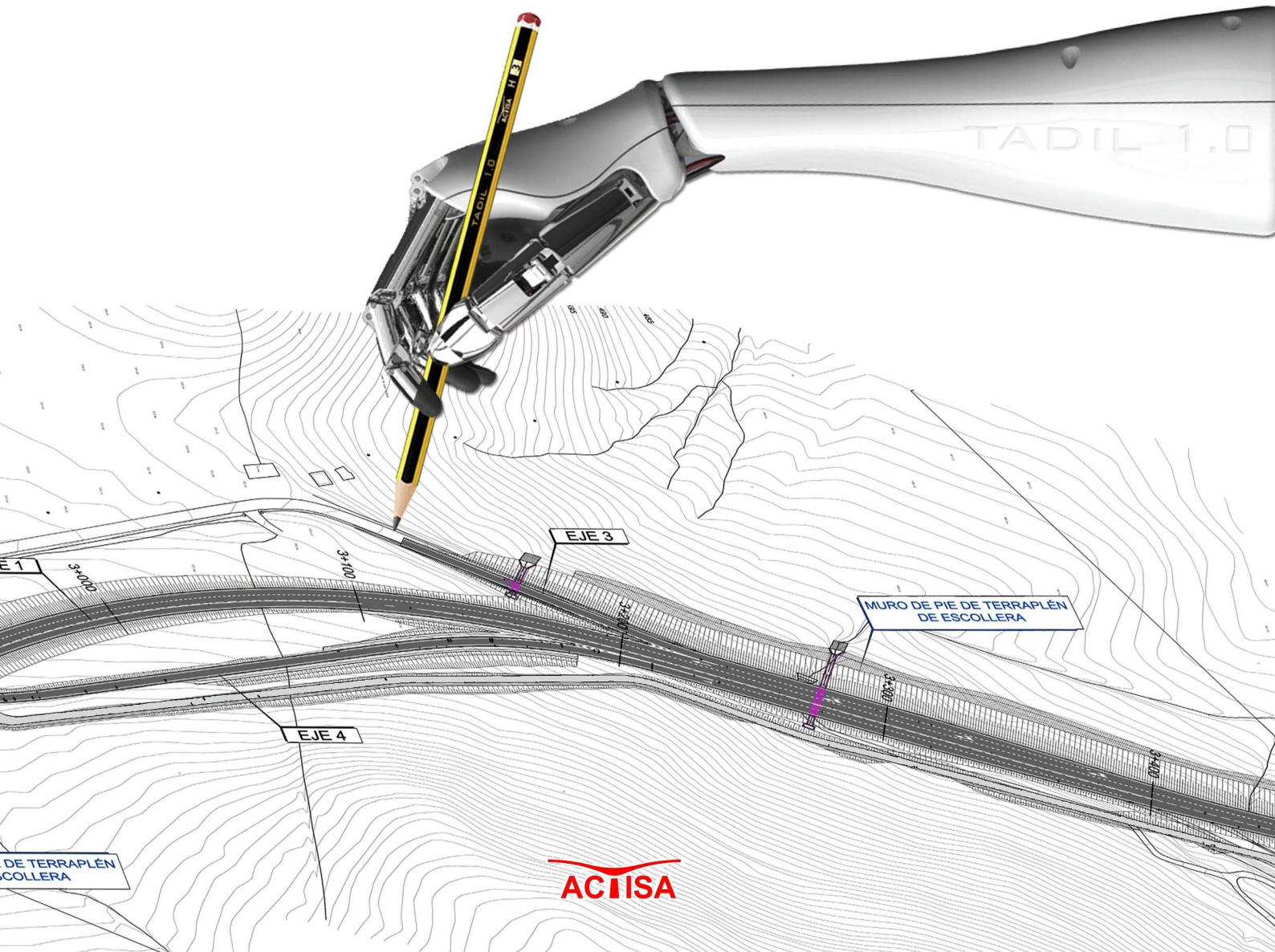
TADIL 3.0

TENCHIQUES FOR THE AUTOMATIC DESIGN OF NEW LINEAR INFRASTRUCTURES

USER'S MANUAL

TADIL-Road



ACTISA

SOFTWARE TADIL

USER'S GUIDE

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SOFTWARE TADIL

USER'S GUIDE

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PRESENTATION

Up to now there have been too little researches aimed at defining methods of automatic draft in lineal works. Some of them have used classical techniques of mathematical optimisation; some others resort to heuristic search or to the knowledge-based methodology of systems to solve the problem. Most recently some techniques of stochastic local optimisation have been applied, mainly by using genetic and evolutionary algorithms.

