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The Geographic Information System PHYSITEL
USER Manual
-
Beginner

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Rapport R2231
PHYSITEL v 4.0.17

ISBN : 978-2-89146-993-7 (version numérique)

Dépôt légal - Bibliothèque et Archives nationales du Québec, 2025
Dépôt légal - Bibliothèque et Archives Canada, 2025

Context

Welcome to the user guide for PHYSITEL. This guide is designed to help you navigate and utilize the features of an existing project. It is not intended for advanced users who wish to create a project from scratch, but rather for those who are new to the software or are looking to understand its functionalities within an existing project.

Getting Started

Before diving into the details, let's ensure you have everything you need to begin exploring the project:

- Access: Make sure you have the necessary permissions to access the project. If you are unsure, contact your project administrator or manager.
- Software Installation: Ensure that the software is installed on your system. If not, you only need to copy paste the necessary files in your chosen directory and create a desktop shortcut for ease of use.
- License: Make sure your license is activated and the language is set to English. If you do not have a license, contact Alain N Rousseau at alain.rousseau@inrs.ca.

Symbols and signs

The following symbols are used throughout this whole document to draw the reader's attention to crucial points.

MUST NOT DO

HELP

INFORMATION

QUICK TIPS

Content

1 PHYSITEL structure

This text is extracted from - Rousseau et al. (2021). As such all references provided in the text are available in the article digitized document attached to the software files.

Rousseau A, Fortin JP, Turcotte R, Royer A, Savary S, Quévy F, Noel P, Paniconi C (2011) PHYSITEL, a specialized GIS for supporting the implementation of distributed hydrological models. Water News 31:18-20.

PHYSITEL is a specialized Geographic Information System (GIS) designed for supporting the implementation of distributed hydrological models in general, and HYDROTEL in particular. Using a DEM, a soil type map, a land cover map, and a hydrographic network; the GIS computes physiographic parameters for Relatively Homogenous Hydrological Units (RHHUs). Namely, this GIS determines internal drainage structure (slopes and flow directions), watershed boundaries, sub-basin and hillslope boundaries, and hydrographic network. For each RHHU, PHYSITEL calculates the topographic index distribution, and characterizes the dominant soil type, and percentages of different land covers. Because of standard data formats and universal data types, output data can be used for a wide range of distributed hydrological models. Use of the D8-LTD algorithm to compute the flow matrix, access to editing tools to modify the flow matrix and correct the digitized river and lake network, and use of a hydrographic network to determine the internal drainage structure of a watershed differentiate PHYSITEL from most GISs.

Figure 1 presents the logical structure of PHYSITEL which is based on a hydrological modeling framework organized into 11 different steps: 1- DEM importation; 2- Digitized River and Lake Network (DRLN) importation; 3- Land cover importation; 4- Soil type importation; 5- Raster network calculation; 6- DEM and DRLN fusion (DEM burning); 7- Slope calculation; 8- Flow direction matrix calculation using the D8-LTD algorithm (Orlandini et al., 2003); 9- Flow accumulation matrix calculation; 10- River network regeneration; 11- Relatively Homogeneous Hydrological Unit (RHHU) delineation; Optionally, the following calculations can also be performed; Wetlands, Elevation differential (HAND) and discharges; Storage map.

Input data include a DEM, land cover and soil type maps and a hydrographic network. It is, however, preferable to use a representative hydrographic network in vector format (.tab, .mif or .shp) as basic input data (Turcotte et al., 2001). This integration is necessary in the case of water surfaces like lakes and reservoirs and meandering rivers which cannot be distinguished from flat areas by a DEM alone. However, river networks are not continuous and may require manual corrections that can be performed using various tools available in PHYSITEL (see Fig. 1). Lately, PHYSITEL was adapted to import filamentary river networks since they are becoming more readily available and almost error free (Rousseau et al., 2009).
This is particularly useful when there is a need to establish a topological correspondence between HYDROTEL's hydrographic network and an already existing filamentary network which is used for water allocation purposes. The GIS can also compute parameters that characterize a hillslope, that is: plan shape and profile curvature; the nine standard hillslope representations of Dikau (1989), derived using a binary or a fuzzy logic approach; and width

function (Noël et al., 2009). PHYSITEL handles many DEM sizes sizes, however, the map display of the user interface of PHYSITEL can handle a maximum of 64 000 000 cells (e.g., 8000 x 8000). It is possible to work with larger DEM sizes with the display of map being deactivated. Prefered source raster format is the GeoTIFF standard, but other popular formats should also be supported (.asc, .dem, .ggf, .grd), and resolutions (unlimited). Additional calculations such as Topographic Index (Beven and Kirby, 1979) calculation for each RHHU, statistics, and histograms are available (see Rousseau et al., 2009). It is also possible to display 3D or Virtual Earth representations of the watershed.

All matrices generated by PHYSITEL are saved in a GeoTIFF format. The software can deal with different map projections and allows users to add others.

It can be noted that new function and calculation were added to PHYSITEL structure including wetland identification and drainage area mapping, also water storage tool and map creation.

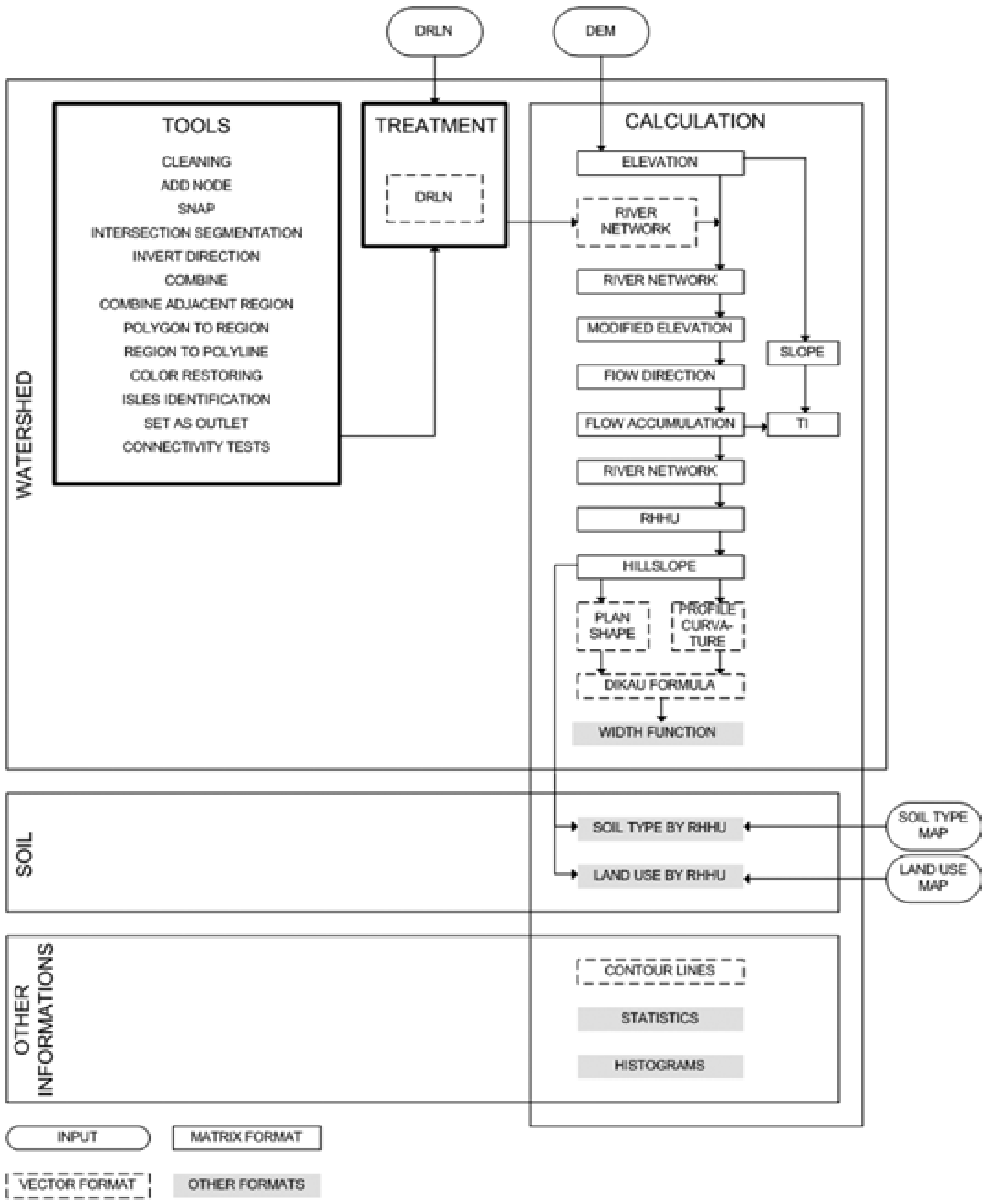


Figure 1: PHYSITEL logical structure

From this point on, we assume that the user has access to a PHYSITEL project already set up by an experienced third party.

2 Navigating the project

Once PHYSITEL is launched, navigating the graphical interface is quite straightforward. It is simply divided into four areas numbered as shown in Figure 2.

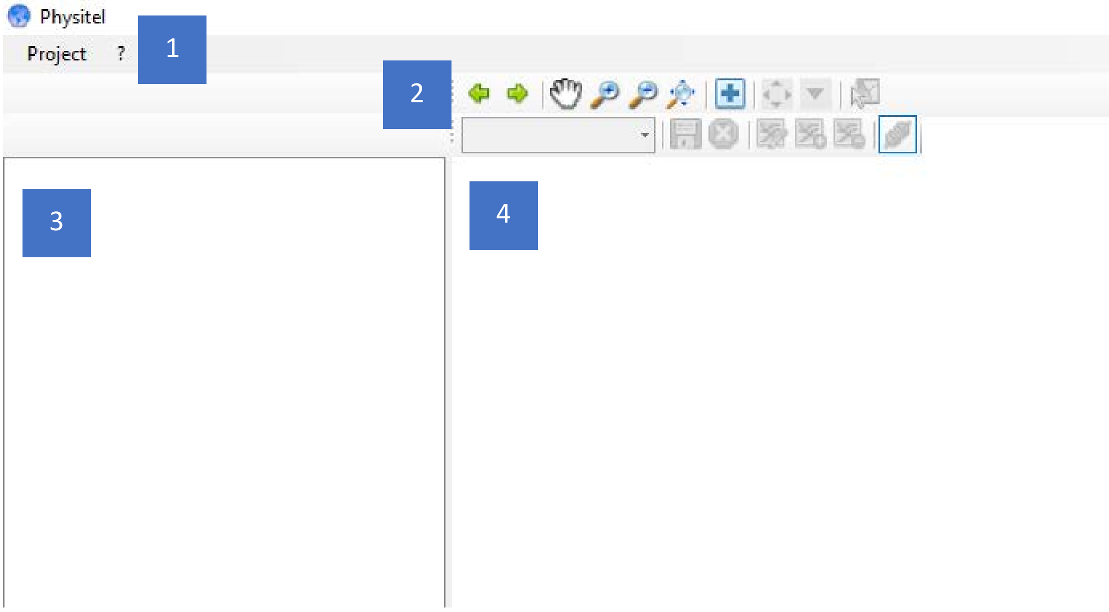


Figure 2: PHYSITEL initial graphic interface

Typically for a GIS, you will find the menu bar (1), navigation icons (2), the window containing the active geographic layers (3), and the main display window (4). Only zone 3 has characteristics that differ from conventional GIS; we will revisit this in a dedicated section.

2.1 Opening an existing project

From the menu bar (1), the accessible options are very limited. You will find the ability to open a project or exit the program. To open a project, simply click on "Open" to display Figure 3.

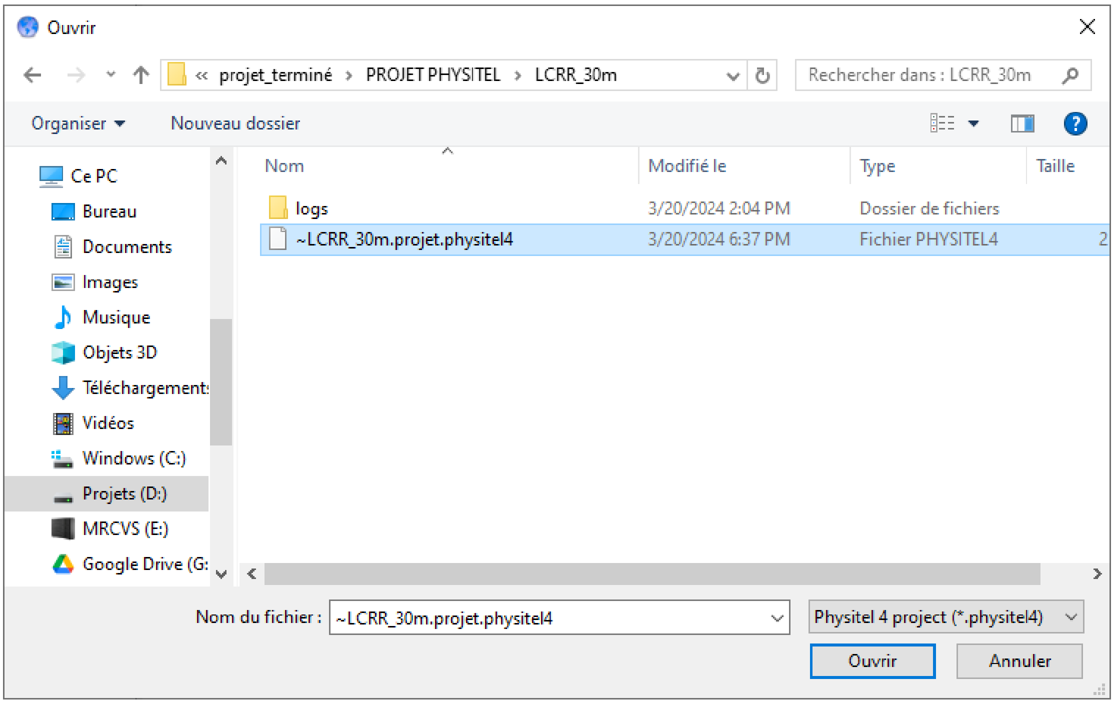


Figure 3: Dialog box that allows opening a PHYSITEL project.

