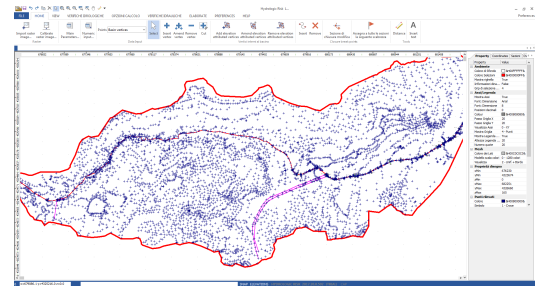
Statistical analysis of rainfall associated with a model of affluence and runoff from the basin are used to determine maximum capacity and probabilities of its being exceeded (Recurrence interval).

Affluence runoff model is conditioned by a number of parameters among which are notable: Time of Concentration, Vegetable cover, Permeability, Inclination etc.

Flow capacity model also yields height of water in the main fluvial flow and subsidiary reaches for verification.

The calculation model for this, in permanent motion state derives these levels on the basis of the sectional geometry and of the constituent materials of the reaches.

Taking into consideration the rates of level rise at the break point closures, this analysis represents a valuable tool for flooding risk prediction as it identifies the areas at risk and the lead times involved.



1.2 The hydro risk

HYDRO RISK

The Hydro Risk is represented in the territory by natural and human factor resultant, in the area of interest made up by surface and natural drainage networks and hydrological dynamics, that characterize the relations between the inflow and outflow of an hydro geographical basin; this can be calculated with:

$$R = H \times V \times E = H \times D$$

where:

R = The risk, Extent of damage expected for a certain area in a certain interval of time, as consequence of a disaster.

H = The danger, i.e. the probability of a disaster within a given period of time in a certain area, considered as an addition to the safety factor, rigidly related to recurrence interval. (time in which the intensity I is exceeded, on average once only – I being the maximum capacity):

$$H = (1 - 1/T)^2$$

V = Vulnerability, i.e the degree value loss caused to a given element exposed to disaster event

E = The risk element value; the monetary value of properties and economic activities at risk in a certain area;

D = The total damage.

With the factors above, having established the specific risk value (of high flood), measures should be designed that reduce it e.g. by structural intervention.

AREA HYDRAULIC RISK QUANTIFICATION

In alluvial context, the extent of danger "H" in flood state. is evaluated through statistical and probabilistic analysis of available data.

These are capacity, rainfall that determine the extent of vulnerable areas and flooding maps with associated recurrence interval.

The extent of danger may be of two classes:

medium : alluvial areas with flood over spill recurrence interval from 10 to 100 years;

low : alluvial areas with flood over spill recurrence interval from 100 to 300 years;

1.3 Definitions

DEFINITIONS

Break point

Point at which an intersecting line crossing the main reach defines a closure of the uphill basin.

Critical inclination

Free flow surface height with an assigned capacity Q for which the specific energy E is in respect to the bed is minimal.

Critical rain height

The rain height obtained from the rain model for a duration equal to t_c (**time of concentration**).

Effective rainfall

The rain water quantity that remains available at the surface after the real evapotranspiration loses.

The effective rainfall **PE** are given by the deduction between rainfall and real evapotranspiration **ETR**.

Free flow

The hydro-current that flows in natural streams or artificial canals.

Free rise

The height from riverbed to surface that the current can reach without overflow.

High flood hydrogram

Graphic representation of the progression of flow in a given break point, related to given recurrence interval.

Hydraulic radius

The ratio between the area of liquid A and the wetted surface perimeter.

Hypsographic curve

The representation on the Cartesian axis of the medium heights h_i (**the Y axis**) of a basin, relative to two contiguous elevation levels, and the partial axis A_i (**the X axis**), delimited by two elevation levels that above to h_i .

Infiltration

The infiltration **I** represents the water quantity that penetrates the soil surface feeding the underground water flow. The infiltrated water quantity reaching the water table surface is called effective infiltration **IE**.

Outflow Coefficient

The ratio for a given break point closure between the value d , outflow and the rainfall's quantity.

Permanent motion state

The gradually varied permanent flow is the one encountered in a free current with gradual variations of the cross section. Naturally, capacity remains constant while speed and cross section vary along the axis of flow.

Potential and total evapotranspiration

The evapotranspiration and the water loss that take place through the physical process of evaporation and the biological one, of plants (**perspiration**). The water quantity consumed by atmospherically evaporation (**potential evaporation**) and plants' activity (**perspiration**) is indicated to be potential evapotranspiration (**ETP**). When the water loss through evapotranspiration is inferior to **RFU (available hydro reserve)** we're dealing with real evapotranspiration **ETR**.

Rain model

For a given recurrence interval, this represents by the relation between height of rain h and time t . (duration)

Recurrence interval

The period within which intensity I is on average, exceeded only once – I being the maximum capacity

The Recurrence interval's values for some hydraulic structures are shown in the table below:

Structure	Recurrence interval [years]
Bridges and river dykes	100÷150
Stream dykes	20÷100

Dikes	500÷1000
Reclamations	15÷25
Urban sewer	5÷10
Tubular footbridge and small river footbridge	30÷50
Underground street passage	50÷100
Gutter and main street groove	10÷20

Riverbed at high inclination.

Riverbed where uniform current is fast.

Riverbed at low inclination.

Riverbed where is verified that the uniform current is slow.

Streaming

Streaming, R , is the portion of **PE** that feeds the surface efflux **QS** and is conveyed into the surface flow network.

Time of Concentration

Longest time of travel for a drop of water to reach the watershed outlet

Uniform motion

A flow can move in uniform motion state within a break point closure if the inclination of the riverbed is equal to that of the water surface.

Wetted surface

The cross section of the reach's surfaces along which the liquid flows.

1.4 Notes

Check conventions list

2 Menu

2.1 Menu

MENU

File Menu

The File menu contains those functions that enable the insertion, recall, printing and closure of project files and their management.

Edit Menu

The Edit menu presents those functions relative to editing data for the currently open project.

View Menu

This menu contains the view options of the project.

Tools Menu

This menu primarily contains functions relative to the setup of the worksheet and for the management of text boxes thereon.

Numeric Input Menu

This menu gathers the functions for the entry of parameters by keyboard action.

Computation Menu

Input data analysis and verifications.

Export Menu

Enables selection of export format for the calculation results.

Preferences Menu

Menu for the assignment of options for the operation of the program.

Help Menu

2.2 File Menu

FILE MENU

The **File menu** contains those functions that enable the insertion, recall, printing and closure of project files and their management.

New

Creates file(s) for a new project. Function is also available from the Standard toolbar

Open

Opens file(s) for a previously created project (**stored with PMP extension**). Function is also available from the Standard toolbar

Save

Save file(s) for the currently open project, replacing any previous version. Function is also available from the Standard toolbar

Save As

Save file(s) for the currently open project (**with PMP extension**) under

the name and in the folder, to be entered in a subsequent dialogue window. This creates a new file with that name. If the file already exists the user is asked to confirm that it should be overwritten

Preview

Recent Projects

Recalls the names of the last three open files

Exit

Program exit.