In general, all these attempts have suffered from some of these lacks:

- Little realism when modelling the problem. Restrictions imposed by road regulations and instructions imply a range of possible solutions with a complicated topology and an irregular shape. On the other hand, the real environment where the lineal work is to be implemented is very complex too. All in all, the suggested systems go without one or several important aspect during modelling.

- Size of the maximum solvable problem. The number of possible solutions increases exponentially with the draft length; hence the approaches based on classical techniques of combinatorial optimisation can only deal, in practice, with very small problems.

- Partial approach of the problem. It is common in literature to find, for example, some software which only consider plan drafts or which only consider earthwork cost.

- Lack of integration with the real workplace. Most of the suggested systems still remain in the theoretical proposal or, at most, in the prototypes, without taking into account the real features of work specified by the planner.

TADIL overcomes all of these limitations to a greater or lesser extent:

- It allows us to model the largest part of the problem aspects and the possible solutions.

- It solves in a few minutes draft problems of order 50 Km.

- It provides complete drafts (plan and elevation) as well as indications about tunnels and crossing works.

- TADIL joins the baseline commercial tool in the field of the Engineering and provides a complete description of the proposed draft on the level of Informative Study.

Therefore, TADIL constitutes a significant step forward from the point of view of R&D in the field of Artificial Intelligence for engineering design.

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1. INTRODUCTION

1.1. What is TADIL?

The initials TADIL stand for the Spanish term "Techniques for the Automatic Design of Linear Infrastructures". TADIL is, therefore, a software which covers several techniques in the field of artificial intelligence to design automatically linear infrastructures.

This software aims to generate infrastructures designs in a quick way. It is possible to define the route plan axis, the longitudinal profile, the cross sections, the earthwork plan and the infrastructure expropriation, the measurements and the earth movement, the earthwork balance, the budget, the profitability and the evaluation of alternatives.

The possibility of obtaining infrastructures in such a quick way will allow administrators, private promoters and consultants to be able to:

- know from the very beginning their investment needs and profitability without having to wait for the project to be completely developed.
- undertake a wide parametric study where multiple variables are considered (speed, type section, cut sections and embankment heights, etc.) enriching the view and analysis of different implementation possibilities of the new infrastructure.
- achieve the best possible integration between infrastructure and territory since geotechnical, environmental, climatic, socio-economical and patrimonial variables are considered.

1.2. Possibilities and abilities of application of software TADIL

We must consider that TADIL is a software intended for designing linear infrastructures in a previous study level. TADIL can design, analyse and value multiple alternatives and select the best one. Afterwards, we might consider which tools are relevant to perfect and define the selected design.

Nevertheless, we must indicate that future versions of TADIL will incorporate new functions which will improve results and provide solutions more and more in line with those of an actual project. This will make user's work easier.

The software includes several algorithms which allow to consider both the ordinary variables in a design (speed, maximum slopes, etc.) and the criteria and preferences of design to be taken into account by the user (rectilinear design or with an harmonic sequence of curves, better adjustment to land or more direct design, etc.). The application of algorithms makes richer the alternatives to be included in the previous or informative study.

1.3. Methodological application guide

This Guide wants the user to become familiar with the software. We have designed software TADIL to be accessible both for users with experience in infrastructures design and starting users. Although users with experience in infrastructures projecting and designing will need no more than a quick read of this Guide to make new studies with software TADIL, we recommend them to read simultaneously the Methodological Application Guide.

The Methodological Application Guide provides a description of each variable taking part in the study as well as recommendations for its application.

It also provides a description of procedures, evaluations and calculations from software TADIL. Knowing these topics will allow the user to get a greater performance and, therefore, to obtain the best results from TADIL.