This dialog box allows you to navigate through the computer's folders and locate the existing PHYSITEL project.

PHYSTEL projects are easy to identify using their file extension name: .physitel4

2.2 Navigation options

The navigation options (2) accessible through icons are standard. A zoom of this zone is provided in Figure 4.

Figure 4: Zone 2 project navigation icons.

From left to right, the different icons allow you to return to the previous view, or next view, navigate on the map, zoom in, zoom out, and return to the full project view. Starting with the blue cross, icons let you add a new data layer, show/hide flow directions, show/hide vector network orientation, and select a reach or RHHU.

Please note that all icons are not active at any given time. They are dynamic and become active when the proper layer has been selected.

Hovering over a data layer or an icon displays its function in a tooltip

2.3 Project overview

Once the project is opened, the main graphical interface is slightly modified as shown in Figure 5. It can be noted that the area reserved for geographic layers is now populated. Also, some information is now available in zone 5.

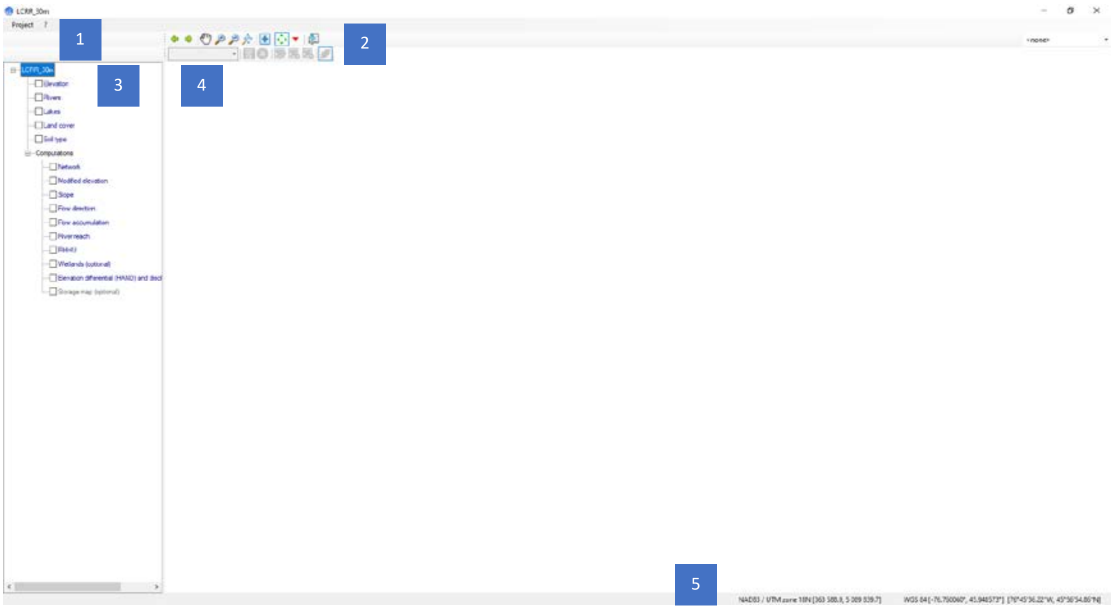
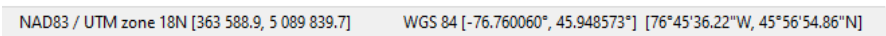


Figure 5: PHYSITEL graphic interface for an open project



Zone 5 allows you to determine the coordinates of the pointer in the source coordinate system (according the source DEM map), UTM, and WGS84 geodetic reference systems.

3 Input data

Zone 3 lets you navigate the project geographical layers. They are divided in two subsections as you can see in Figure 6.

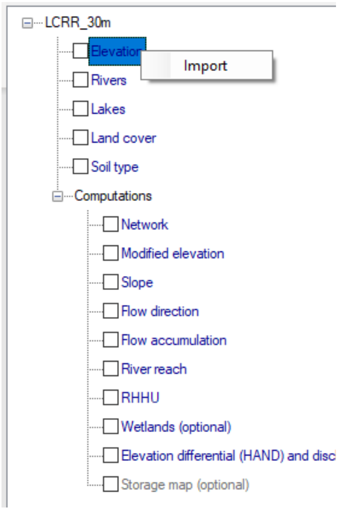


Figure 6: The different geographical layers of a finished PHYSITEL project

The first subset of layers appears under the project's name (in our case LCRR_30m for Lake Champlain Richelieu-River, at a resolution of 30 m) and list all input data. The second subset appears under "Computations" and list all layers that can be computed using PHYSITEL.

We'll first go through each layer of the input data subset before delving into the computation subset.

Right-clicking on one of the layers displays the available functions for that layer. Figure 6 shows that for elevation data, the only available function is "Import."

3.1 Elevation

The elevation layer displays the topographic data available for the watershed set up in PHYSITEL as depicted in Figure 7.

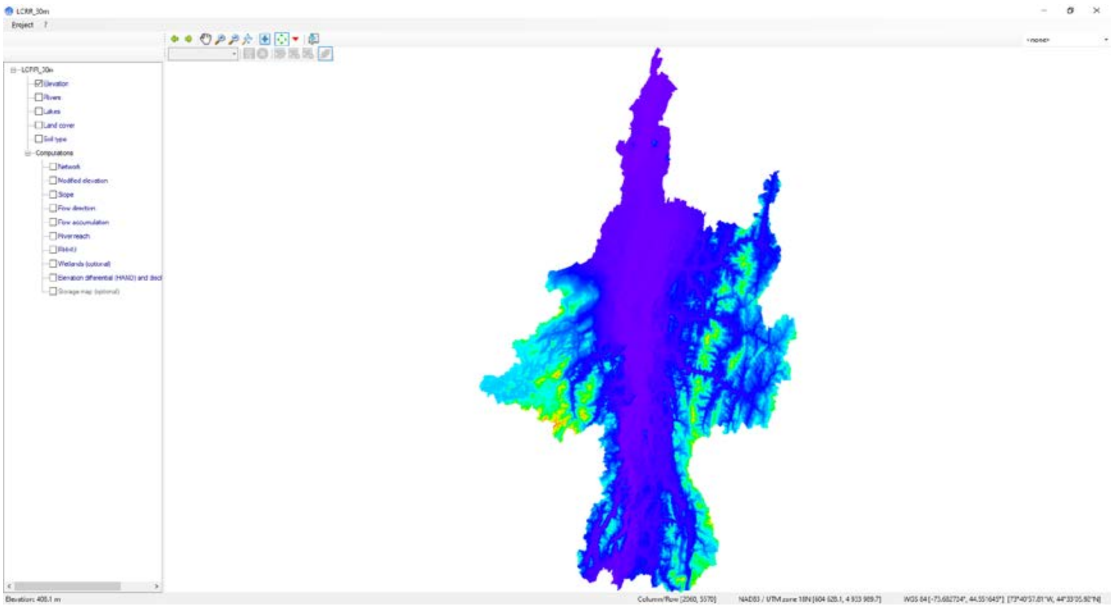


Figure 7: Elevation input data displayed in PHYSITEL

The color legend is not available; however, you will notice that from blue to red, passing through green and orange, elevations increase. Users are free to zoom in on areas of particular interest.

Don't forget the bottom navigation option which let you identify the pointer exact position, including the data point information for all displayed layers in the bottom left corner.

3.2 Rivers

The river layer displays the hydrographic network of the watershed mounted in PHYSITEL as displayed in Figure 8.

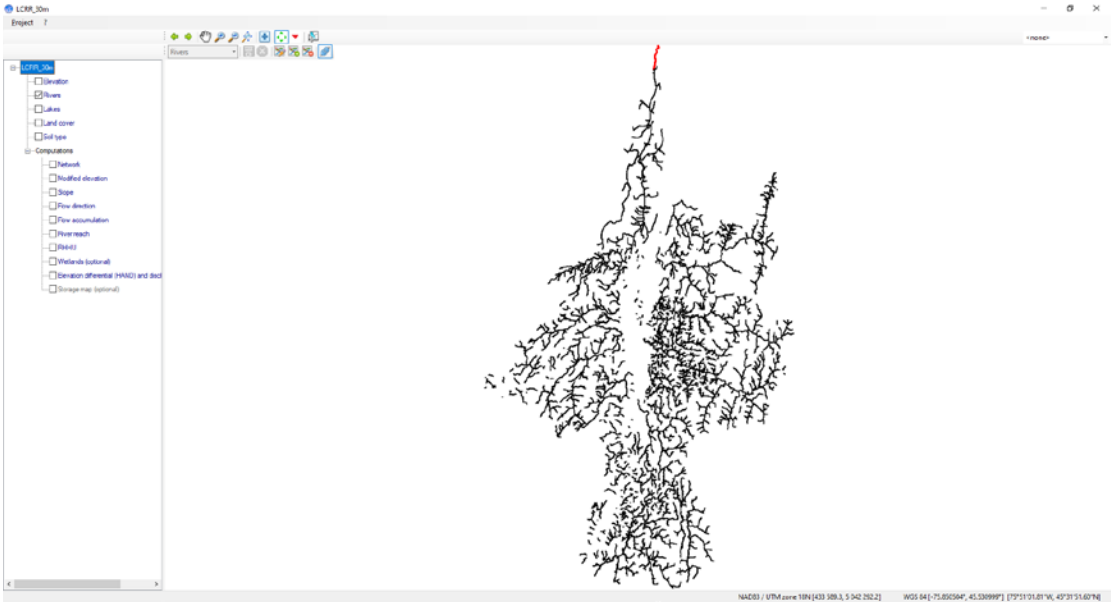


Figure 8: River input data displayed in PHYSITEL

The river reach in red helps identify the outlet of the watershed. Figure 9 depicts the network when you enable displaying the river network orientation. This is particularly useful when first implementing the network or to verify some local flow.

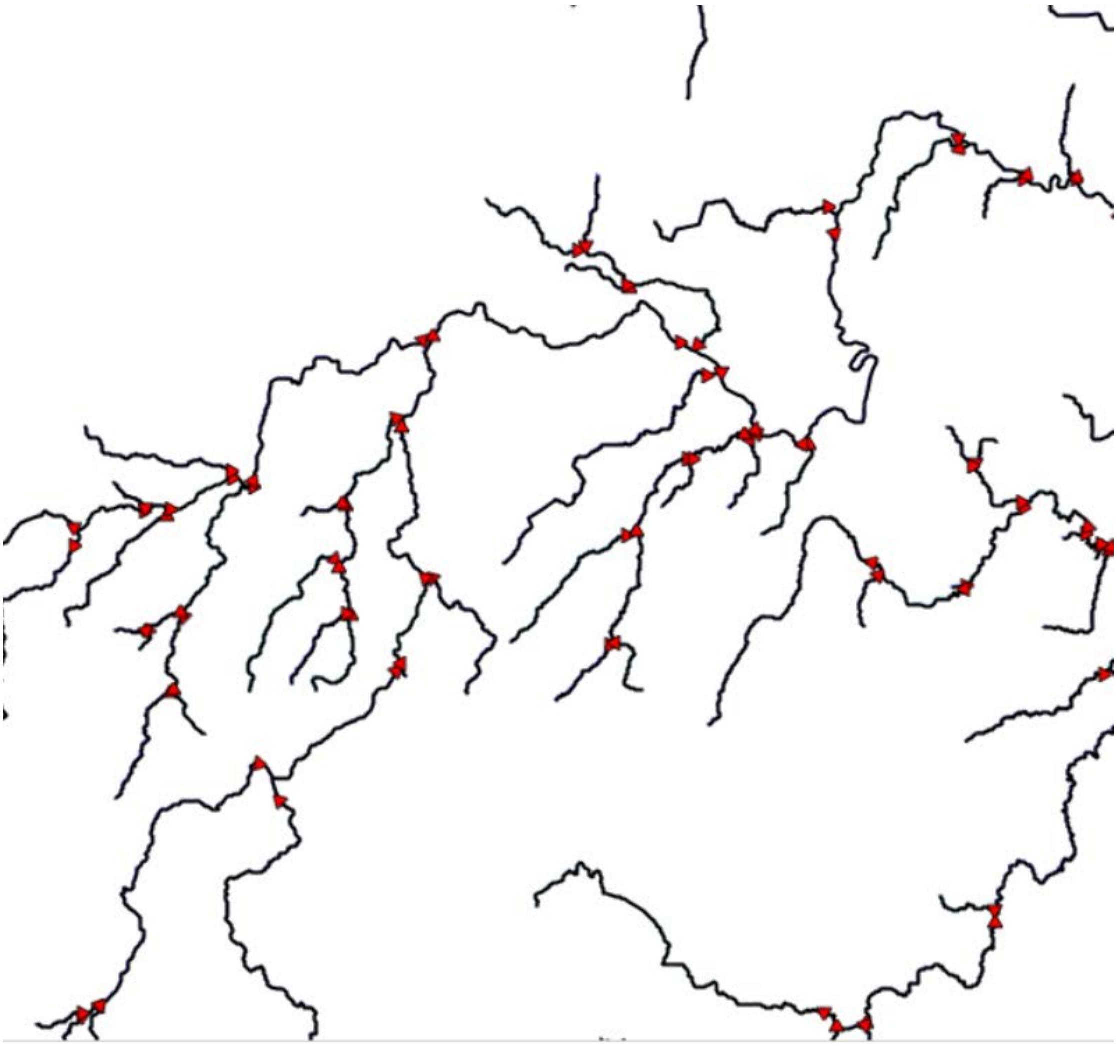


Figure 9: Zoomed-in portion of the river network showing the flow orientations.