2.3 Edit Menu

EDIT MENU

The ***Edit menu*** presents those functions relative to editing data for the currently open project.

Undo

Cancels the last amendment restoring the situation as before the change. The function is available for more levels.

Redo

Reapplies the actions undone by the undo function. The function is available for more levels, the same as for the undo function.

Copy

Copies to the clipboard the selected area of the active window. (Function is also available from the Standard toolbar). This function is particularly useful to copy bitmaps of images in the various phases of computation to a preferred editor (**Word, Works etc.**)

2.4 View Menu

VIEW MENU

In the ***View Menu*** you can find the following options:

Redraw

Redraws the basin. *Function is also available from the Standard toolbar;*

Move

Enables frame around the drawing to be moved by dragging the drawing. Note that actual coordinates of the drawing do not change but the frame's scales do. *Function is also available from the Standard toolbar;*

Zoom

Its presents the following zoom options:

Zoom Window

Lets you draw a selection rectangle or "window" to view part of your display in the drawing window. Use the left button to select one corner of the view you want. Now the cursor becomes a stretching rectangle. Select a second corner for the view. The screen is redrawn to show the part of your drawing that fits within the rectangle. *Function is also available from the Standard toolbar;*

Dynamic Zoom

Provides an interactive zoom effect using the mouse to control it. Once the left mouse key is pressed the pointer alters into an enlargement lens. Dragging the pointer upwards increases the size of the image, while downwards drag reduces it. The zoom factor may be read in the toolbar display. *Function is also available from the Standard toolbar*

Previous Zoom

Returns to the zoom factor current before the last operation. Function is also available from the Standard toolbar

Zoom All

A zoom factor is applied, such that the whole contents of the worksheet are displayed. *Function is also available from the Standard toolbar*

Zoom ±

Function is also available from the *Standard toolbar - Zoom Factor*

2.5 Tools Menu

TOOLS MENU

Distance Measurement

This function activates a mode whereby the length of the line created from the point clicked and the point to which it is dragged is displayed. The mode remains active until the menu item is again selected. The measured distance is reported on the start bar (**below the work sheet**);

Insert text

Allows to insert text in the work sheet; after you activate this option you'll have to choose the point for the insertion of the text box. Click at one diagonal point, drag the mouse to the opposite diagonal point and click again to record this point. A dialog window opens that allows the text itself, its font type & size and color to be entered;

Changes on an inserted text

Choose the select button and click near the text to amend, then by pressing the right button of mouse you can choose *<Text Properties>* for making the changes.

2.6 Data Input Menu

DATA INPUT

General Data

Here are brought the indispensable data at the beginning of a new project, therefore there is binding, for the course of the input, the insertion of the asked information.

Numeric Input

The command allows the basin's and river reaches' coordinates numeric input.

Raster Image Import

command for raster image import (**cartography view**), for basin's coordinates graphical insertion and connected hydro graphical network.

Raster Image Calibration

command allowing inserted image calibration to real scale.

Select

command making the selected object enabled; it allows alterations on basin's vertices, river reach's vertices...

Vertex insert

Allows vertex introduction in the selected object (**basin, river reach, internal vertices...**) For the Conventions to use see **GRAPHIC INPUT** .

Vertex alteration

Allows selected object's vertices alteration (**basin, river reach, internal vertices...**)

Vertex elimination

Allows selected object's vertices elimination (**basin, river reach, internal vertices...**) Once the command is selected the pointer changes its form within the point to be eliminated.

Cut

Cuts the element defining the selected object, inserting a new vertex. Once the command is selected you have to bring the pointer on the element to cut and click.

Adding basin's elevation vertices

By selecting this command vertices can be inserted inside the basin for the DTM's creation. The insertion of more vertices leads to a more accurate model. The insertion of a new vertex can be done by a click on the selected basin point.

elevationed vertices alteration

This command allows quote vertices' alteration within the basin. Once the command is selected the pointer changes its form within the point to be altered: now it can be moved into another position just by clicking and displacing it in the new position with the mouse down.

elevationed vertices elimination

This command allows elevation vertices' elimination within the basin. Once the command is selected the pointer changes its form within the point to be eliminated: now it can be eliminated just by clicking it.

Transversal section

This command allows the introduction of the verification sections. The verification sections' position and number along the water course can be determined by this command of the **Numeric Input**. The sections' displacing

to the highest point of the river reach is done starting from downwards. Every section must be determined starting from the left with the mouse down towards its the final point. The section's form and dimensions are graphically and numerically individuated in the sections' view window that can be activated with a double click of the mouse in the correspondent area (see also Numeric Input)

*Note: the sections are being inserted after the creation of the terrain's digital model, therefore after the basin's and river reach's insertion. Thurther more, in **General Data** must have been previously inserted the overfills.*

Transversal section's elimination

This command allows the transversal section's elimination with a click on the section that you want to eliminate.

2.7 Computation Menu

COMPUTATION MENU

In this menu you can find the commands that help establish the basin's balance, its high flood flows for every section, homogeneous and permanent flow conditions verification and the riverbed section view (**longitudinal profile**).

Hydro graphical and Morphometrical Analysis

For every basin defined by a break point an analysis is performed regarding its morphometrical proprieties and its time of concentration. During this phase the program carries out also the computations for every sub-basin automatically generated according to the position of each breakpoint.

After the analysis is completed alterations can be undertaken for every sub-basin from the control panel in the right of the work area. Activating the *<Basin vertices alteration>* command every sub-basin can be shaped according to the project requires. After doing this the calculation must be redone.

Triangularization

This operation is carried out automatically by the program for the morphometrical and hydro graphical analysis. This command enables the basin's 3D view and its printing from the preview window - to activate it press the right button of the mouse.

Kennessey's flow coefficient

Carries out the computations using Kennessey's flow coefficient. For this parameter, compulsory for the next step in the hydrological balance, the following data must be provided:

- rainfall**: expressed in mm of rain, for expressing P rushes;
- medium temperature**: monthly medium temperature;
- maximum temperature**: monthly maximum temperature;
- minimum temperature**: monthly minimum temperature.

The program calculates the aridity index for provided data, from which, depending on the calculation for the surface slices that define the vegetal distribution, the steepness and the permeability, the partial and total efflux coefficient are obtained.

Basin's hydrologic balance

In this window are asked the main basin's inflow and outflow data.

Rain model

In this window are computed long rain data (**1 - 3 - 6 - 12 - 24 hours for several years**); consequently the basin's Rain model is defined. The program performs the calculation of the rain's maximum and critical height corresponding to every day and period (**1, 3, 6, 12, 24 hours**), in function of every recurrence interval assigned by the user in **General Data** from the **Data Input menu**.

Rain data acquired from a rainfall station can be directly filled in the period's table or copied from another file.

The program computes data with Gumbel's probability distribution, and finds the parameters, the medium standard deviation, k and m.

The Rainfall Probability Curve graphic is available in semi-algorithmic and algorithmic scale (**x and y**). By pressing the right button of the mouse you can copy the graph to clipboard, paste it in bitmap image format or copy the containing values for another project.