1.4. Steps to be taken with software TADIL

When we work with software TADIL, the steps to be taken will depend on the type of study we want to make; in section 7 we describe the differences between previous study and informative study.

For the previous study, after having entered the design preferences and criteria, we can proceed to obtain the plan and profile design. For the informative study, before entering the design criteria, we should have first defined completely the Geographic Information System, the data base with the construction units and prices applied as well as the cross sections. In the same way, we will have to indicate those data allowing configuring the budget and the profitability study and, finally, the weighting coefficients of variables taking part in the multi-criteria evaluation.

Therefore, the steps to be taken in the informative study are the following:

- **a.** Defining the construction units and prices to be used in the study.
- **b.** Defining the Geographic Information System.
- **c.** Defining the type section.
- **d.** Budget data.
- **e.** Profitability data.
- **f.** Criteria for the valuation of alternatives.
- **g.** Entering criteria and preferences of design.
- **h.** Generating plan design.
- **i.** Generating elevation design.
- **j.** Obtaining cross and plan sections of earthwork and expropriations.
- **k.** Evaluating jointly the alternatives.
- **l.** Obtaining lists.

The previous study only includes steps g, h and i, obtaining exclusively the plan axis and longitudinal profile of the alternatives.

1.5. About this User's Guide

This User's Guide aims, on the one hand, to give a general overview of this software and, on the other hand, to provide a quick guide of use. For that reason, we include a complete example of previous study as well as of informative study.

The User's Guide distribution is the following:

- **In section 2** we give a general overview of the software structure.
- **In section 3** we describe the file management made by TADIL.
- **In section 4** we describe the layers management. This section together with section 3 are considered essential to achieve the best possible order in processing the great number of data necessary for making an informative study.
- **In section 5** we describe the installation process and the boot up process.
- **In section 6** we describe the available languages of TADIL, the User's Guide and the Application Guide.
- **In section 7** we explain in detail the differences between a previous and an informative study.
- **In section 8** we describe how to create and edit the Digital Terrain Model.
- **In section 9** we explain the procedure to simplify polylines with many vertexes.
- **In section 10** we show a complete example of a previous study, to which we will add two previous studies to describe the qualities that software TADIL offers in calculation.
- **In section 11** we make a tour of each menu and show an example of informative study. This section is structured in two large points: introduction of data in database or TDB module and calculation of informative study with the module TDI. At the end, we include the lists we can obtain with TADIL.
- Finally, in **section 12** we describe the treatment of measure units and monetary units, **in section 13** we describe some frequent errors and **in section 14** we answer the FAQ.
- **In section 15** we make a general description of applied algorithms.

2. WORK ENVIRONMENT OF TADIL

The work environment of software TADIL is structured into two separate sections: the Database Administrator and the Project Administrator. Next we specify the content of each one

2.1. Database administrator

The Database Administrator is used for the development of informative studies, where we have a detailed study of the land, a basis of prices appropriate for the infrastructure to be planned and we know the type section.

The database administrator has the following windows:

- Construction Units and Prices
- Geographic information system
- Macro-prices
- Type Sections

2.2. Project administrator

The setting up will be different if we choose a Previous or an Informative Study.

When we are developing an informative study, we will be able to fill in the menus of the project administrator. In contrast, when we are developing a previous study, we will be able to calculate only the route plan axis of the alternatives and its longitudinal profile without cross sections, measurements and budgets, hence, without elaborating the profitability study. For developing the previous study, we do not need a database.

The project administrator consists of the following sections:

- ***Setting up - file paths***
- ***Initial Data***
- ***Informative Study:***

  - Visibility Axis
  - Type Section and General Areas
  - Basic Axis Editor
  - Solutions Editor
  - Budgets
  - Profitability
  - Evaluation of Alternatives
  - Report Manager

3. FILE MANAGEMENT AND COMMANDS IN TADIL

The file generated with the project administrator will have always the extension "tadil", whereas the one generated with the database administrator will have the extension "tadbd".

The files of regulations will have extension "tadno" for defining the plan axis, whereas the files of regulation for defining its grade line will have the extension "tadkv".