As you can see in Figure 10, selecting the layer “rivers” enables the use of new navigational icons. DO NOT USE THEM, THEY WILL MODIFY THE HYDROGRAPHIC NETWORK, THEY ARE MEANT FOR ADVANCED USERS

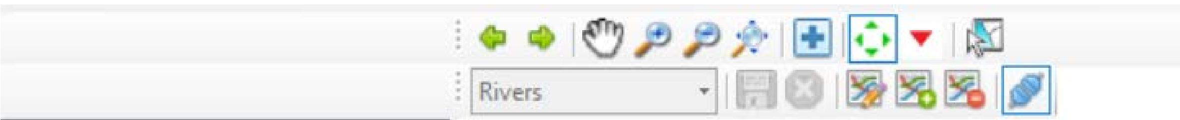


Figure 10: Navigation ribbon when the layer "Rivers" is selected

The downstream most reach is always attributed the reach ID 1.

3.3 Lakes

The lake layer displays the sections of the hydrographic network identified as lakes in PHYSITEL, as shown in Figure 11. Right-clicking on the “Lakes” layer (same for the “Rivers” layer) provides access to the search tool shown in Figure 12. From this tool, it is possible to identify and locate any river reach or lake.

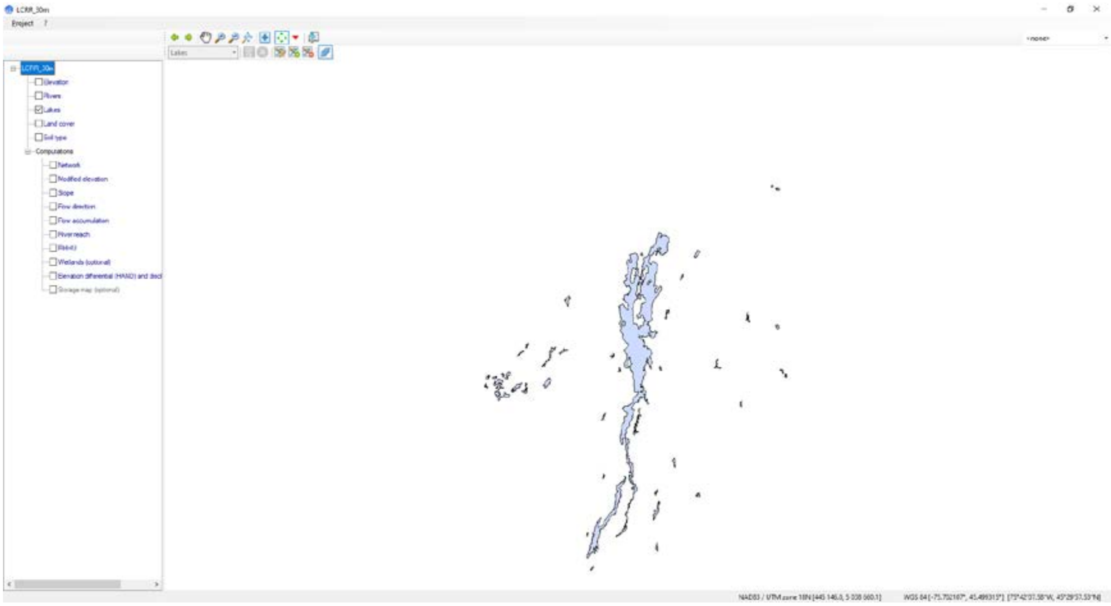


Figure 11: Lake input data displayed in PHYSITEL

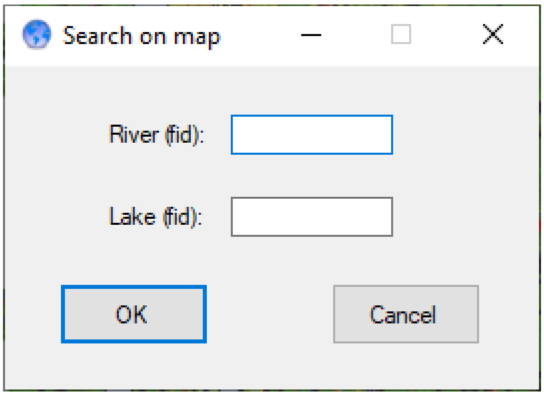


Figure 12: Search on map tool for the PHYSITEL hydrographic network (rivers and lakes)

As in all GIS, you can display many layers one on top on the other according to the order displayed in the geographic layers window. Figure 13 displays the result for the “elevation”, “rivers”, and “lakes” layers.

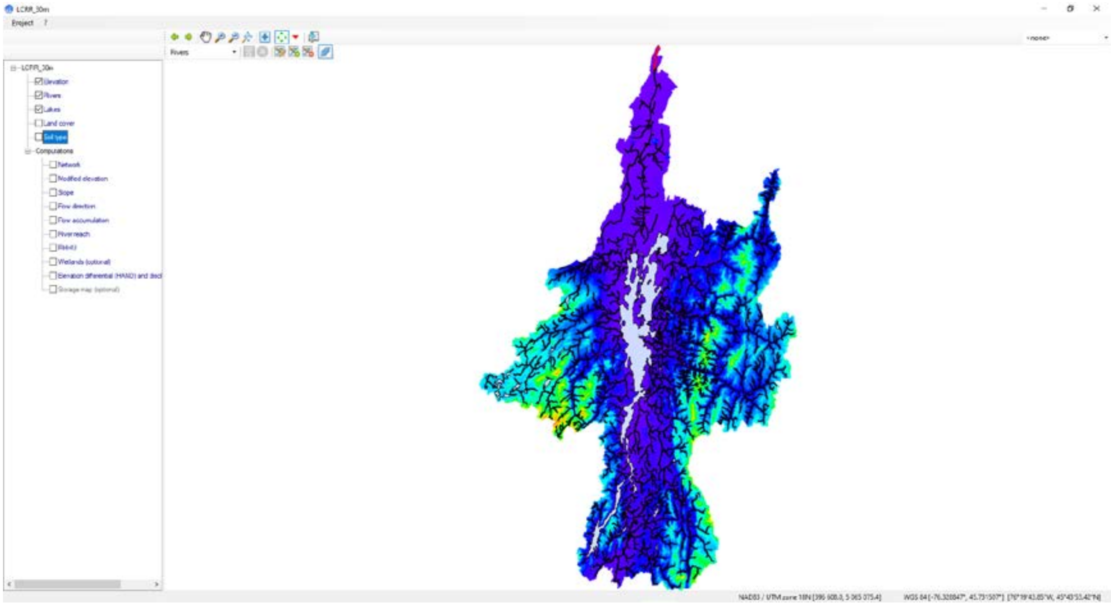


Figure 13: Main display window in PHYSITEL showing Elevation, rivers, and lakes all together.

3.4 Land cover

The land-cover layer displays the land use/land cover of the watershed set up in PHYSITEL, as shown in Figure 14.

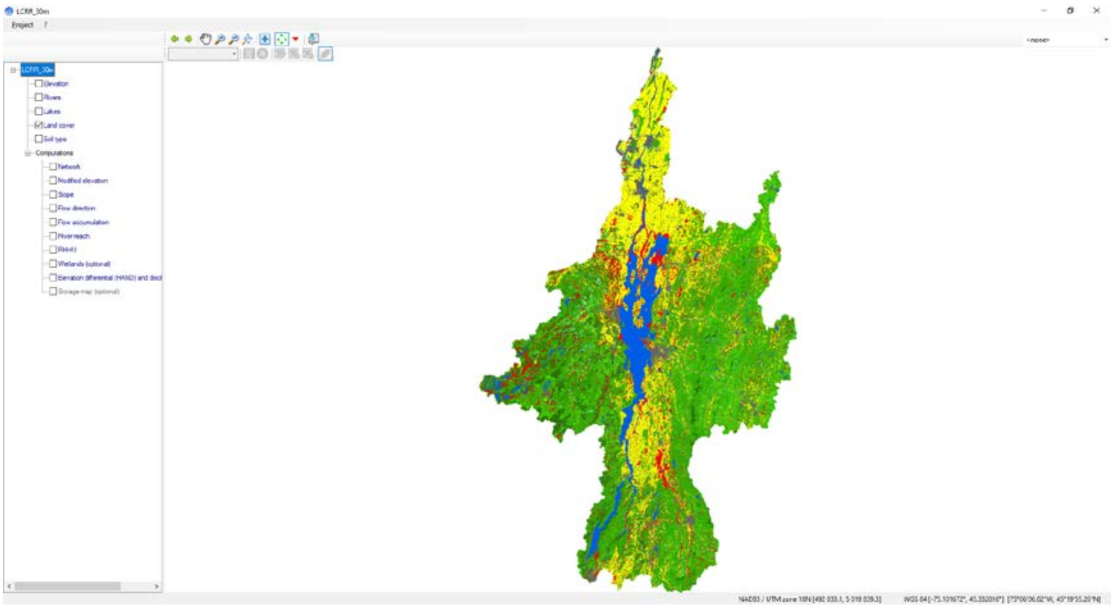


Figure 14: Land cover input data displayed in PHYSITEL

The color legend is not available; however, you will notice that right-clicking on Land-Cover lets you access the Land cover property table as depicted in Figure 15. Each color is associated with a class. For example, urban areas (#6) are depicted in black as visible on Figure 16. Moreover, the Land cover property table allow the advanced user to optionally specify the class associated to wetlands and storage map tool.