The print report allows sending input data and results to the printer.

High flood flow - Empirical Methods

For every transversal section the high flood flow is calculated with empirical methods. This requires the author's selection. The program reads the flow value in m³/sec, the specific flow in m³/sec Km².

High flood flow - Empirical and Rational Method

For the assigned Recurrence interval the program calculates the high flood flow corresponding with the specified transversal section. The program develops a flow analysis for every sub-basin on the activation of the

<Flows analysis> command. The calculation differs on the selection of the method to use Rational, Analytical or TCEV IN **General Data**.

High flood hygrograph

For every recurrence interval assigned by the user the program generates the high flood hygrograph with Nash's method. In the respective window, for every elected transversal section can be viewed: k and n function parameters, basin's characteristics (**calculated with Nash or Mc Sparran**) and n and a Rain model parameters (**for every Tr**). Calculation step, in hours, and the maximum period (**hours**) are user defined; in order to change them press the <Recalculate> button. The graphic can be copied to clipboard and can then be pasted in bitmap image format by holding down the mouse and choosing the <Copy Graphic> command. For exporting the curve's values you can choose the <Copy Format> from the same menu.

Uniform flow hydraulic verification

For every selected section the program carries out the uniform flow conditions verification. The verification sections definition (**transversal sections**) takes place before this stage, so, after having developed the Hygrograph and Morphological Analysis, the program proceeds with the determination of the maximum high flood flow (**empirical and classical methods**). Every sections' roughness and form must be defined. Sections' generation can be obtained by activating the <Transversal section> command from the **Data Input** menu (**or the toolbar**) and clicking on the section line previously determined.

Permanent flow conditions

In this window the user can assign the analysis conditions for the permanent flow for every recurrence interval. Regarding the downhill conditions the liquid section's height is defined within the transversal section; regarding the uphill conditions the liquid section's height is determined within the uphill liquid source section.

These conditions, once defined the scanning step between the sections, are use in computing the total weight and the free elevation in the successive sections.

Knowing the initial section's geometry and flow (**downhill and uphill conditions**) - that we indicate as i section, the program calculates the J fall and the total load, so, once the scanning step has been determined the same dimensions (**fall and load**) are being calculated for different h values (**around the h defined**).

In the next step, the program calculates the load loss between the initial section and the successive one (**i+1**) and obtains, for the

interpolation of the values found for different h heights, the section's liquid height (**$i+1$**). For the first height obtained h_{i+1} , the program develops the computation of J fall and obtains the medium value of the fall (**the average of the fall in i and that of the fall in $i+1$**), from which follows the computation of the total load loss. At this point the program finds the h_{i+1} height by interpolating the previously found values with the constant scanning step.

Permanent fall hydraulical verification

For every transversal section it is being calculated the liquid section's height for a determined verification flow, as shown previously. The computation can be done for the several overflow periods' flows. In order for the computation to converge the verification flow for every section is extremely important. Once the computation has been performed the program has determined for every section the h height, establishing for every fragment if its dealing with a low or high inclination riverbed and consequently if the current is slow or fast.

Overfill mapping

The command shows the high flood area for every recurrence interval. The overfill mapping is available only after the sections' verification in permanent flow conditions. For printing it choose the *<Print Preview>* command.

Riverbed section preview

Views the longitudinal section of the riverbed with the water profile height determined in slice by slice flow conditions. For returning to the basin's view deselect the command.

Data block/free

command that allows to block or free the input/ output data.

2.8 Export Menu

EXPORT MENU

Enables selection of export format for the calculation results.

Export in RTF format

Display the computation report in an internal editor window which permits its Save in a file of RTF (**Rich Text Format**). The text editor where the

report appears allows text modifications (**format, font, copy, paste, tab...**);

Export in DXF format:

Export in DXF format the contents of the worksheet window for the purpose of further computation by a CAD program. Its selection is viewing its saving route;

Export Bitmap

Exports in BMP format (**image editor format**) the contents of the worksheet window (**basin, sections...**).

2.9 Preferences Menu

PREFERENCES MENU

Menu for the assignment of options for the operation of the graphics and texts.

Text composition Options

Visualizes the Printing options sheet in which it is possible to choose the input data that must be included in the report.

General Data

When choosing this command the program visualizes the basin's hydrologic data filled in by the user in **General Data** from the **Data Input** menu.

The flow coefficient

Once selected it brings the data filled in by the user in the *<Flow coefficient>* sheet from the **Computation menu**, requested for establishing the Kennessey's coefficient.

Hydrologic balance

Once selected it introduces in the report the data for the basin's hydrologic balance filled in by the user in the of *<Hydrologic balance>* from **Computation menu**.

Rain fall series computation with Gumbel

If selected it views the user filled in data in the *<Rain model>* command from the **Computation menu** and its computations (**a and n parameters**).

Basin's coordinates

If selected it views the basin's coordinates filled in by the user.

Main reach coordinates

If selected it views the main reach's coordinates filled in by the user.

Secondary reach coordinates

If selected it views the secondary reaches' coordinates filled in by the user.

Hydrology and morphometry

If selected it inserts the computations regarding the morphometrical and hydrological characteristics of the main basin and the ones for every sub-basin.

Note: for every section defined by the user the program considers automatically the presence of an alimentation sub-basin of the corresponding section.

High flood's maximum flow - empirical methods

If selected it brings into the report the high flood's maximum flow for every recurrence interval with empirical methods.

High flood's maximum flow - rational method

If selected it realizes the high flood's maximum flow report with the rational method determined for every section and for every recurrence interval.

Hydraulic sections verifications

If selected it realizes the hydraulic verification of every section of uniform or/and permanent flow.

Graphic Options

It visualizes the *<Drawing options>* sheet where is possible to choose the fill and lines color, the style for the representation of certain components (**main reach, secondary reaches,...**).

3 Input

3.1 Data Input

BASIN INSERTION IN HYDROLOGIC RISK

Basin's identification features within the program can be done from ***Numeric Input*** or ***Graphic Input*** menus.

The ***Numerical Input*** can be activated from the ***Input data*** menu. At the first level of this window must be filled in the coordinates that define the basin's extension (***X, Y, Z***), its external vertices and the main reach's vertices.

At the second level secondary reaches' vertices are entered (***ramifications that meet in the main reach***).

At the third level are defined the transversal section coordinates and at the last level of input the eventual sub-basins coordinates (***alimentation areas for the main reaches***) are specified.

Graphic Input gives the possibility to determine the basin with the help of the mouse.

This type of input is based on a raster base (***mapping scanning***) that is inserted into the program.

For both the cases (***numerical or graphic input***) the program converts the declared data into a ***Digital Terrain Model (DEM, Digital Elevation Model)*** of triangular network. Every point is connected to the other by Deluney's triangular elements method.

It is clear that the net generated this way depends on the triangles' dimensions and therefore on the number of point filled in by the user.

3.2 Conventions

CONVENTIONS

For a correct input the user has to respect the following conventions:

Basin's input

The vertices that define the basin have to be assigned as rising from left to right;

Hydro graphical network input

The hydro graphical network can be assign by defining a main river reach and the secondary ones.