The file of activation of TADIL in AutoCAD is acTadil.dll. is located in the folder 10.00-Tadil/app.

The files of design of section of structures, tunnels and barrier have an extension dwg and are located in the folder 10.00-Tadil/cad. We must not modify the name of the files to incorporate to TADIL, otherwise the software will not do the automatic search of the structure or tunnel section according to our preferences.

We can save the files of images in the folder 10.00-Tadil/img.

TADIL generates files of work in the folder 10.00-Tadil/gis.

Each time we want to load a new version in TADIL, we should replace the folder 10.00-Tadil in its location; afterwards, we should write "netload" in the Command Bar of AutoCAD, then we go to the location of the file "acTadil.dll" and we load it. Next we can load the database administrator by writing the command TDB or the project administrator by writing the command TDI.

To set the version switch, we use the command TDSET. After that, each time we open AutoCAD, we just have to write the command TDI or TDB.

To change the menus into English we use the command TDEN and to change it into French, we use TDFR.

4. LAYERS MANAGEMENT

Given the great quantity of information inside TADIL, in the Geographic Information System, we recommend generating the areas and polylines of interest in differentiated layers before logging in the database administrator. This way, TADIL will be more effective as we will just need to select the corresponding polyline without having to wait for creating it. Searching the polyline will be easier too if it is located on a differentiated layer.

In turn, TADIL, as polylines are assigned to the database and the project administrator, generates layers in AutoCAD. Among others, TADIL generates the following:

- *_Tadil_VisibilidadEje*, which includes the visibility axis used.
- *_Tadil_VisibilidadGrafo*, which includes the degree of automatic visibility.
- *_Tadil_ZonasNoPasoPendiente*, which includes the triangles of maximum slope specified by the user.
- *_Tadil_ZonaNoPasoUsuario*, which includes the banned areas specified by the user.
- *_TADIL_Gis_XXX_xxx*, are the layers generated by TADIL, some of them environmental layers, (if it includes the term AMB), climatic, (if it includes the term CLI), socioeconomic, (term SOC), or patrimonial, (term PAT). Likewise, the layer name refers to the variable that we define (SECPRI for first sector, URBANO for urban land, etc.)

The layers whose name is _Tadil_Sol_ refers to the definition of basic axis, route plan axis, profile and sections of each one of the calculated solutions.

5. SOFTWARE INSTALLATION

The license of TADIL incorporates an Installation Wizard. This wizard needs to know the location of the folder 10.00 Tadil as well as the protection data of the software.

When we finish this process, we can use software TADIL.

We recommend a minimum RAM memory of 8 MB. For bigger cartographies, 12 MB RAM memories will speed up the process.

6. AVAILABLE LANGUAGES

Software TADIL is available in Spanish, English and French. The software, the User's Guide and the Methodological Application Guide are in these languages too.

For license support, written or telephonic enquiries can be attended in Spanish and English.

At the request of any user, ACTISA, the company commercializing, updating and supporting the software, will offer a translation into the applicant's language. This service is free if a determined number of licenses are requested.

We will be able to load the menus in English (with the command TDEN), in French (with the command TDFR) and in Spanish (with the command TDES).

7. PREVIOUS STUDY AND INFORMATIVE STUDY

A previous deep knowledge on the territory where the infrastructure is aimed to be implemented allows distinguishing both types of analysis:

- in the previous study we do not have a detailed study of the territory-defining variables. The infrastructure to be design aims to solve a problem between an origin and a destination (an infrastructure with a lack of capacity, absence of connection, etc.); we usually start from a study on traffic or demand and do not detail the type of infrastructure.

- in the informative study we start beforehand from defining the features of design. Likewise, we have a full study of the territory and all the variables affecting the design (environmental, geotechnical, climatic, socio-economical, patrimonial, etc.).

The main differences between both studies are as follows:

Design: whereas in the previous study different solutions of type sections are considered according to the decisions on the traffic previous study, in the informative study we start from a specific type section. On the other hand, whereas in the previous study we consider a range of speeds, in the informative study, speed is not generally detailed in advance. Finally, whereas in the previous study we analyse the possibilities of implementing route axis in the territory, in the informative study we make a detailed multi-criteria study analysing different alternatives regarding the occupied plan space of the linear infrastructure, the cross sections and the measurements of the construction units.