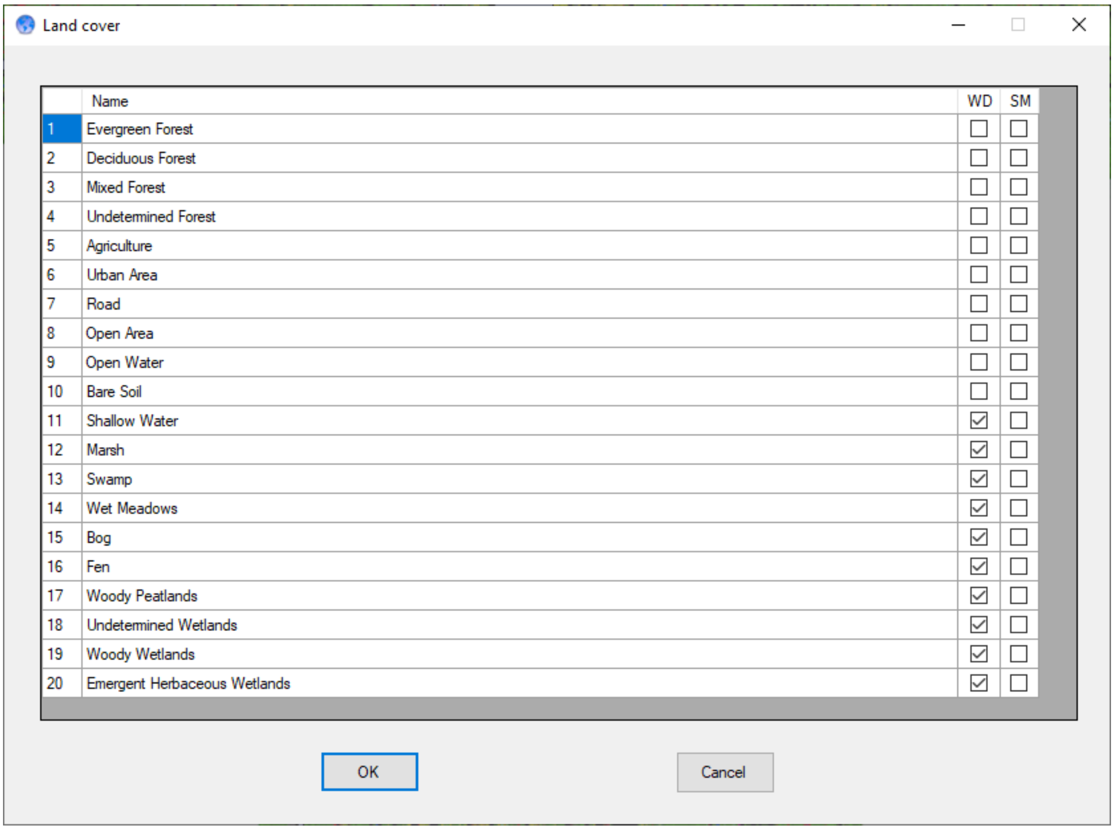


Figure 15: Land cover property table

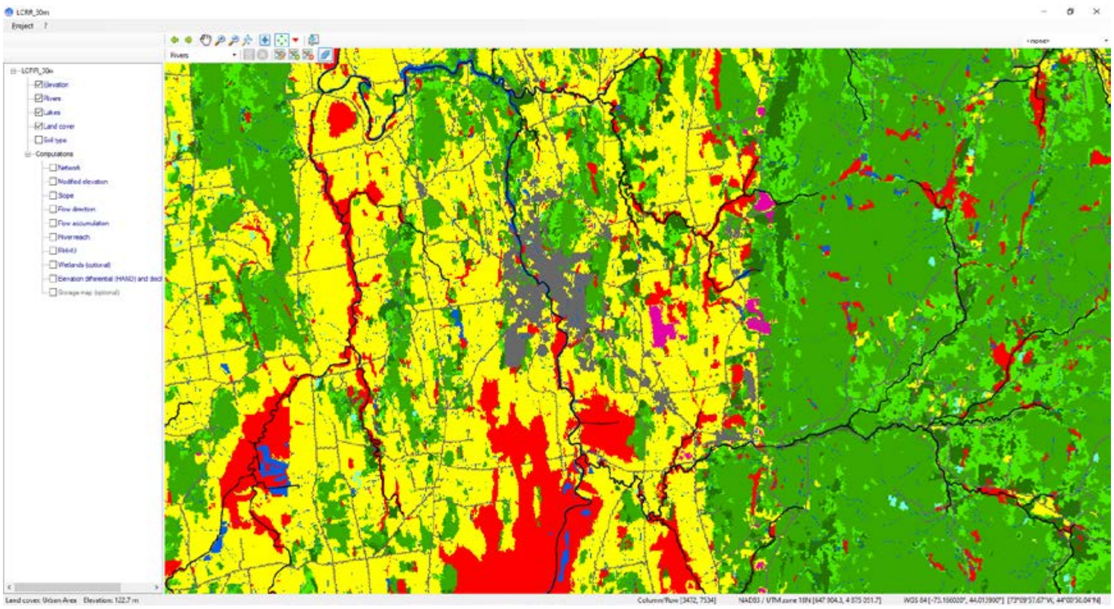


Figure 16: Zoomed in land cover area displayed in PHYSITEL

3.5 Soil type

The soil type layer displays the types of soil of the watershed set up in PHYSITEL, as shown in Figure 17.

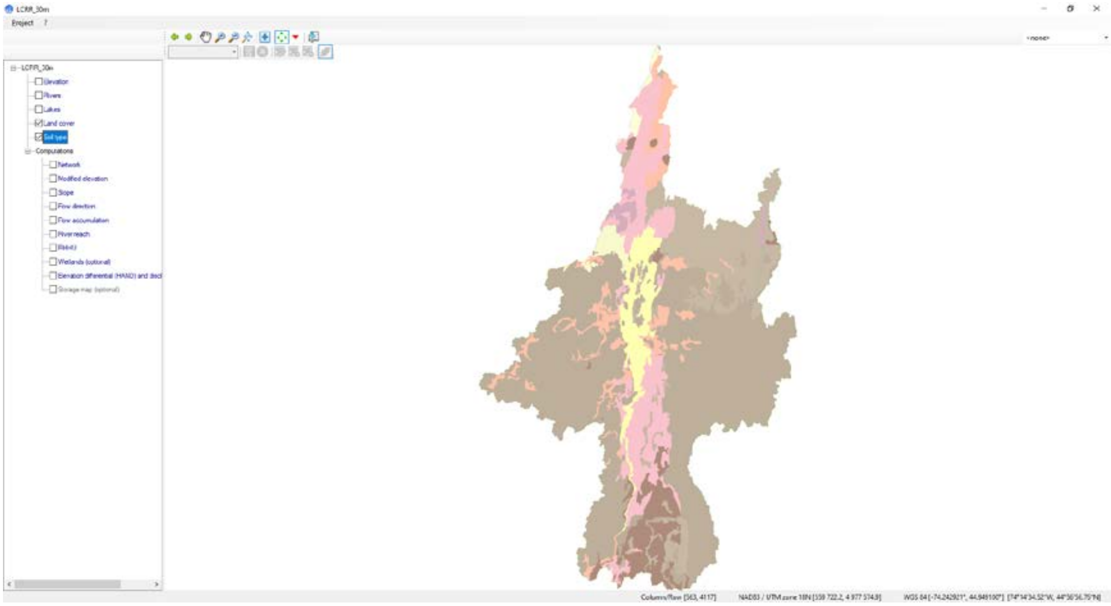


Figure 17: Soil type input data displayed in PHYSITEL

The color legend is not available; however, you will notice that right-clicking on “Soil-type” lets you access the Soil type property table as depicted in Figure 18. Each color is associated with a class. For example, sand (#1) is depicted in light yellow as visible in Figure 18. Moreover, the Soil type property table allow the advanced user to optionally specify the classes associated to the storage map tool.

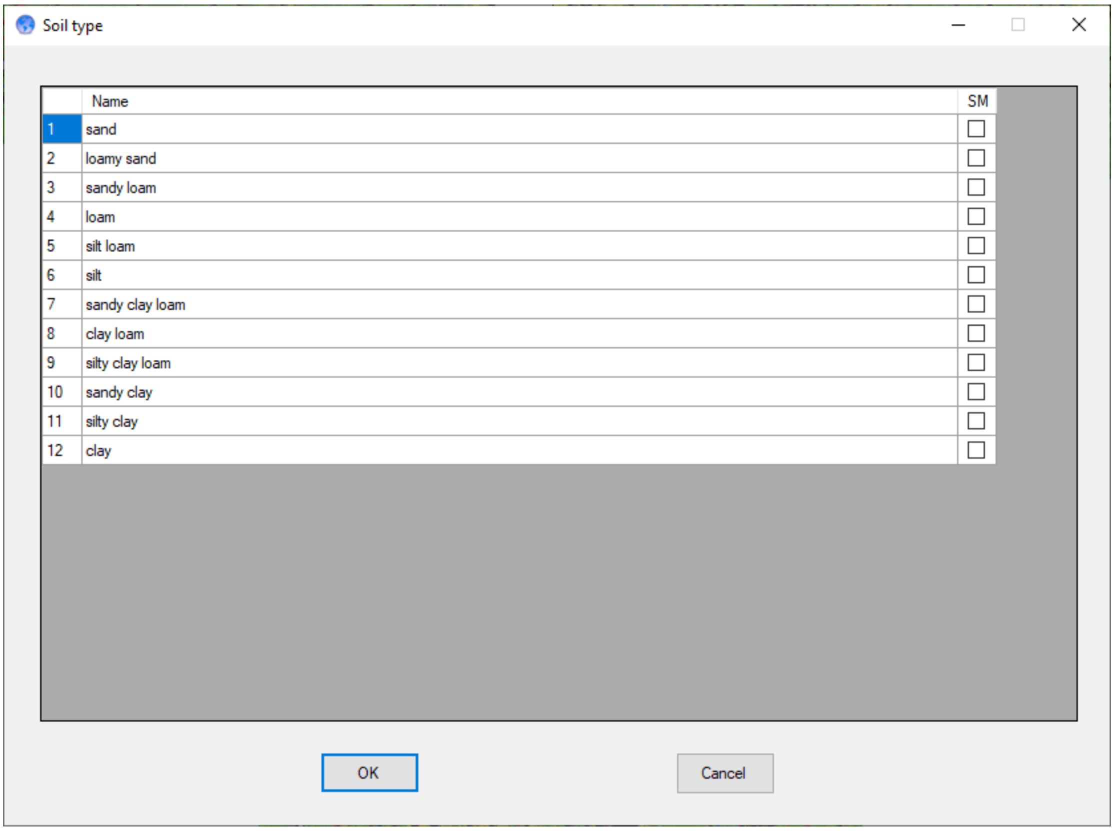


Figure 18: Soil type property table

4 Computations

The second subset of layers, under “Computations”, lists all layers that can be computed using PHYSITEL. They are detailed one after the other in the following subsections.

4.1 Network

As its name suggests, the layer “Network” finalizes the transport of water from upstream to downstream using all defined reaches and lakes, given the defined network orientations. This operation actually helps consolidate the effective water pathway as described in Figure 19.

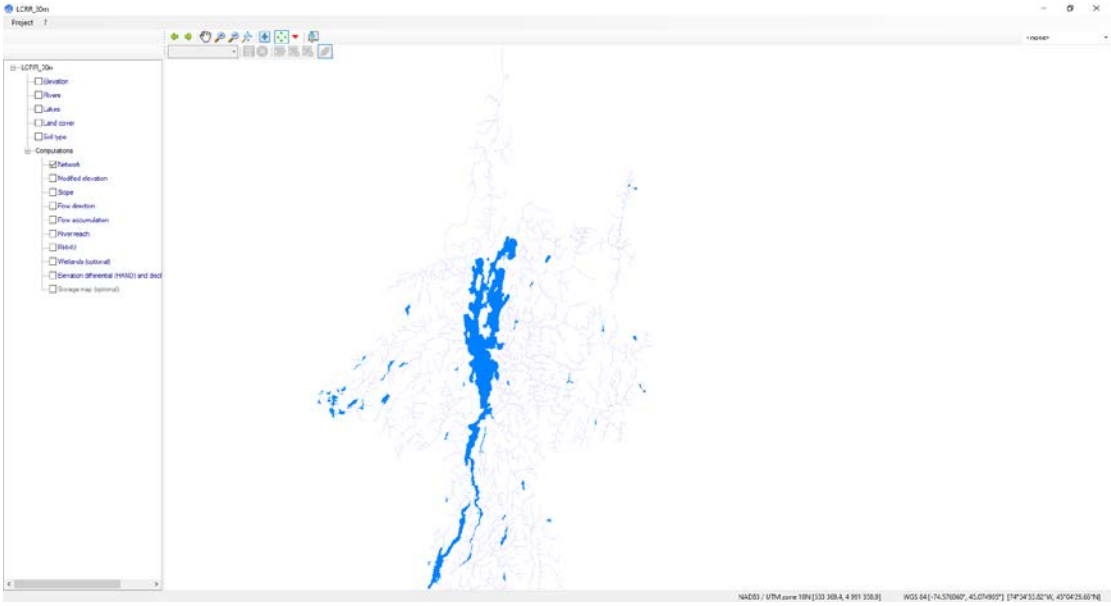


Figure 19: Hydrographic network computed in a set-up PHYSITEL project.

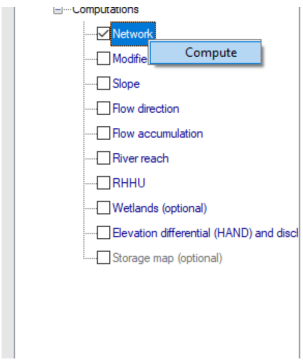


Figure 20: Available functions for the network computation in PHYSITEL

As Figure 20 shows, the only available function for “Network” is “Compute”. DO NOT CLICK “COMPUTE” as computations are already made, and it may take a very long time to compute again.

4.2 Modified elevation

The layer "modified elevation" depicts the elevation data modified to integrate the river network (operation knows as burning) and mitigate potential errors from the initial data. The result is shown in Figure 21, it is rather similar to Figure 7.