Reach input

Every river reach is inserted from the highest elevation downwards; the same criteria is applied for the secondary reaches: from the highest elevation point to the lowest.

Break point's input

The verification break points are inserted, in sequence, starting at the main reach's lowest break point to the highest. For every inserted break point the program determines a basin section (**a sub-basin**) of all reaches that outflow at that break point. This sub basin cut off line can be altered by the user after all break point input, by selecting the Coordinates panel in the right side of the work sheet. In this phase the transversal section of the sub-basin can be altered by blocking the *<Automatic generation of the basin's transversal section>* and by selecting the *<Vertex alteration>* command from the **Data Input** menu, followed by the vertex position alteration with the mouse or by the input of the new coordinates in the upper part of the panel.

Alterations must precede computation.**Break point's form**

Break point definition can be done by clicking the uphill line after activating the selection command. A new worksheet will be opened in which, in the right side, a panel allows entry of all its proprieties (**form, roughness ...**).

Recurrence interval determination

Every time a new file is created the Recurrence interval must be determined in the **General Data** menu.

3.3 Numeric Input

NUMERIC INPUT

In the **Data Input** menu select **Numeric Input**.

For every basin the data input is structured on more levels: at the first level the basin vertices, basin's internal vertices coordinates and those of the main reach.

Basin vertices

It is a condition that the basin be defined as rising from left to right.

The option selection enables a grid where we can find:

N = vertex order number;

X = vertex abscise;

Y = vertex ordinate;

Z = vertex elevation;

Name = vertex identification.

Once the coordinates' entry is confirmed by pressing OK in the work area is viewed the watershed line; on the right of the work area can be viewed the in coordinates, so the alteration of every filled in vertex is possible in this phase.

Adding basin's elevation vertices

The user fills in the basin's interior vertices coordinates X, Y, Z. This is necessary for determining the morphological proprieties of the basin (**areas, inclinations, etc**) at the end of DEM's creation (**Digital Elevation Model**).

Main reach vertices

The main reach represents the water course that has its origins and its last point in the basin's transversal section; All its confluent ramifications are considered secondary reaches. The main reaches are determined starting from the spring point of the basin to its closing point. These vertices are important to determine the DEM and to determine the triangularisation, so they are compulsory for the further computation of the project.

At the second level of the numeric input are determined the secondary reach's vertices, confluent on the main reach.

Secondary reach vertices

The number of secondary reaches is entered in this phase: the program automatically considers the presence of a single secondary reach, so to add more you have to position the mouse on reach 1, make a click on the right button of the mouse and select **New Secondary reach**. To eliminate a reach proceed like explained before and select **Eliminate**.

The vertices that define every secondary reach are filled in the grid (**N, X, Y, Z, Name**) from the spring point of the reach to the confluence one.

At the third level of the numerical input the transversal sections are defined.

Section line

Every transversal section (**more than one might be present**) must be defined by points (**X, Y, Z**) so from the left to the right. To fill in more sections proceed from down upwards. Depending on every section's line the program will develop the hydraulically checking.

Hydrologic Risk takes into consideration a feeding sub-basin for every transversal section, whose coordinates are defined at the next level.

The section line must be drawn with the mouse (**GRAPHIC INPUT**) on the river's reach, from the left side with the mouse down by displacing it to the right. Once the mouse is released section's size is defined and the work window is opened where the section can be viewed. In the section's right side can be viewed the section's data within the work window.

- **Type:** in this sheet are presented the predefined forms for determining the section (**circle, rectangle, parabola, trapeze**); for each predefined form the programs asks for the dimensions that define the exact geometry of the section (**ex: the diameter, for circle; the base and height for the rectangle; etc.**)
- **Section Data:** the filled in data in the precedent worksheet are viewed with the possibility to alter them. Here there are specified the watered outline through indicating section's pints that have been watered. The *<Generate Section>* command views the water level and realizes the first hydraulical computations:
 1. **Aria:** watered section area in m².
 2. **Watered outline:** watered section's perimeter made from the solid basin's walls (**free currents**) in m.
 3. **Hydraulic ray:** the liquid section area and the watered outline in m.
 4. **Section water height:** liquid section' s height in m.
- **Flows:** the flows sheet views the high flood flows calculated with the empirical and analytical methods, for the specified Recurrence interval T (**General Data**); these results are viewed at the end of the computation (**Computation Menu** – Maximum high flood flow) according to the

empirical and rational methods. The user can check each section for every recurrence interval, assigning personalized values.

At the fourth level are defined the eventual sub-basins within the main one.

3.4 Graphic Input

GRAPHIC INPUT

As was already said (see ***BASIN' S INPUT IN HYDROLOGIC RISK***), basin's vertex insertion and its river network can be performed graphically with the mouse.

The programs allows increasing levels of detail input so to start with the vertices that determine the basin's outline may be inserted (***its inner points***) and after these, the main reach's vertices.

Basin's vertices

For the watershed boundary insertion press Select <*Basin vertices*> in ***Data Input:*** so the program allows the user by selecting the <*Vertices input*> command to insert vertices by clicking the work area; these will be inserted as rising from left to right to the complete closing. Once the vertices input is completed, in the right side of the screen will be viewed the coordinates inserted that can be altered. The <*Vertex input*> command can be also selected from the Standard toolbar.

Vertex alteration

The command allows the graphical alteration of a vertex position, by placing the mouse on it pressing and holding the left button of the mouse, placing the vertex into its new position. When you pass the mouse on the vertex its coordinates can be viewed on the right part of the screen. The <*Vertex alteration*> command can be also selected from the Standard toolbar.

Vertex elimination

Allows vertex elimination. Position the mouse on the point you want to eliminate after having selected the command and click. The command can be selected also from the toolbar.

Cut

The command is indicated when you want to insert another vertex with the two already inserted.

elevation vertices input

To graphically insert basin's interior vertices you have to select the command and click on the work sheet. For every vertex the coordinates grid is automatically viewed in the right part of the screen.

elevation vertices elimination

This command allows elevation vertices' elimination within the basin.

Transversal section

This command allows the introduction of the verification sections from the ***Numeric Input***. The sections' displacing to the highest point of the river reach is done starting from downwards. Every section must be determined starting from the left with the mouse down towards its the final point. The section's form and dimensions are graphically and numerically shown in the sections' view window that can be activated with a double click of the mouse in the correspondent area (see also ***Numeric Input***)

Transversal section elimination

This command allows the transversal section's elimination with a click on the section that you want to eliminate.

3.5 Raster Image Import

RASTER IMAGE IMPORT

Select the ***Raster Image Import*** command in the ***Data Input*** menu.

Basin's and its hydrological network input can be done by the import of a raster graphic model obtained by mapping scanning.

One the command is selected the image properties window is viewed; in this window you can select the file from which the image import will be imported, this has to be an image folder with **BMP** or **JPG** extension (**the last one would be advisable**).

Calibration parameters

These allow the image calibration at the end of the digital coordinates insertion.