Cartography: in the previous study we use published cartographies going from the 1:25.000 to the 1:5.000 and in the informative study we start generally from a specifically-made cartography for the studying area.

Costs: whereas in the previous study we consider global costs on implementation, cut sections, embankments, structures and tunnels, in the informative study we detail the units that best fit with the crossed geotechnical groups including earthwork, pavements and esplanades and we can also consider costs regarding different typologies of structures and tunnels.

Geotechnics: in the previous study we use geological and geotechnical regional analysis and we make general proposals for the cut section slopes and embankments; in the informative study we set out in detail features to differentiate geotechnical areas and groups with specific data on slope, protection, scaling, pavement and esplanade.

Structures and tunnels: in the previous study we only consider global costs whereas in the informative study we distinguish typologies of structures and tunnels with differentiated costs depending on the area.

Environment: in the previous study at most we consider environmental banned areas as for the alternatives, whereas in the informative study we can implement a wide range of variables depending on the full study of environmental impact, which establishes territory evaluations and, like in the previous study, creates banned areas.

Climatology: in a previous study the climatological variables are not usually considered, except for those which affect decisively to the design; in the informative study we analyse those conditioning aspects which affect traffic safety (frost, rain, fog, heavy wind, etc.).

Socio-economy: in the previous study we only consider those aspects regarding the traffic prognosis, whereas in the informative study we include a complete analysis of use areas with their corresponding productive evaluation.

Patrimony: whereas in the previous study we only consider big areas of patrimonial protection, in the informative study we carry out a wide study about the soil evaluation, distinguishing use areas, infrastructures crossings, farm tracks, etc.

The informative study can be preceded by a previous study, which will provide information about the type of infrastructure to be developed in the territory.

TADIL allows making previous studies without having to implement the GIS menu, the Construction Units and Prices menu or the Type Sections menu; just entering the data in the Design menu.

In contrast, before developing an informative study, we should enter the GIS variables, the values of units and prices and the type sections to implement. Once all the information is entered, we would be able to access the Design menu and generate alternatives.

The information that we will be able to obtain in each study differs considerably as it is described next:

- Previous study:

  - Route plan axis.
  - Longitudinal profile

- Informative study:

  - Route plan axis.
  - Longitudinal profile
  - Cross sections

- Earthworks plan.
- Budget and earthwork balance.
- Profitability results.
- Evaluation of alternatives.

8. CREATING THE DIGITAL TERRAIN MODEL (DTM)

The first step to start using TADIL will be to create the Digital Terrain Model (from now on, TDM). We will be able to create the TDM out of points or contour lines.

8.1. Previous recommendations

If the TDM is created out of contour lines, always represented by polylines, we must take some recommendations into account:

8.1.1. Cartography of broken polylines (contour lines)

It is quite common that we find cartographies whose contour lines are not joining. To solve this problem, we just need to select all the contour lines and to write the AutoCAD command "Bind" so that these contour lines will join. Repeat this step as many times as needed until the contour line is included in a single polyline.

8.1.2. Cartography of several plans whose borders are joining

When working with big cartographies, we normally join several plans. To avoid possible problems when creating the TDM, select all the plans and write the AutoCAD command "Bind" so that the contour lines will join and the smaller plans will be included into a bigger one.

8.1.3. Cartography of polylines whose level numbers are positive and negatives

Another common problem is to find cartographies whose polylines are not joining and besides of that, one level is positive the other is negative. This is due to the labels originated from creating the contour lines out of the cartographic view. To solve this problem, use the AutoCAD command "qselect" so that we separate the negative level and the positive level in different layers. Then, open only the layer with negative polylines, select them all and click on the button "Explode" in the AutoCAD Toolbar. Finally, switch on the two layers with positive and negative polylines, and write the AutoCAD command "editpol" to join them. This way, the cartography will have only positive level numbers.

8.1.4. Cartography with 3D polylines, lines, splines, etc.

As mentioned previously, to create the DMT, out of contour lines, these will be represented exclusively by polylines. Therefore, if we have 3D polylines, lines or other elements inside the layer of contour lines, it will be necessary to turn them into polylines or to remove them.