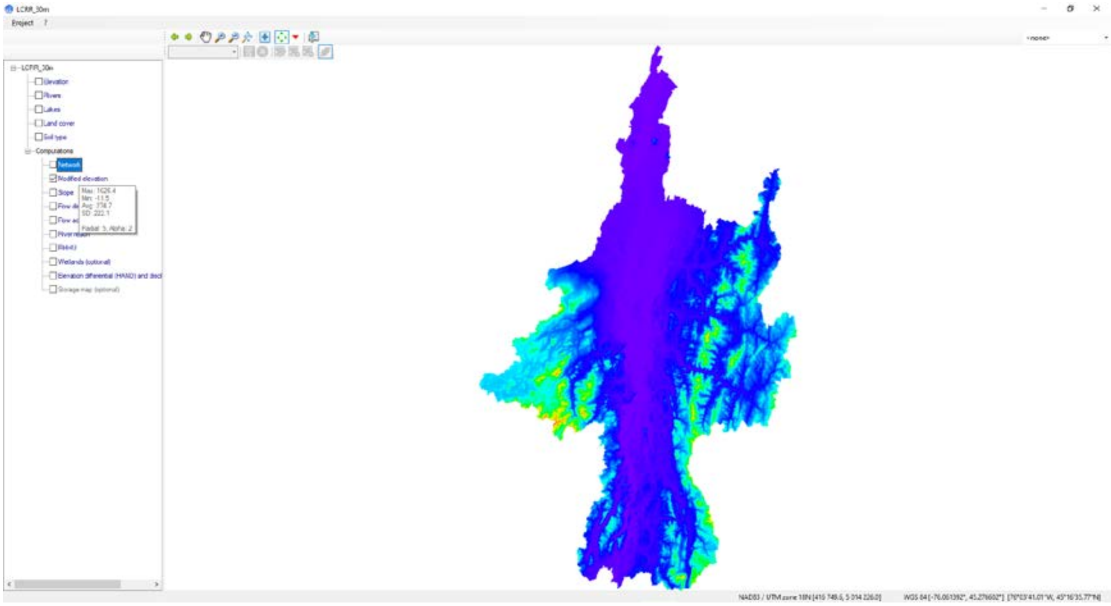


Figure 21: Modified elevations computed in a set-up PHYSITEL project.

The only function available for "modified elevation" is "Compute". DO NOT CLICK it as computations are already made, and it may take a very long time to compute again

4.3 Slope

The layer "slope" depicts the computed slopes (in °) as shown in Figure 22

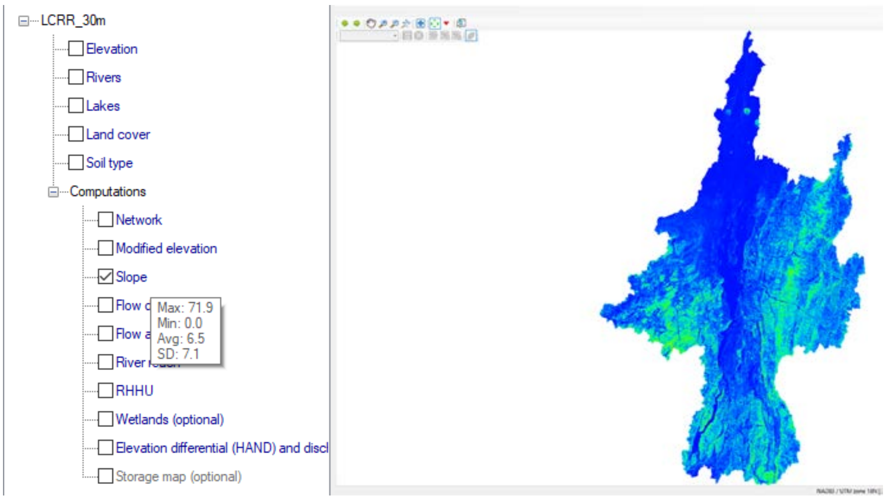


Figure 22: Slopes (°) computed in a set-up PHYSITEL project.

The only function available for "slopes" is "Compute". DO NOT CLICK it as computations are already made, and it may take a very long time to compute again

As the zoomed in portion of Figure 22 (left side) demonstrates, if you leave your pointer on the slopes layer, information about the distribution of values will appear.

4.4 Flow direction

The layer "Flow direction" depicts the computed terrain flow directions (in °) as shown in Figure 23.

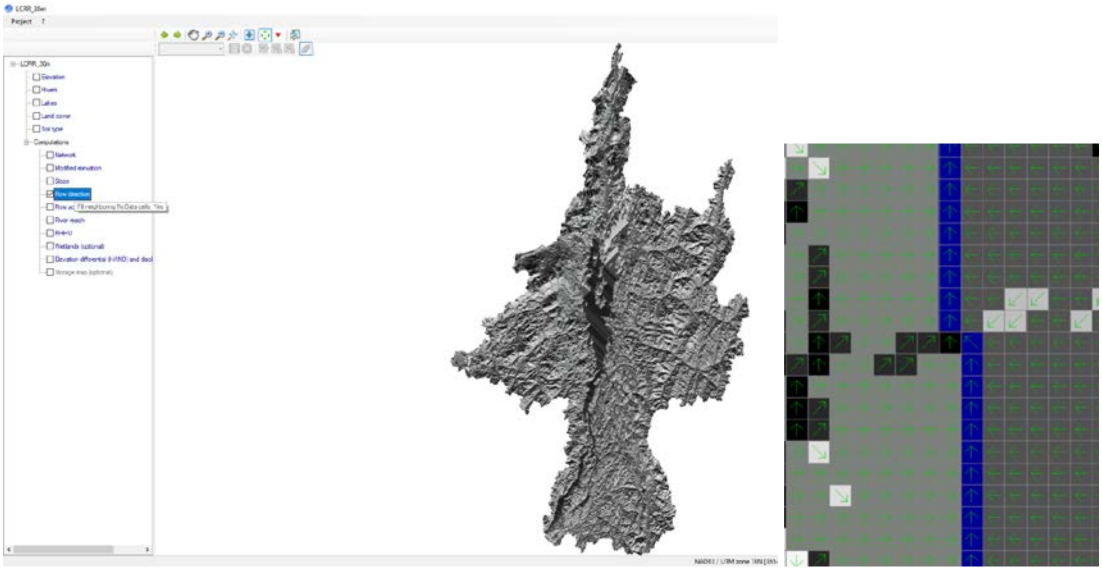


Figure 23: Terrain flow directions computed in a set-up PHYSITEL project

The zoomed-in portion of Figure 23 shows the matrix of directions represented as arrows than can take 8 different values corresponding to the cardinal directions (North, North-East, East, South-East, South, South-West, West, North-West). Blue pixels represent the hydrographic network.
Note that PHYSITEL allow manual modification of flow direction, but such operation is not required in the actual and existing project.

Navigating the image will show flow direction of each pointed cell in the lower left corner of the navigation windows.

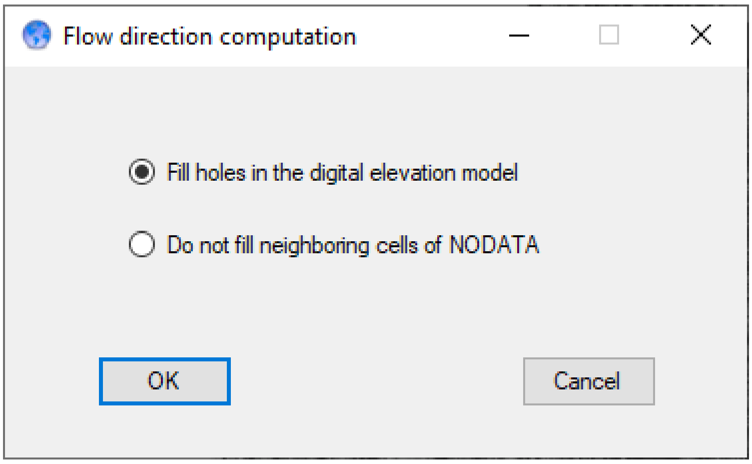


Figure 24: Flow direction computation option table

The only function available for "flow direction" is "Compute". DO NOT CLICK it as computations are already made, and it may take a very long time to compute again. For information only, as Figure 24 *shows, there are two options for dealing with NODATA cells. This option is reserved to ADVANCED USERS.*

4.5 Flow accumulation

The layer "Flow accumulation" depicts the cumulated number of cells upstream of each cells as depicted in Figure 25.

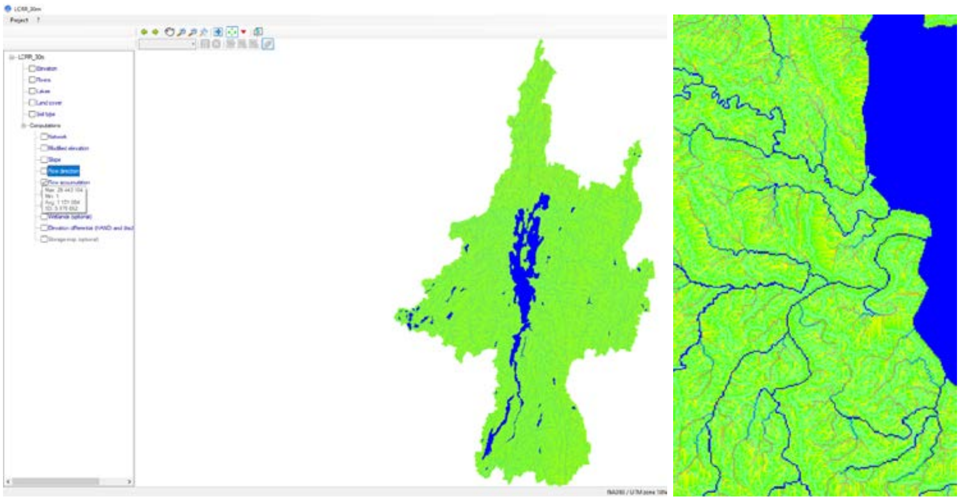


Figure 25: Flow accumulation computed in a set-up PHYSITEL project.

The color legend is not available. However, the zoomed in portion of Figure 25 shows that from green to blue, passing through yellow and marron, explicates the color gradient and demonstrates that this method allows for visualizing the main, secondary, and even tertiary hydrographic network.

Navigating the image will show numbers of cells upstream of each pointed cell in the lower left corner of the navigation windows.

The only function available for “flow accumulation” is ”Compute”. DO NOT CLICK it as computations are already made, and it may take a very long time to compute again.

4.6 River reach

The layer "river reach" depicts discretized hydrographic network into homogeneous reaches as shown in Figure 26. Each reach will be the basic computational unit of HYDROTEL within the hydrographic network.

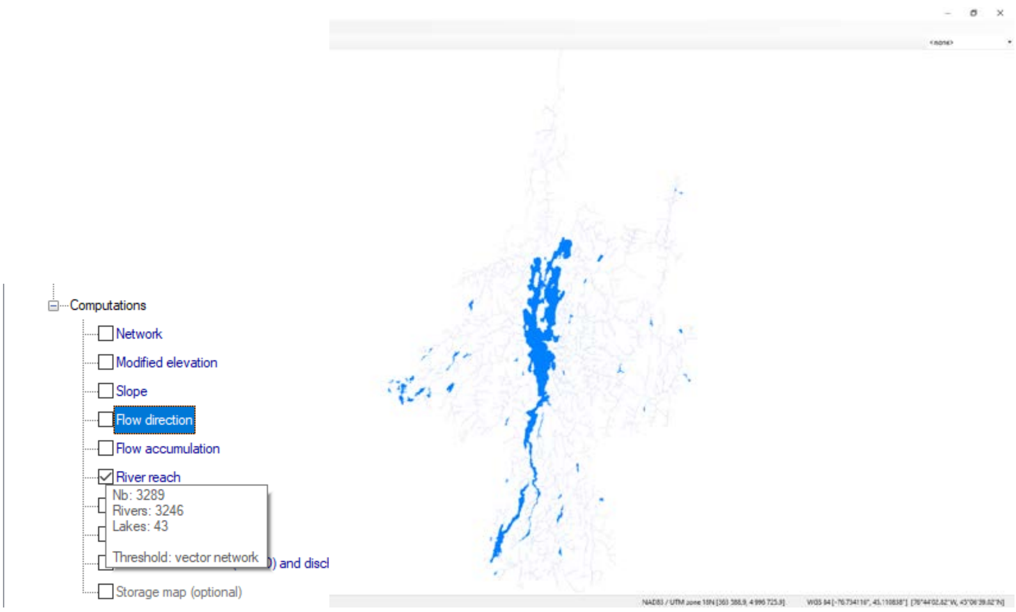


Figure 26: River reaches computed in a set-up PHYSITEL project.

User nodes

Column	Row
3458	1949
3297	2067
3121	2413
2824	2450
2902	3959
2510	3900
2744	4259
2611	5076
2551	5233
2551	5404
2170	5939
2838	6270
2683	7814
3200	9576
3111	8985

Figure 27: River reaches user nodes.

Two functions are available for this layer, "compute" (DO NOTE USE), and "User Node" which property table is shown in Figure 27. This table allows the advanced user to include nodes at locations where discharge computations are explicitly needed, notwithstanding the automatic definition of segments.