Measured distance

Insert the video measured distance between two points of the imported image. The program will start the distance definition by considering it equal to 1; therefore after

the import the user has to measure the distance between the two points and insert the calibration parameters.

Real distance

Insert the real distance in meters between the specified points (**the measured distance**). By knowing the video measured distance, the real one and the image dimensions, the program can define the scale report between pixel and points.

Left interior vertex (X)

Left interior vertex image abscissa, depending on the local user chosen reference system.

Right interior vertex (Y)

Right interior vertex image ordinate, depending on the local user chosen reference system.

Horizontal Width

Insert real scale scanning width.

Original Height

Insert real scale scanning height.

Calculated Width

The program views, in function of the inserted distances (**measured and real**) and the area's dimensions images calculated width.

Calculated Height

The program views, in function of the inserted distances (**measured and real**) and the area's dimensions images calculated height.

Image calibration

For making the raster model a real scale one the calibration must be repeated more than once and in more directions. For this select the image and press the right button of the mouse to view image proprieties.

4 Output

4.1 Hydro graphic and Morphometrical Analysis

HYDRO GRAPHIC AND MORPHOMETRICAL ANALYSIS

For every basin defined by **GRAPHIC INPUT** or **NUMERIC INPUT**, after triangularisation, the program performs a series of computations that define the basin's morphological aspects returning its principal proprieties (**area, perimeter, average altitude, average inclination**) and its 2D properties (**river's axis length, average inclination, etc.**)

Basin

Running through the list of sub basins for every delimiting break point, the following properties are displayed:

Surface

The basin's surface in Km²; the basin is defined by the watershed boundary and the break point line ideally extended, in both directions, to the intersection with the watershed boundary.

Center of gravity coordinates

The basin's Center of gravity X and Y coordinates in function of the Cartesian axis system in use.

Perimeter

Basin's perimeter expressed in Km.

Altitude (Max, Medium, Min)

Views the basin's maximum, medium and minimum altitude. The medium altitude can be calculated with the weighted average of the heights or by the Hypsographical curve, selectable from the **General Data** in the **Data Input** menu.

Maximum length

Basin's width corresponding to the planimetric extent.

Average inclination

Basin's average inclination as calculated.

Form factor

Drainage density

Hierarchic order

River Reaches

Corresponding to the basin, its linear proprieties can be viewed:

Main reach length

Main reach length for the current basin whose origin is the basin's origin and end the delimiting break point line.

Closure break point elevation

Displays elevation of reach bed of the delimitation break point.

Average inclination of the main reach

The average inclination of the main reach calculated from the average inclination of each individual single reach.

Time of Concentration

Displays the time of concentration of the basin calculated with the user's selected options in **General Data** from the **Data Input** menu.

4.2 Kennessey's coefficient

FLOWING COEFFICIENT

Not all water that falls into a basin contributes to formation of river, torrent or stream etc. Only the quantity that is not absorbed by the terrain determines the affluence. This quantity depends on factors inherent to the basin's morphology, its permeability, its vegetal cover etc

There are several methods to determine the **flow coefficient**, or the ratio between inflow and outflow quantity, referring to a transversal section.

Hydrologic Risk uses **Kennessey's method**, applicable particularly to small basins.

Its value is determined on the sum of three interconnected index values: basin's medium steepness (C_a), the vegetal cover (C_v) and its medium permeability (C_p).

Generally, a higher **medium steepness** contributes to a more intense flowing, reducing the infiltration and evaporespiration. The presence of a right **vegetal cover** makes the surface out-flow and the infiltration slower. To this is added the dispersed water by plants perspiration.

A greater **permeability** contributes to the increasing of the water quantity that infiltrates into the soil, reducing the surface flowing.

To these three factors we have to add **the climate** of the zone we want to analyse: actually, the flowing coefficient is very influenced by the meteorological events' distribution over the year, rather than by temperature and rainfall values. Generally, the maximum rainfall associated with high temperatures bring a greater evaporespiration with consequent decrease of the surface runoff; therefore maximum precipitations contribute to a greater flow.

To take into consideration the climate factor we have to define **an aridity index I_a** :

$$I_a = \frac{P}{T+10} + \frac{12p}{t} \quad \frac{dH}{dx} = i_r$$

where:

- P** = monthly medium inflow;
- T** = annual medium temperature;
- p** = inflow of the most arid month;
- t** = temperature of the most arid month.

With **Kennessey's** method we can identify three intervals of the values for the I_a coefficient for every factor (C_a , C_v , C_p):

Aridity index I_a	$I_a < 25$	$25 < I_a < 40$	$I_a > 40$
Permeability (C_p)	Coefficients		
Very low	0.21	0.26	0.30
Low	0.17	0.21	0.25
Medium	0.12	0.16	0.20
Good	0.06	0.08	0.10
High	0.03	0.04	0.05
steepness (C_a)	Coefficients		
> 35%	0.22	0.26	0.30
35% - 10%	0.12	0.16	0.20
10% - 3.5%	0.01	0.03	0.05
< 3.5%	0.00	0.01	0.03
Vegetation (C_v)	Coefficients		
Rock without vegetation	0.26	0.28	0.30
Pasture	0.17	0.21	0.25
Tilled soil	0.07	0.11	0.15
Forest	0.03	0.04	0.05

Depending of every zone's aridity index is calculated the contribution of every factor (steepness, permeability and vegetation) considering their distribution on the inner zone of the basin.

Or for every slice of the basin area (basin's area percentage) the coefficient referring to every factor of the zone is multiplied (in percentage): every factor will result from the coefficients' sum as explained before.

The annual medium defflux coefficient will be obtained from the sum of the partial defflux coefficients: C_a , C_v , C_p .

Here is **an example of calculation** for the partial flowing coefficient depending on the permeability C_p :

Basin's zone = 25 Km² with the aridity index < 25

Distributed as follows:

5 Km² are on a high permeability terrain (**20% from the total surface**);

10 Km² are built on a medium permeability terrain (**40% from the total surface**);

10 Km² are on a low permeability terrain (**40% from the total surface**);

Defflux coefficient computation C_p :

0.03 (high permeability coefficient) \times 0.20 = 0.0060

0.12 (medium permeability coefficient) \times 0.40 = 0.0480

0.21 (low permeability coefficient) \times 0.40 = 0.0840

$C_p = 0.0060 + 0.0480 + 0.0840 = 0.570$

The corresponding process must be followed by the determination of other two flow coefficients. C_a and C_v .

4.3 Hydrologic balance

HYDROLOGIC BALANCE

Basin's Hydrologic balance is the equality of affluence and runoff.

Water goes through a closed circuit that is composed by the evaporation phase, the precipitations (**rain, snow, etc.**) terrain infiltration and the outflow into the sea, from where the circuit starts again.

The Hydrologic balance generic express is:

$$P = EV + R + I$$

where:

P = precipitation;

EV = evapoperspiration;

R = flowing;

I = infiltration.

General Data

Basin's position:

Choose between the two options *mountain basin* and *ground level basin*;

Basin's area:

The program calculates the basin's area automatically, after its input, but it also allows assigning a different value for it.