In order to know if those elements are inside our layer of contour lines, we select all the elements inside the layer and execute the AutoCAD command "qselect". In this window, we can see the type of drawings we have.

Normally a 3D polyline represents a broken line, whose grade lines vary. So, if this is the case, we recommend breaking down the 3D polyline in lines with the AutoCAD command "explode" and introducing it inside the layer of broken lines.

In contrast, if the 3D polyline is a contour line, in which by any reason there is a mistaken grade line, we will have to break it down in the same way and eliminate the troubled segments. Once we eliminate these segments, with the AutoCAD command "bind" we join the remaining lines that were formed when we broke the 3D polyline down. These remaining lines will form one or several polylines.

Finally, we type "editpol" in the AutoCAD command bar and select all the elements in the layer of contour lines. If there are elements which are not polylines, TADIL will ask us if we want to turn them into polylines. We need to click on "yes", then "escape" and we will have all the contour lines made exclusively out of polylines.

8.2. Load the software

TADIL is a software that works inside the software AutoCAD. Therefore, first of all, we must open the cartography in (.dwg) format.

After that, we load TADIL. For doing so, we need to write "netload" in the Command Bar. Then, when the dialogue box "Select .NET Assembly" will open, we select the folder where TADIL is in our system, we select the folder "app" and we load the file "acTadill.dll". To finish the installation process for TADIL, we write "TDSET" in the Command Bar. From now on, the software will load automatically each time we open the software AutoCAD.

8.3 Creating the MDT

8.3.1. Loading TDM Menu

To load the TDM Menu, we just need to write "TDM" in the Command Bar of AutoCAD.