As the zoomed in portion of Figure 26 *(left side) demonstrates, If you leave your pointer on the slopes layer, information about the distribution of values will appear.*

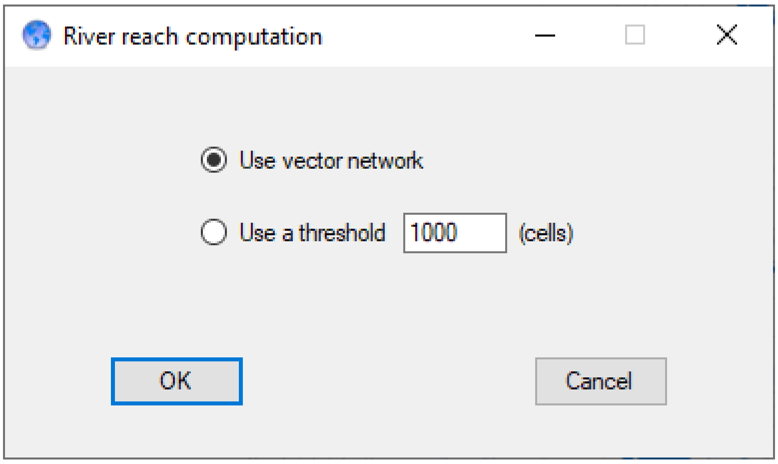


Figure 28: River reaches computation options

The "Compute" function available for "river reach" enables the user to choose between two computing option. The "use vector network" option forces PHYSITEL to discretize the vector network given as INPUT data. The "Use a threshold" option allows computing river reaches given the number of cells it drains. This option is crucial for getting a detailed discretized hydrographic network (in turn impacting computation costs) but is reserved to ADVANCED USERS.

4.7 RHHU

The layer "RHHU" shows the discretization of the terrain into *Relatively Homogeneous Hydrological Units*, which are the base terrain computational units as depicted in Figure 29.

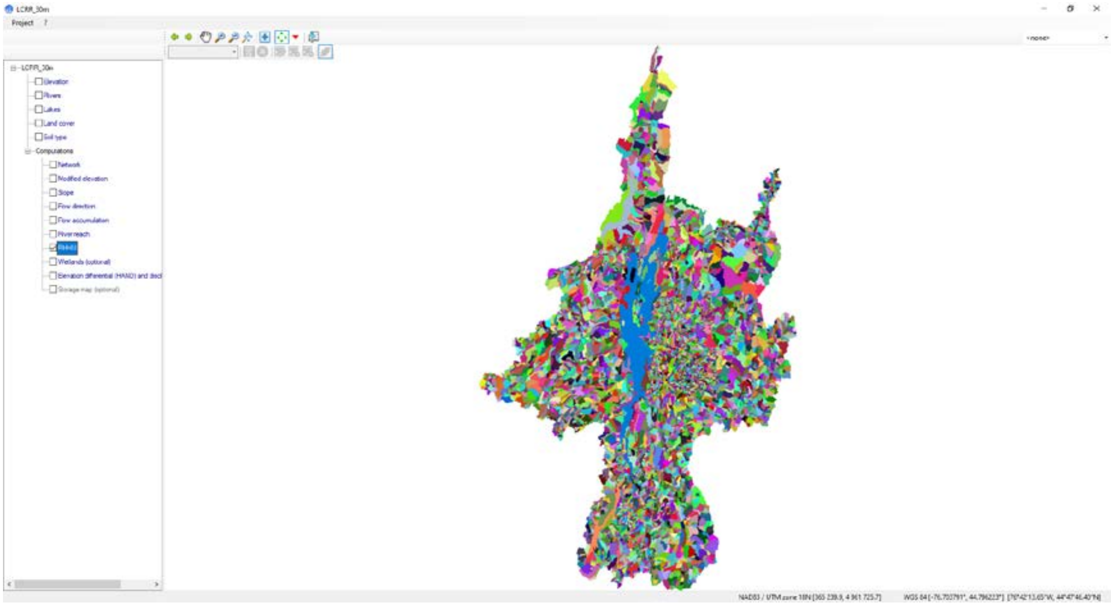


Figure 29: RHHU computed in a set-up PHYSITEL project.

Colors *per se* do not have meaning, they simple serve to distinguish a RHHU from its neighbours.

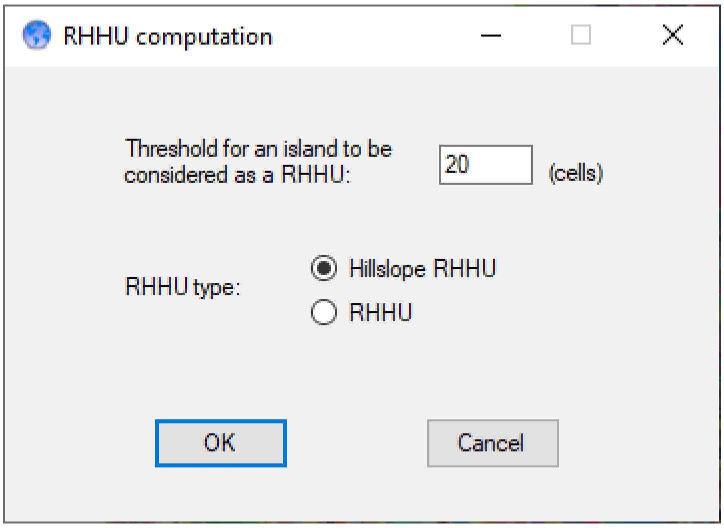


Figure 30: RHHU computational options

The "Compute" function available for "RHHU" enables the user to choose between two computing option. Figure 30 shows the computation options available for ADVANCED USERS. RHHUs can be computed as mere base sub-watershed or hillslope RHHUs. Islands can be integrated if draining enough cells from the accumulation matrix (Figure 25).
Do not click compute.

4.8 Wetlands (optional)

The layer "wetlands" shows the wetlands than can be considered by the future hydrological model set up using PHYSITEL. It extracts all wetlands characteristics from the land cover data and compute their drainage areas while separating wetlands into two types: isolated and riparian as shown in Figure 31.

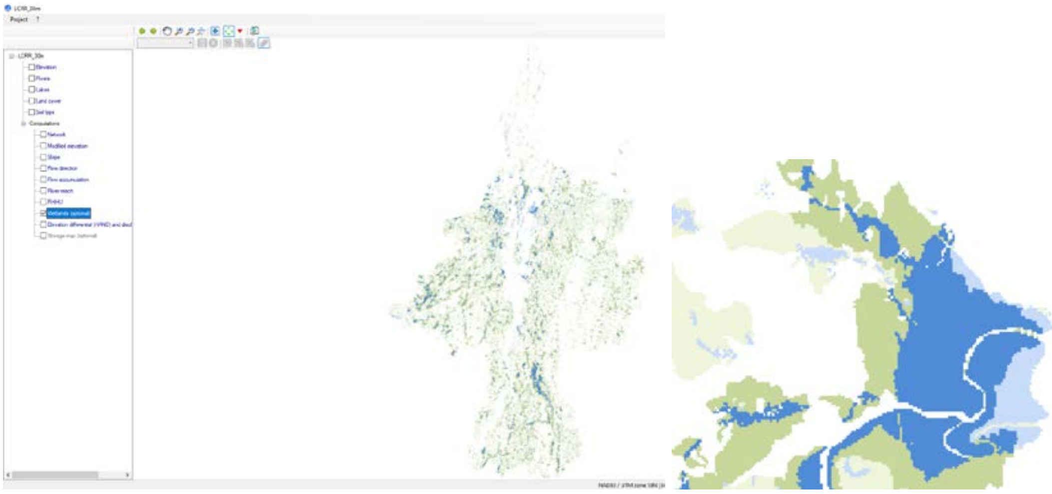
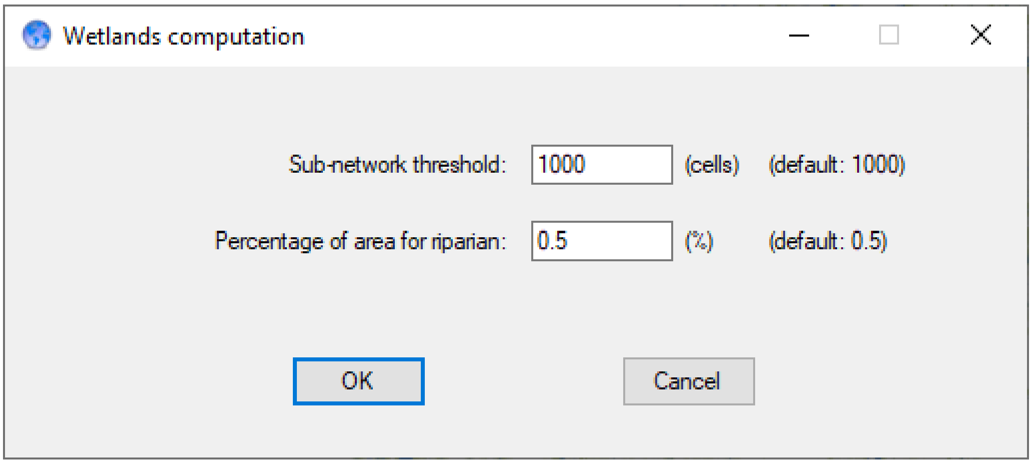


Figure 31: wetland and their drainage areas computed in a set-up PHYSITEL project.

The color legend is not available; however as is shown in the zoomed-in portion of Figure 31, green and light green mark the riparian and isolated wetlands respectively; blue and light blue mark their respective drainage areas.



Navigating the image will display wetland type or drainage area type in the lower left corner of the navigation windows.

The "Compute" function available for "wetlands" enables the user to choose between two computing options. The "sub-network "threshold" allows to set the sub-network thresholds. The "Percentage of area for riparian" option allows to fix the adjacent wetlands surface contact threshold to river network. Both thresholds determine and contribute to separate *wetlands types. DO NOT CLICK "COMPUTE" as computations are already made, and it may take a very long time to compute again and is reserved for ADVANCED USERS.*

4.9 Elevation differential (HAND)

The layer "elevation differential (HAND)" shows the optional 0D computation of the HAND matrix, or *Height Above the Nearest Drainage* as depicted in Figure 32.

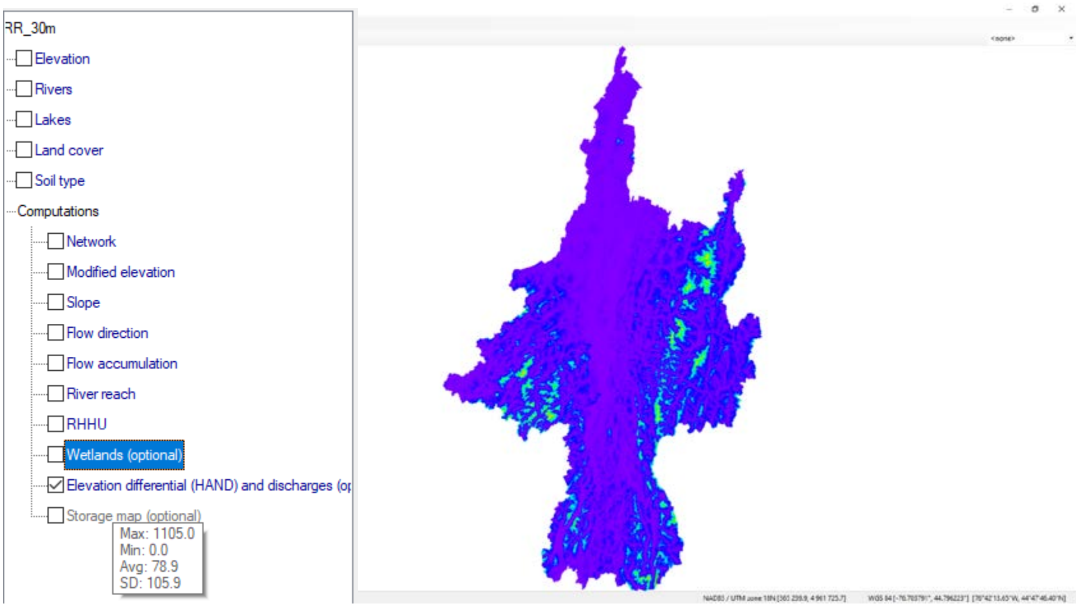


Figure 32: HAND matrix computed in a set-up PHYSITEL project.

The color legend used is the same as for elevation data (Figure 7 and Figure 21). It depicts the height of water needed to flood any pixel of the terrain given the flow of water to its closest neighbouring river cell. It is useful in accounting for water volumes and flood prone areas.