Annual rain fall

This data is read by the program in **General Data** window from the **Data Input** menu.

Annual medium temperature

This data is read by the program in **General Data** window from the **Data Input** menu.

Real Evapoperspiration Computation

Hydrologic Risk performs the computation for ETR, based on the formula of Keller or Turc, as being the water height in mm

Inflow

Meteorite precipitations

Insert flows's percentage (**water volume in m³**) due to the precipitations.

Adjacent basins contributions

Calculates the percentage of the contribution from other basins.

Residual water

Insert the water volume (**as percentage from the total inflow**) from the civil and industrial consumers.

Secondary surface infiltrations

Adjacent GWT contribution.

Adjacent GWT water contribution**Outflow****Real evapoperspiration ETR****Well share****Flows to other basins****Present springs****Surface outflow****Flows to other GWT****Hydrological reserves storage variation****4.4 Permanent flow****PERMANENT MOTION STATE HYDRAULICAL VERIFICATION**

The permanent motion with gradual variations flowing is that which is occurs in a free current with gradual variations in the beds cross section. continuity determines that capacity is constant, while velocity and cross section vary gradually along the flow's s axis.

If we consider a permanent flowing current with a minor inclination and a constant Q flow, isolating a riverbed section with ads length (**with the s abscissa measured from a point that was not previously calculated, in the horizontal direction towards the coincident with the flowing point**) the depth is being subsided with $i_f ds$ and the total load line with Jds , indicating the fall with J.

From simple geometrical considerations we have:

$$i_f ds + E = E + \frac{dE}{ds} ds + J ds \quad a)$$

$$\frac{dE}{ds} = i - J \quad b)$$

The expression **b)**, in which for simplicity i_f was specified with as being equal to i , it indicates the total specific energy that refers to the depth, grows by the depth's subsidence and is diminished through the resistance effect.

Substituting the finite growth differences $b)$ becomes:

$$\Delta s = \frac{\Delta E}{i - J}$$

E results depending on s , through the h height we have:

$$\frac{dh}{ds} = \frac{i - J}{\frac{dE}{dh}} \quad c)$$

From E 's displacement depending on h , we know that E is decreasing and increasing in function of h ($dE/dh < 0$) for rapid currents ($h < h_c$), and is increasing ($dE/dh > 0$) for lent currents ($h > h_c$); in function of the critical state $dE/dh = 0$.

Accepting for the charge loss J the following formula:

$$J = \frac{V^2}{C^2 R} = \frac{Q^2}{C^2 R A^2}$$

results that J is as decreased as h is increased, assuming that all the denominator's terms are increasing with h .

c)'s numerator is positive ($i > J$) for water heights that surpass those of the uniform flow ($h > h_0$), negative for water heights that do not surpass those of the uniform flow ($h < h_0$).

The considerations made until now are at the base of the water profile's permanent flow represents: we note that when the water height is approaches that of the uniform flow dh/ds tends to zero, or the profile tends to lie parallel to the bed and to the uniform flow.

But when the height is tending to the critical value $k_d E/dh$ tends to be annulated so the profile tends to be displayed perpendicularly on the base (depth).

So the permanent flow profiles are analytically described by the expression **b)**, so specify at least one arbitrary constant to determine by defining a section's height like this $h = h^*$.

Such a condition is calculated in function of a perturbatory cause that provokes, in a section, a height h different from that of the uniform flow; for this purpose the perturbatory cause can have influence uphill only if the current is slow (or becomes slow), it can have influence downhill only if the current is a fast one (or it becomes rapid because of this influence).

All these get to the conclusion that the profile's relation - the displacement's depart point - is found downhill if the current is slow and uphill if the current is fast.

In such a section we have to note the height h^* determined as the cause of perturbation and the level difference $h^* - h_0$ will be known in reference to uniform flow.

4.5 Rain Model

RAIN MODEL or RAINFALL PROBABILITY

Hydro graphical Services or the competent authority is regularly measure precipitations at gaging stations distributed in the territories of competence. calculating the inflow's data for the field measurements. Such measurements are normally published in yearly reports.

Data computation can determine the rain model for a specified recurrence interval, or finds the relation between the rain's height h and time t . Generally, for such an computation data for an extended period are required (at least 20 – 30 years).

All Rain models have this form:

$$h = a \cdot t^n$$

where a and n are constants that vary depending on the recurrence interval and are determined depending on the case.

GUMBEL'S DISTRIBUTION

The most statistical-probabilistically computation of rainfall data is that of Gumbel's, that expresses the probability that the h value might not be surpassed for a determined period. You can find it below:

$$P(h) = e^{-e^{-k_1(h-k_2)}}$$

where, for a determined period:

P(h) = the probability that the h value might not be exceeded; (1-P) represents the probability;

k1 and **k2** = distribution parameters.

For k_1 and k_2 parameters estimation the moment method can be applied, with the resulting values:

$$\begin{aligned} k_1 &= 1.283/s \\ k_2 &= M - 0.450 \cdot s \end{aligned}$$

Where **M** represents the events' average and **s** is the mean standard deviation.

The recurrence interval **Tr** represents the reversed overflow probability (1-P), that can be expressed:

$$T_r = 1/(1-P)$$

So the probability depending on the recurrence interval can be expressed:

$$h = k_2 - \frac{1}{k_1} \ln \left[-\ln \left(\frac{T_r - 1}{T_r} \right) \right]$$

4.6 Empirical methods

EMPIRICAL/UDOMETRICAL METHODS FOR HIGH FLOOD'S MAXIMUM FLOW ESTIMATION

With the empirical methods the maximum high flood's flow estimation depends on adopting a law regarding the probability distribution of peak flow's annual maximum. Authors have searched for the best definition and approach.

Forti's formula

Forti proposed two formulas for the calculation of the specific flow, or the **high flood unitary contribution** in $\text{m}^3/\text{sec Km}^2$, for surfaces below 1000 Km^2 , and with maximum rain in 24 h of 400 mm

$$q_{\max} = 3.25 \frac{500}{A+125} + 1$$

and of 200-250 mm

$$q_{\max} = 2.35 \frac{500}{A+125} + 0.5$$

Marchi's formula (1939)

Valid for basins with a inferior surface to 150 Km^2 , with maximum rain in 24 h of 400 mm. The udometric coefficient will be calculated:

$$q_{\max} = 2.35 \frac{500}{A+125} + 1$$

Pagliari's formula (1936)

Valid for basins between 20 and 1000 Km^2 , the specific high flood maximum flow is calculated:

$$E = h + \frac{\alpha V^2}{2g} \quad q_{\max} = \frac{2900}{90 + A}$$

where **A** represents basin's surface and the flow is the specific one, or for the basin's surface unit expressed in $\text{m}^3/\text{sec Km}^2$.

Scimeni's formula (1928)

Valid for basin not larger than 1000 Km^2 , the specific high flood flow is calculated:

$$q_{\max} = \frac{600}{A+10} + 1$$

where **A** represents basin's surface and the flow is a specific one, or for the basin's surface unit, expressed in $\text{m}^3/\text{sec Km}^2$.