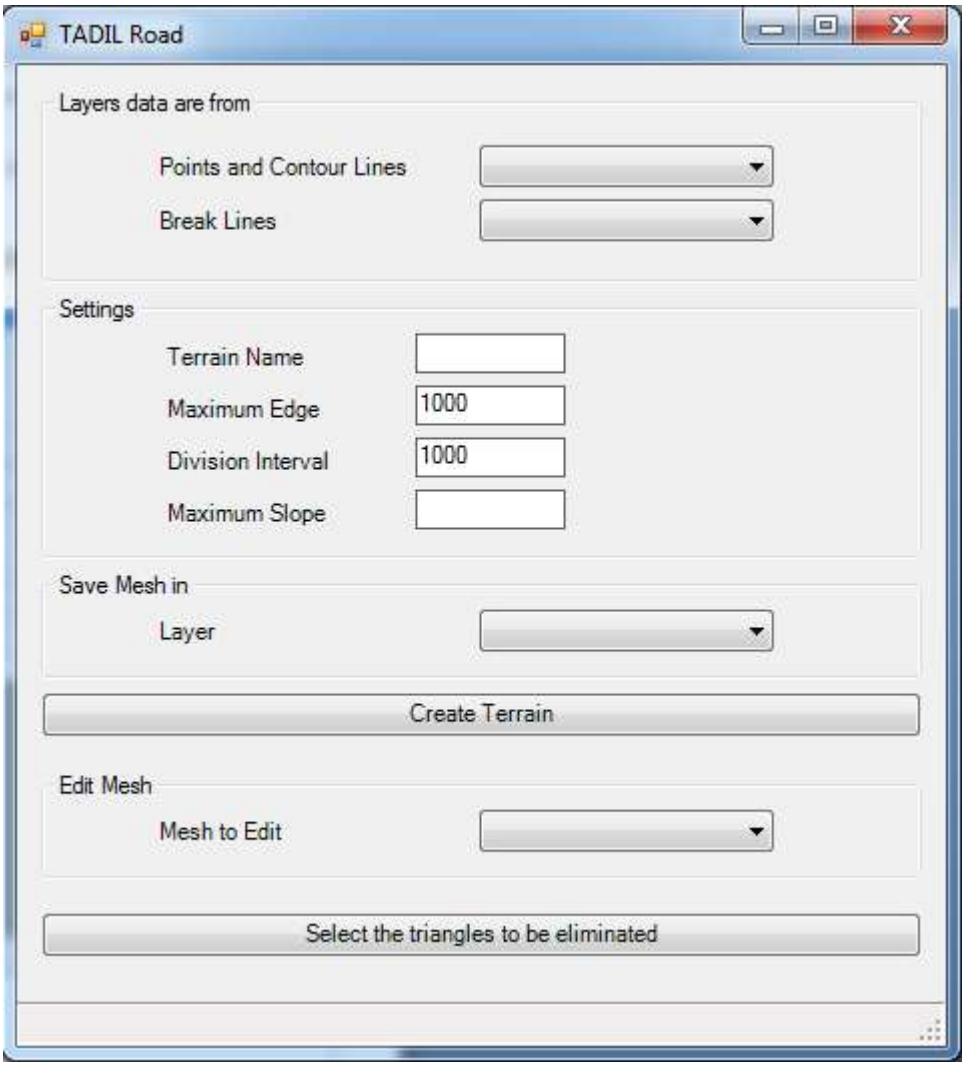


Image 1. TDM Menu.

8.3.2. Creating the TDM

Depending on whether we want to create the TDM out of points or contour lines, in the pull-down menu "Points and Contour Lines", select the layer where either the points or the contour lines have been saved in format .dwg.

If we want to add broken lines to TDM, create them previously and save them in their own layer. Then, select the layer where the lines where saved in the pull-down menu "Broken Lines" to incorporate them.

The next step is to set the TDM features. Name the land to be created and define the maximum angle and the division interval, both measured in meters.

The division interval denotes how often we divide the contour line and the maximum angle denotes the maximum side of the triangle in the network, so that if we want to avoid conflicts and obtain a reasonably good DMT, we recommend entering a division interval value lower than that of the maximum angle. For long and narrow cartographies, quite common in linear works, we need to enter low values for both variables.

Another advantage of TADIL is the possibility to analyze the land slope before getting the study started. So, in the section "Maximum Slope" we enter the maximum slope value we want. This value is entered in parts per unit and once we have created the TDM, TADIL will create a layer with polygons which will define those areas whose slope is equal or higher than the maximum. Afterwards, we can select these polygons and turn them into banned areas because of their slope, as explained in section "10.1.3.2. Land".

Finally, we just need to assign the layer where we would like to save the DMT. This layer must have been created previously.

After entering the data, click on the button "Create Land" and in a few minutes the TDM will be set in the layer we had appointed.

Once we have created the TDM, we can edit it. Sometimes when the borders of the cartography is sinuous, triangles appear between vertex where there was no cartography. In other words, triangles outside the cartography are created distorting it in some borders. To prevent TADIL from getting solutions based on these triangles, we suggest editing the TDM. For doing so, we need to select the TDM to be edited in the pull down menu "Mesh to be edited". We click on "Select triangles to be edited" and go to the mesh. With the left mouse button we specify the triangles we want to eliminate. Once selected, we click on "Enter" and an identical to the original mesh will be created but without the selected triangles. This way we will obtain a proper TDM according to the cartography.