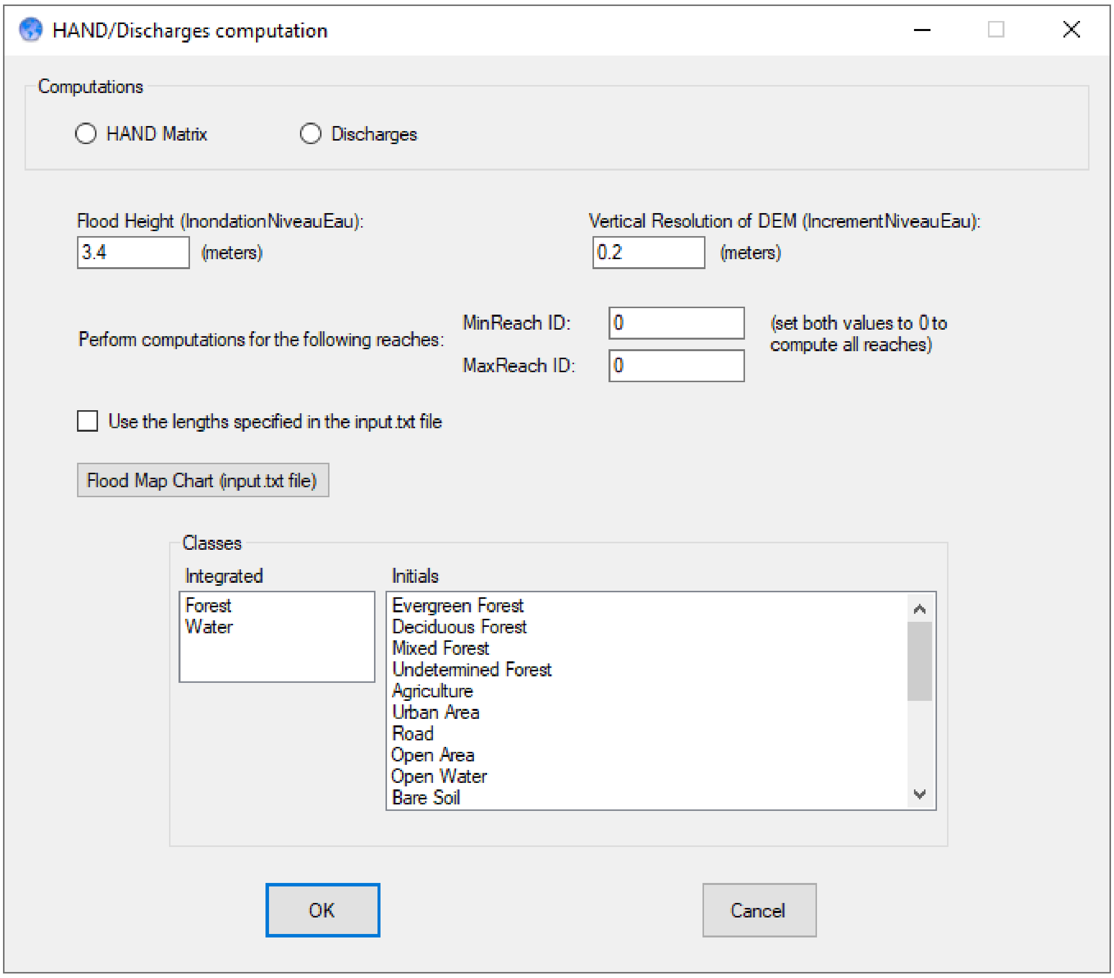


Figure 33: HAND computational options available in PHYSITEL

Navigating the image will show HAND value of each pointed cell in the lower left corner of the navigation windows.

Figure 33 shows the HAND computational options available to ADVANCED USERS. They allow the user to modify the flood height to account for as well as its incremental stepwise increase (often set using the vertical Resolution of the input DEM). They also permit to apply HAND on a subset of the whole hydrographic network and modify what is actually included into the forest and water integrated classes given the actual land cover classes of the input data. DO NOT CLICK OK.

4.10 Storage map (optional)

An innovative and alternative approach was developed to assess and map water storage capacities on appropriate landscapes, using relevant spatial information and having different potential objectives. A specific GIS tool was developed and integrated into PHYSITEL to produce water storage maps. As a general description, the water storage tool refers to an algorithm that allows, if needed, incremental variation of water storage on specific land uses to achieve specified objectives or targets under diverse conditions or limitations using a graphical user interface (GUI) (see Figure 34). The tool is described in detail in Section 5.2.

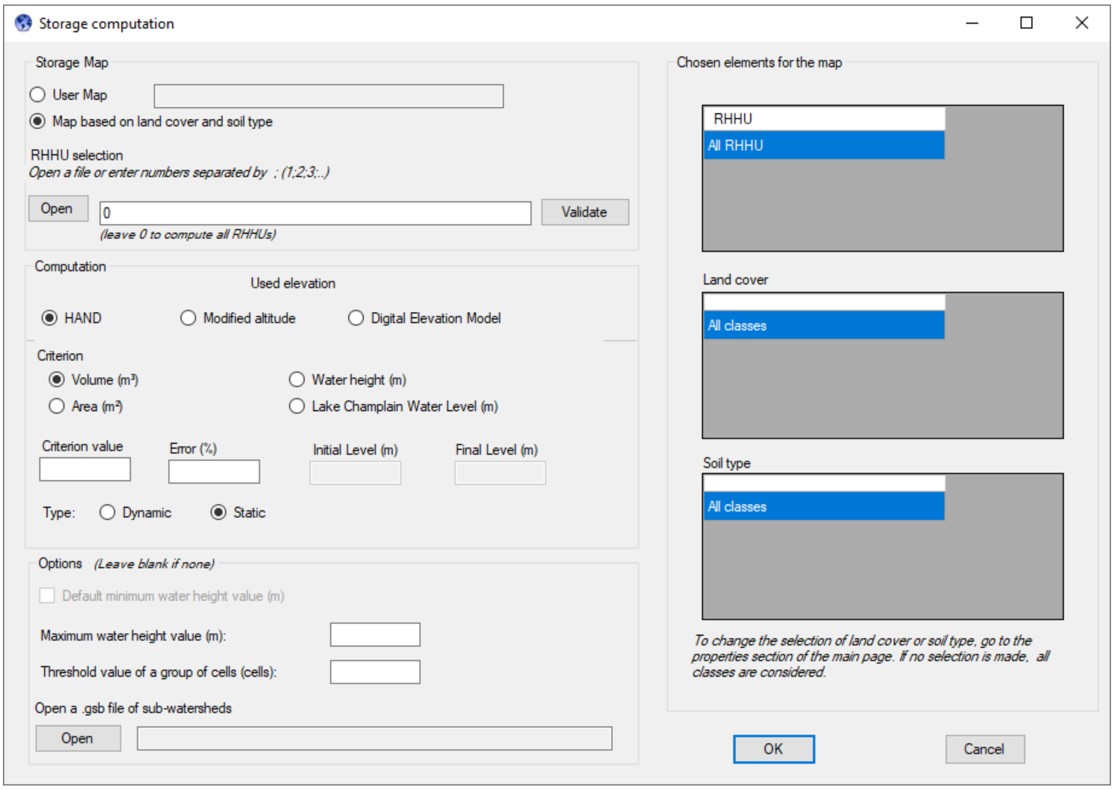


Figure 34: Storage computation, computational options in PHYSITEL

5 Available Functions

This section describes the functions available for beginner level users in sufficient details for them to use them and modify their main computational parameters.

5.1 Export project to HYDROTEL

Once all input data is provided to PHYSITEL and geomatic operations are completed, the next step is to export the files needed for the chosen hydrological model (in most cases HYDROTEL). To do this, simply right-click on the project name in the geographic layer management window and then select "Export Data for HYDROTEL project" as shown in Figure 35.

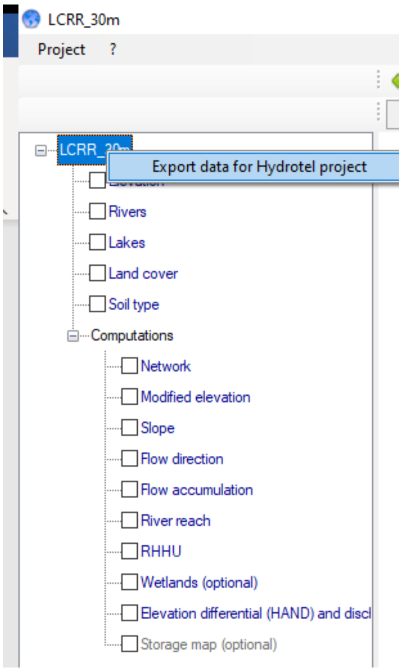


Figure 35: How to export PHYSITEL data for building a HYDROTEL project?

By default, all exported data will be available in the folder containing your current PHYSITEL Masterfile. A successful export will be indicated by a message represented in Figure 36. The list of exported data is shown in Figure 37.

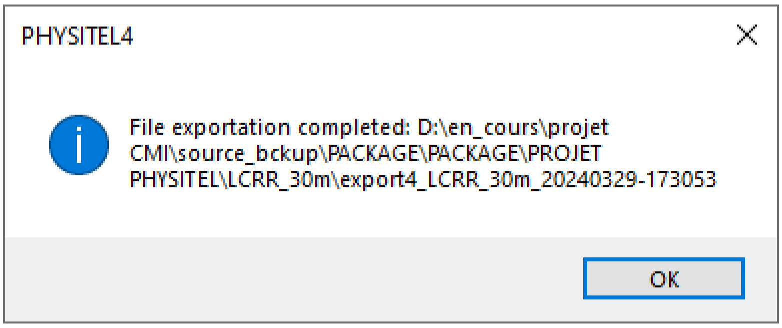
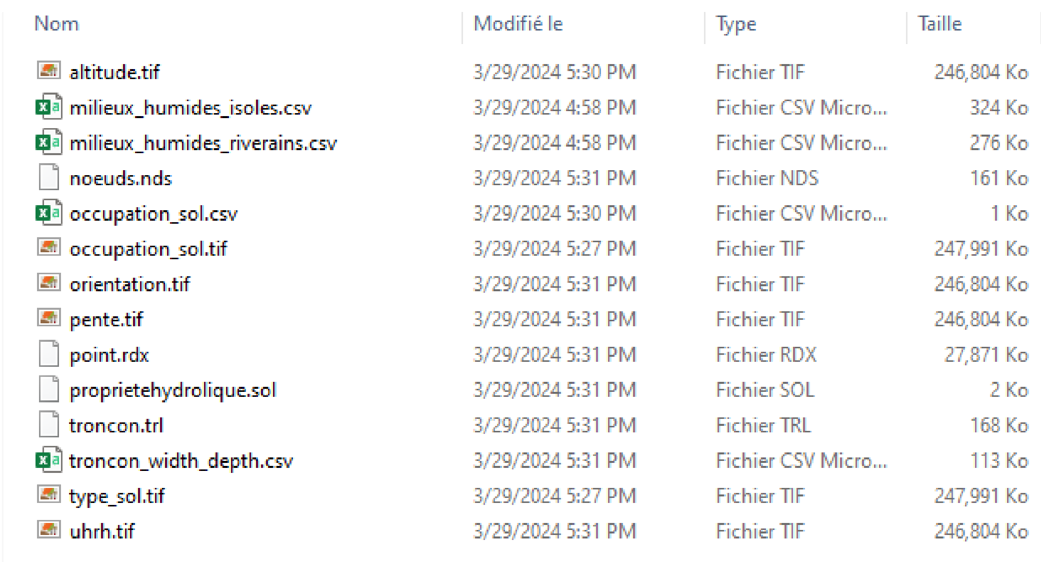


Figure 36: Successful exportation message



Nom	Modifié le	Type	Taille
altitude.tif	3/29/2024 5:30 PM	Fichier TIF	246,804 Ko
milieux_humides_isoles.csv	3/29/2024 4:58 PM	Fichier CSV Micro...	324 Ko
milieux_humides_riverains.csv	3/29/2024 4:58 PM	Fichier CSV Micro...	276 Ko
noeuds.nds	3/29/2024 5:31 PM	Fichier NDS	161 Ko
occupation_sol.csv	3/29/2024 5:30 PM	Fichier CSV Micro...	1 Ko
occupation_sol.tif	3/29/2024 5:27 PM	Fichier TIF	247,991 Ko
orientation.tif	3/29/2024 5:31 PM	Fichier TIF	246,804 Ko
pente.tif	3/29/2024 5:31 PM	Fichier TIF	246,804 Ko
point.rdx	3/29/2024 5:31 PM	Fichier RDX	27,871 Ko
proprietehydrolique.sol	3/29/2024 5:31 PM	Fichier SOL	2 Ko
troncon.trl	3/29/2024 5:31 PM	Fichier TRL	168 Ko
troncon_width_depth.csv	3/29/2024 5:31 PM	Fichier CSV Micro...	113 Ko
type_sol.tif	3/29/2024 5:27 PM	Fichier TIF	247,991 Ko
uhrh.tif	3/29/2024 5:31 PM	Fichier TIF	246,804 Ko

Figure 37: List of files required for creating a HYDROTEL project from a PHYSITEL export

5.2 Water storage mapping tool

An innovative and alternative approach was developed to assess and map water storage capacities on appropriate landscapes, using relevant spatial information and having different potential objectives. A specific GIS tool was developed and integrated into PHYSITEL to produce water storage maps. Figure 38 depicts the storage computation tool options and is divided into five subsections for detailed explanation.