Giandotti's formula (1940)

Valid for basins non larger than 1000 Km^2 , the specific flow is:

$$Q_{\max} = \frac{532.50}{A + 16.20} + 5$$

4.7 High flood maximum flow

THE HIGH FLOOD'S MAXIMUM FLOW ANALYTICAL (RATIONAL) METHOD

In the *Rational Method* the high flood's maximum flow is corresponding to an established recurrence interval T_T .

$$Q_T = c \cdot h \cdot A \cdot \frac{k}{t_c}$$

where Q_T the flow in m^3/sec , with:

A = flowing surface [Km^2];

h = rain's elevation that drops in a period equal to the concentration one [mm];

tc = time of concentration [hours];

c = flowing coefficient;

k = factor that take into consideration the measurement units.

4.8 Tcev

HIGH FLOOD FLOWS EVALUATION

The high flood flows' evaluation for T values (**recurrence interval**) can be done on hydrologic data (**direct methods**) and on specific studies performed (semi empirical direct methods).

It's clear that such an important figure must be done with an uniform procedure on all national territory, so all evaluation should begin by probabilistically determination of the annual maximum flows with extreme value distribution or with a double component (**TCEV – Two Component Extreme Value**).

With X is indicated the high flood's peak flow annual maximum and with X_T X' s maximum value that corresponds to a predefined overflow period T expressed in years, so we have:

$$X_T = K_T m(X)$$

Where:

K_T = probabilistic Seismic corrections' inertial effects growing factor, constant for homogeneous surfaces;
 $m(X)$ = X variable maximum annual distribution average;

TCEV takes into consideration the following cumulated probability function for X' s maximum annual value:

$$F_X(X) = e^{\left[-\Lambda_1 \exp(-X/\theta_1) - \Lambda_1 \Lambda_*^{1/\theta_*} \exp(-X/\theta_*\theta_1) \right]}$$

where X is the considered variable (the annual peak maximum flow for t period rain) and Λ_1 , θ_1 , Λ_* , θ_* are the distribution parameters.

For homogeneous rainfall sub-zones the parameters Λ_1 , Λ_* , θ_* are considered constant, and the X variable is substituted with a dimensional value X' that is obtained with:

$$X' = X/\mu$$

Where μ is the index flow, for medium X.

With this variable the cumulative probability function can be expressed:

$$F_{X'}(X') = e^{\left[-\Lambda_1 \exp(-X'\eta) - \Lambda_1 \Lambda_*^{1/\theta_*} \exp(-X'\eta/\theta_*) \right]}$$

with $\eta = \mu/\theta_1$

So, for X_T expression a T value must be assigned and $F_{X'}(X')$ is determined with:

$$F_{X'}(X') = 1 - 1/T$$

so, next is the estimation of X'_T (**fill factor**).

For the practical estimations of the fill factor we can use:

$$X'_T = a_0 + a_1 \ln T$$

- a_0 and a_1 are variable coefficients depending on the region.

For the estimation of the index flow μ we can appeal to the arithmetical average of the observed vales of X, or, if the data is not available, we can

appeal to inter polar relations for every homogeneous region or zone with the following generic expression:

$$m(Q) = \bar{X} = c_1 \cdot A^{c_2}$$

with A the basin's area and c_1 and c_2 the parameters for each region of the various zones.

With the obtained values it's determined:

$$X_T = X_T' \bar{X}$$

4.9 High flood mapping

HIGH FLOOD MAPPING

Apart from the climax flow it may be useful to know the flow's evolution, in the section referred to, depending on the period.

The construction of such a graphic is obtained with the method proposed by **Nesh**:

$$Q(m \times \Delta t) = S_b \cdot \frac{\sum_{i=1}^m e^{-i\Delta t/k}}{k \cdot \Gamma(n)} \cdot (i \cdot \Delta t/k)^{n-1} \cdot h_{m-i+1} \Delta t$$

where:

Q(m·Δt) = the instantaneous flow m·Δt, with m variable from 1 to N;

N = the maximum number of intervals considered;

Δt = the temporary time interval (1 hour);

m = interval number;

Γ(n) = the gamma function;

S_b = basin's area [Km²];

h_{m-i+1} = the effective inflow [mm] in the interval (m-i+1);

k, n = basin's characteristic coefficients.

*For estimating the coefficients **k** and **n** there are available several correlations, the program uses:*

Nash (1960)

n and k are known by determining the m_1 and m_2 parameters with:

$$m_1 = n \cdot k$$

$$m_2 = \frac{n \cdot k^2}{m_1^2}$$

with:

$$m_1 = 27.6 \cdot A^{0.3} \cdot i_b^{-0.3}$$

$$m_2 = 0.41 \cdot L^{-0.1}$$

where:

- A** = basin's area expressed in square miles;
- L** = water course length, prolonged, in miles;
- i_b** = basin's medium inclination in parts on 10000.

Mc Sparran (1968)

Mc Sparran calculates:

$$n = 4.1 \cdot \frac{t_p}{k_1}$$

$$k = \frac{t_p}{n-1}$$

with:

$$t_p = 5.52 \cdot A^{0.208} \cdot i^{-0.447}$$

$$k_1 = 3.34 \cdot A^{0.297} \cdot i^{-0.354}$$

where:

- A** = basin's area expressed in square miles;
- i** = the medium inclination of the water course in parts on miles.

4.10 Uniform Flow

UNIFORM FLOW HYDRAULICAL VERIFICATION

The hydraulically verification of the section in uniform flow conditions can be done rationally in the artificial canals, where section's form is regular enough and perturbations are not present .

In the case of the uniform flow the free current inclination and the specific load line fall are equal to the riverbed's inclination.

The equations that describe the uniform flow are:

$$Q = \text{const}$$

$$\frac{dH}{dx} = i_f$$

Where:

Q = the flow;

H = current's total load [m];

i_f = riverbed's depth inclination.

In the uniform flowing the medium velocity of the current depend on the riverbed's characteristics (**the inclination, the roughness and the form**) and on the currents characteristics (**depth, liquid zone area, the hydraulic range**) and it is expressed with Chézy's formula:

$$V_0 = C \cdot \sqrt{R_0 i_f}$$

where i_h of the load line is equal to the riverbed's inclination i_f , R_0 is the hydraulic range and C is the roughness coefficient (**Strickler, Bazin Kutter, etc.**).

Strickler's expression of the roughness coefficient is:

$$C = c \cdot R^{1/6}$$

where:

c = roughness coefficient;

R = hydraulic range.

Section's verification problem is that of the guarantee that the project's flow (**high flood's maximum flow**) will pass through the considered section's interior.

After the computation of the uniform condition's flow is calculated the liquid height in the section for the calculated flows (that refer to the Recurrence interval).

Generating the energy graphic, corresponding to the user specified flow, the program views the section's energetically features graphic and the critical height velocity values.

The current's energy in the section is expressed as follows:

$$E = h + \frac{\alpha V^2}{2g}$$

with E measured from the riverbed's depth elevation.