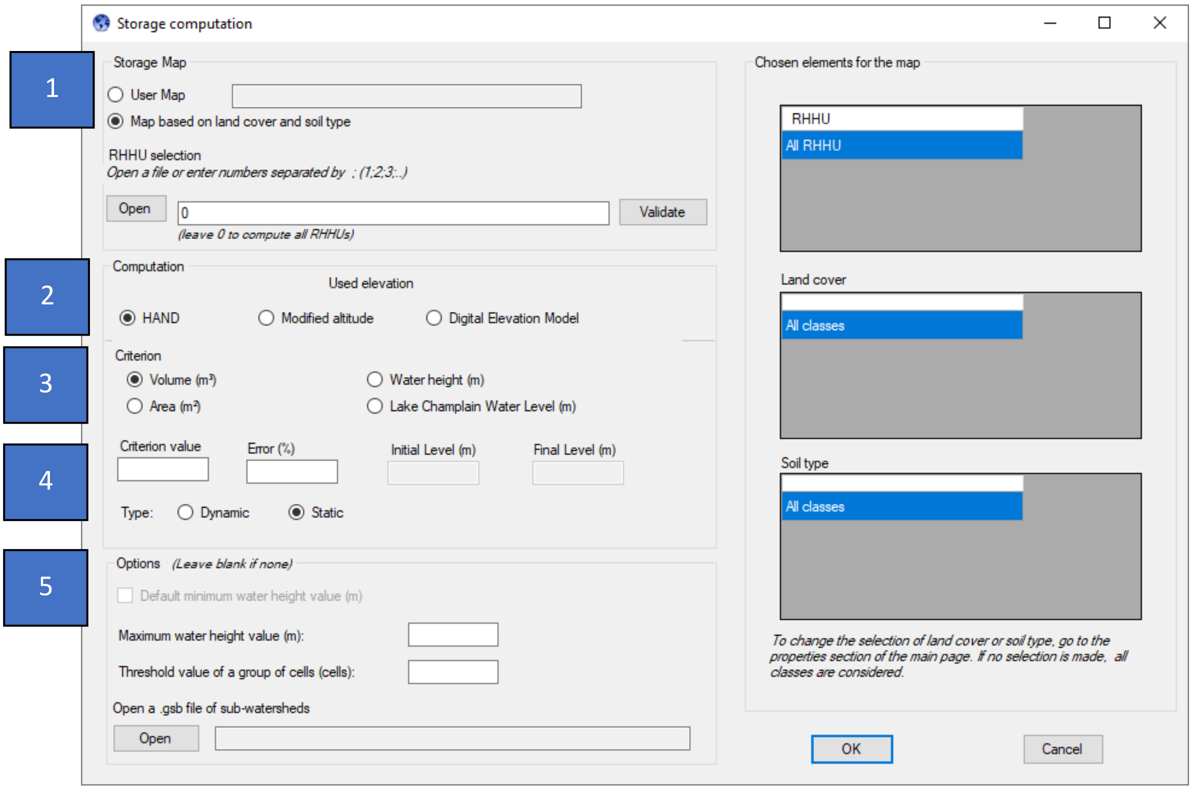


Figure 38: Storage computation, computational options in PHYSITEL

5.2.1 Mapping potential water storage

The potential water storage map (labelled as Tag 1, Figure 38) is used to delineate locations where it is desired to allow storage. There are two options, either using a user-supplied map or building a potential map based on selected land cover and soil type classes. The user-supplied map is converted into a map with predefined storage areas. Only the selected cells of the map can store water and, therefore, only these cells are considered for storage calculation. For the other option, default land cover and soil type maps are used to select the land cover and the soil type where it is desirable to store water. For this specific option, the user must open the properties section of the land cover and soil type PHYSITEL project maps, then check the covers to be considered in the calculation. Finally, the last step to create the initial storage map is the optional selection of RHHUs where the water can be stored. The union of all inputs identifies the cells where water can be stored and represents the potential storage map, as shown in Figure 39.

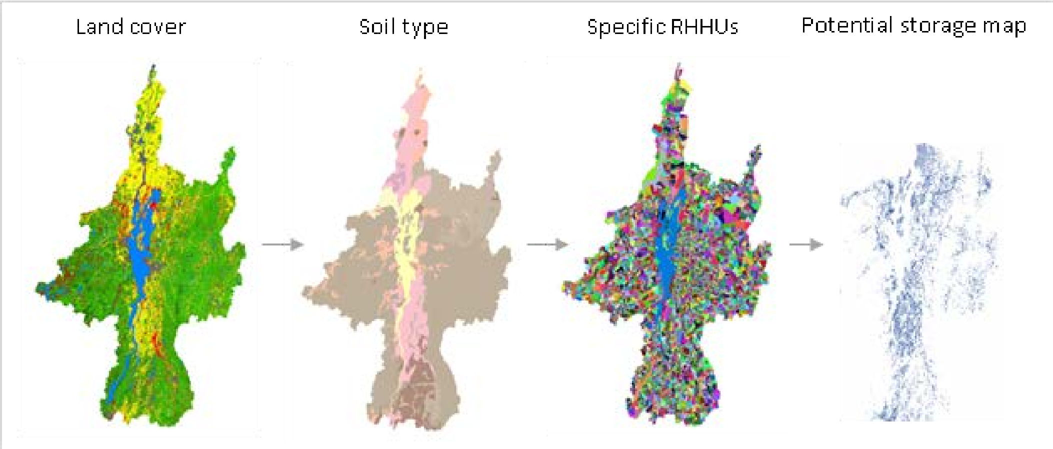


Figure 39: Basic steps to build a potential water storage map (PHYSITEL screen capture).

5.2.2 Spatial reference for computation

The next section of the interface (*computation*) (Tag 2, Figure 38) deals with the selection of the reference datum map. This reference represents the elevation map to be used for water accumulation; this is the basis of the storage calculation, since the vertical elevation value of each cell must be known to obtain the topography. The lower the vertical elevation of a cell, the more likely it is to store water. There are three different elevation maps that can be used to store water: the HAND map, the modified elevation map, and the digital elevation model (DEM) map.

The HAND map (see Figure 40) is a conceptual model allowing the normalization of the topography of the ground according to local relative heights at the periphery of the hydrographic network. The value obtained then corresponds to the water level threshold to cause flooding. The HAND value can be seen as a relative assessment of where water would accumulate naturally, corresponding to small HAND values. This method is useful when calculating a dynamic storage map since it integrates the notion of water flow from one cell to another. In the case of the SRTM-30m DEM the relative vertical height accuracy is less than 10 m. Note that using the HAND conceptual model would not be impacted by the DEM vertical accuracy as this model provides relative information.

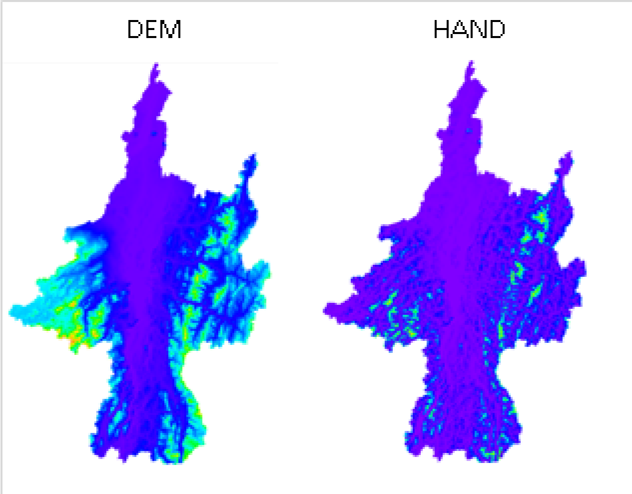


Figure 40: Reference elevation map (PHYSITEL print screen).

5.2.3 Water storage target

To build the water storage map, the program must know how much water needs to be stored or the targeted parameter for the water storage calculation (Tag 3, Figure 38). The tool has four (4) options to specify the target, either a volume in cubic meters, an area in square meters, a water level in meters or a reduction of water level in Lake Champlain (specific to the LCRR watershed). This section refers to the calculation criteria in the GUI: volume, area, water height and level of Lake Champlain, as displayed in Figure 41.

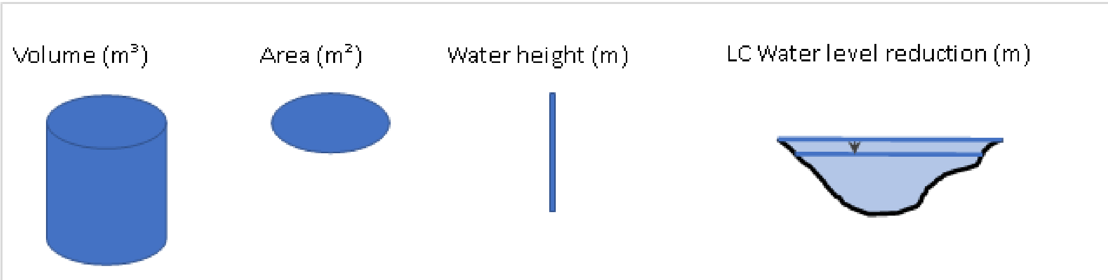


Figure 41:Calculation criteria.

One of the options of the mapping tool is to specify a maximum volume or storage area. Once the targeted value is met, the accumulation algorithm stops, and the final storage map is built. For these two targets, the user must specify the value of the volume or the area and indicate the tolerated error in percentage. The water height criterion corresponds to a threshold water height on a cell of the storage map.

Finally, the option of lowering the Lake Champlain water level is specific to this project. It calculates the total volume of water that must be stored to produce a decrease in Lake Champlain water level, as governed by a level-stored volume rating curve (see Figure 42below). This specific option must be constrained to RHHUs located upstream of Lake Champlain.

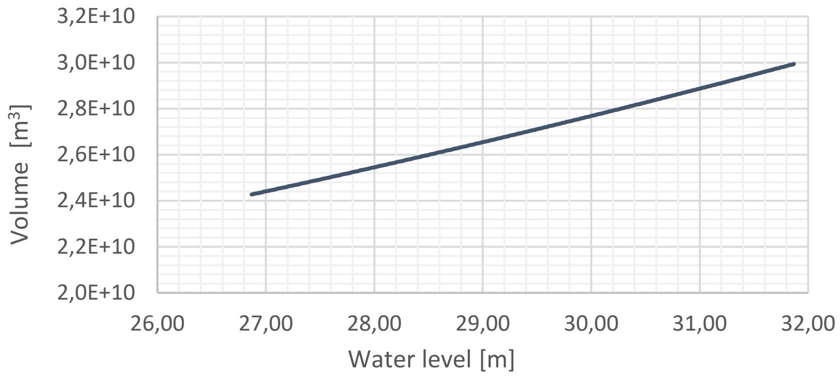


Figure 42: Relationship between the water level of Lake Champlain and the volume.

5.2.4 Type of storage: dynamic and static

The type of storage, static or dynamic, must also be specified (Tag 4, Figure 38). Static means there is no flow or movement of water over the flooded surface; in other words, water fills in the DEM or the HAND map. On the other end, dynamic aims to include the notion of flow and movement of water into the storage areas. The static approach when using the HAND map as a reference can represent water overflowing from the river network onto adjacent land (i.e., floodplain area). The differences between these types of storage are displayed in Figure 43.

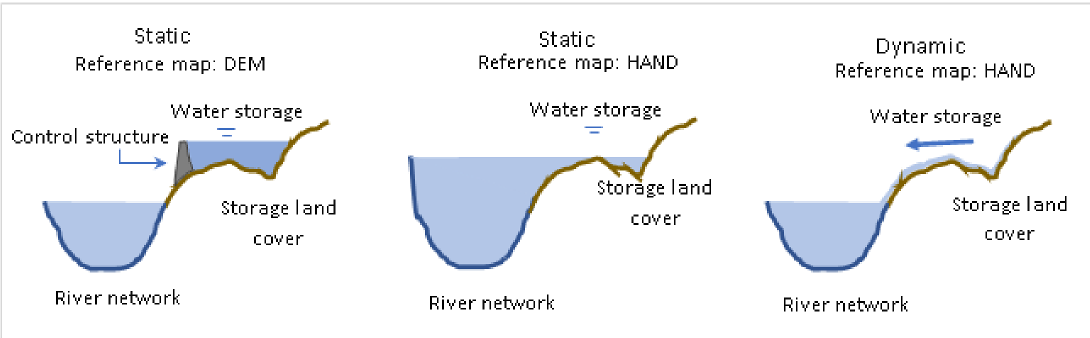


Figure 43: Water accumulation in the storage area

One of the advantages of the mapping tool based on HAND values is in the dynamic nature of storing water. The water stored on each cell has different, non-uniform elevations. Water is stored by adding water according to the minimum DEM value of a RHHU, up to a maximum value. Therefore, each RHHU is independent of one another, and their respective minimum elevation values are considered when running the algorithm. This makes it possible to divide the territory into different subwatersheds. It is particularly useful when the storage map covers a large area and where there should not be any dependency between two RHHUs that are far apart from each other.

5.2.5 Water storage option

Different options can be added to the input parameters, allowing the user to specify certain characteristics or limitations (Tag 5, Figure 38). The automatic minimum water height option is used to find the minimum height to be achieved (i.e., the volume or area target value specified by the user). Another option is to set a maximum value for the water height to be stored on land cover cells. The total volume and area must be reached while satisfying the maximum value. Otherwise, it could happen that the maximum water height would not be sufficient to meet the targeted volume or area.

Finally, a pixel threshold value can be specified to filter results and limit flooding at specific locations. This option allows water to be stored on a cell if the number of available adjacent cells for water storage is greater than the threshold value specified by the user. The intent here is to determine which flooded cells are grouped together and to eliminate isolated cells.