Its a-synthetic characteristic flowing, for h tending to zero and for h tending to infinite, allows the definition of its minimum point of the k value of the current's critical height that defines the Q flow.

We must remember, that according to the critical state the current passes from being rapid, with the height $h < h_{crit}$, to being slow, with $h > h_{crit}$.

So, the critical height of a calculated free current flow Q, is the height h that from where the minimum specified energy E for the riverbed's depth is calculated.

4.11 Computation

COMPUTATION MENU

In this menu you can find the commands that help establish the basin's balance, its high flood flows for every section, homogeneous and permanent flow conditions verification and the riverbed section view (**longitudinal profile**).

Hydro graphical and Morphometrical Analysis

For every basin defined by a break point an analysis is performed regarding its morphometrical proprieties and its time of concentration. During this phase the program carries out also the computations for every sub-basin automatically generated according to the position of each breakpoint.

After the analysis is completed alterations can be undertaken for every sub-basin from the control panel in the right of the work area. Activating

the *<Basin vertices alteration>* command every sub-basin can be shaped according to the project requires. After doing this the calculation must be redone.

Triangularization

This operation is carried out automatically by the program for the morphometrical and hydro graphical analysis. This command enables the basin's 3D view and its printing from the preview window - to activate it press the right button of the mouse.

Kennessey's flow coefficient

Carries out the computations using Kennessey's flow coefficient. For this parameter, compulsory for the next step in the hydrological balance, the following data must be provided:

- rainfall**: expressed in mm of rain, for expressing P rushes;
- medium temperature**: monthly medium temperature;
- maximum temperature**: monthly maximum temperature;
- minimum temperature**: monthly minimum temperature.

The program calculates the aridity index for provided data, from which, depending on the calculation for the surface slices that define the vegetal distribution, the steepness and the permeability, the partial and total efflux coefficient are obtained.

Basin's hydrologic balance

In this window are asked the main basin's inflow and outflow data.

Rain model

In this window are computed long rain data (**1 - 3 - 6 - 12 - 24 hours for several years**); consequently the basin's Rain model is defined. The program performs the calculation of the rain's maximum and critical height corresponding to every day and period (**1, 3, 6, 12, 24 hours**), in function of every recurrence interval assigned by the user in **General Data** from the **Data Input menu**.

Rain data acquired from a rainfall station can be directly filled in the period's table or copied from another file.

The program computes data with Gumbel's probability distribution, and finds the parameters, the medium standard deviation, k and m.

The Rainfall Probability Curve graphic is available in semi-algorithmic and algorithmic scale (**x and y**). By pressing the right button of the mouse you can copy the graph to clipboard, paste it in bitmap image format or copy the containing values for another project.

The print report allows sending input data and results to the printer.

High flood flow - Empirical Methods

For every transversal section the high flood flow is calculated with empirical methods. This requires the author's selection. The program reads the flow value in m³/sec, the specific flow in m³/sec Km².

High flood flow - Empirical and Rational Method

For the assigned Recurrence interval the program calculates the high flood flow corresponding with the specified transversal section. The program develops a flow analysis for every sub-basin on the activation of the *<Flows analysis>* command. The calculation differs on the selection of the method to use Rational, Analytical or TCEV IN **General Data**.

High flood hygrograph

For every recurrence interval assigned by the user the program generates the high flood hygrograph with Nash's method. In the respective window, for every elected transversal section can be viewed: k and n function parameters, basin's characteristics (**calculated with Nash or Mc Sparran**) and n and a Rain model parameters (**for every Tr**). Calculation step, in hours, and the maximum period (**hours**) are user defined; in order to change them press the *<Recalculate>* button. The graphic can be copied to clipboard and can then be pasted in bitmap image format by holding down the mouse and choosing the *<Copy Graphic>* command. For exporting the curve's values you can choose the *<Copy Format>* from the same menu.

Uniform flow hydraulic verification

For every selected section the program carries out the uniform flow conditions verification. The verification sections definition (**transversal sections**) takes place before this stage, so, after having developed the Hygrograph and Morphological Analysis, the program proceeds with the determination of the maximum high flood flow (**empirical and classical methods**). Every sections' roughness and form must be defined. Sections' generation can be obtained by activating the *<Transversal section>* command from the **Data Input** menu (**or the toolbar**) and clicking on the section line previously determined.

Permanent flow conditions

In this window the user can assign the analysis conditions for the permanent flow for every recurrence interval. Regarding the downhill conditions the liquid section's height is defined within the transversal section; regarding the uphill conditions the liquid section's height is determined within the uphill liquid source section.

These conditions, once defined the scanning step between the sections, are use in computing the total weight and the free elevation in the successive sections.

Knowing the initial section's geometry and flow (**downhill and uphill conditions**) - that we indicate as i section, the program calculates the J fall and the total load, so, once the scanning step has been determined the same dimensions (**fall and load**) are being calculated for different h values (**around the h defined**).

In the next step, the program calculates the load loss between the initial section and the successive one (**$i+1$**) and obtains, for the interpolisation of the values found for different h heights, the section's liquid height (**$i+1$**). For the first height obtained h_{i+1} , the program develops the computation of J fall and obtains the medium value of the fall (**the average of the fall in i and that of the fall in $i+1$**), from which follows the computation of the total load loss. At this point the program finds the h_{i+1} height by interpolating the previously found values with the constant scanning step.

Permanent fall hydraulical verification

For every transversal section it is being calculated the liquid section's height for a determined verification flow, as shown previously. The computation can be done for the several overflow periods' flows. In order for the computation to converge the verification flow for every section is extremely important. Once the computation has been performed the program has determined for every section the h height, establishing for every fragment if its dealing with a low or high inclination riverbed and consequently if the current is slow or fast.

Overfill mapping

The command shows the high flood area for every recurrence interval. The overfill mapping is available only after the sections' verification in permanent flow conditions. For printing it choose the *<Print Preview>* command.

Riverbed section preview

Views the longitudinal section of the riverbed with the water profile height determined in slice by slice flow conditions. For returning to the basin's view deselect the command.

Data block/free

command that allows to block or free the input/ output data.

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6 Geoapp

Geoapp: the largest web suite for online calculations

The applications present in Geostru Geoapp were created to support the worker for the solution of multiple professional cases.

Geoapp includes over 40 applications for: Engineering, Geology, Geophysics, Hydrology and Hydraulics.

Most of the applications are free, others require a monthly or annual subscription.

Having a subscription means:

- access to the apps from everywhere and every device;
- saving files in cloud and locally;
- reopening files for further elaborations;
- generating prints and graphics;
- notifications about new apps and their inclusion in your subscription;
- access to the newest versions and features;
- support service through Tickets. Enter topic text here.

6.1 Geoapp Section

General and Engineering, Geotechnics and Geology

Among the applications present, a wide range can be used for **Hydrologic Risk**. For this purpose, the following applications are recommended:

- Georisk
- Draining trenches
- Hydraulic invariance
- River bed protection, Riprap
- Hydraulic behaviour
- Uniform motion calculation
- Debris Flow

7 Contact

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