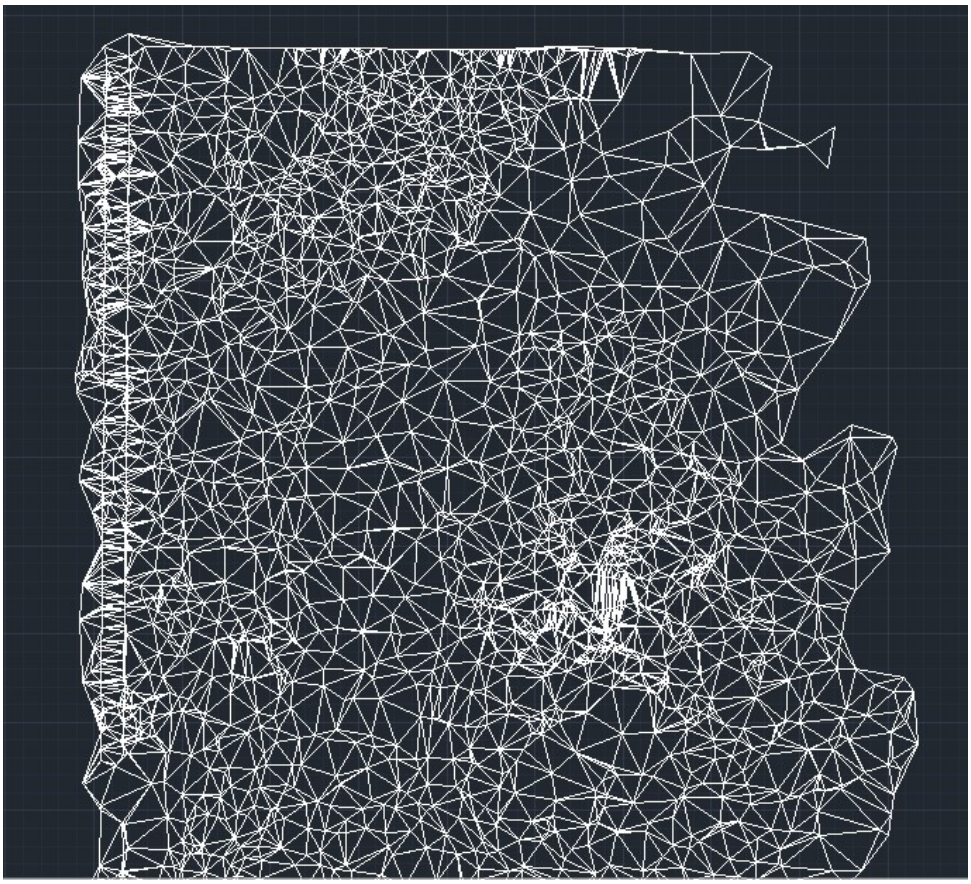


Image 2. Example of TDM created with TADIL.

9. SIMPLIFYING POLYLINES OF BANNED AREAS

Sometimes, when we import polylines that close banned areas, many of them have a huge number of points, which can slow down excessively the calculation of the visibility axis. To solve this problem, TADIL has implemented an option. We open a box with the command TDS. The first thing TADIL will ask for is the polyline to be simplified. We indicate which layer we can save the simplified polyline in and we click on the button "Simplify polylines".

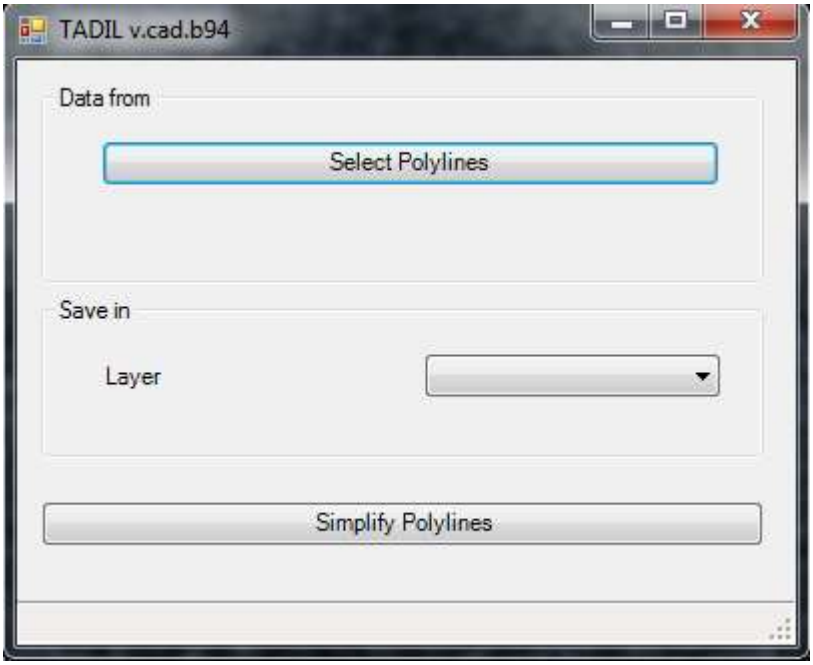


Image 3. TDS Menu.

In the following example we can notice how the original polyline (in white) is simplified and how the new polyline (red) has up to four less vertex.

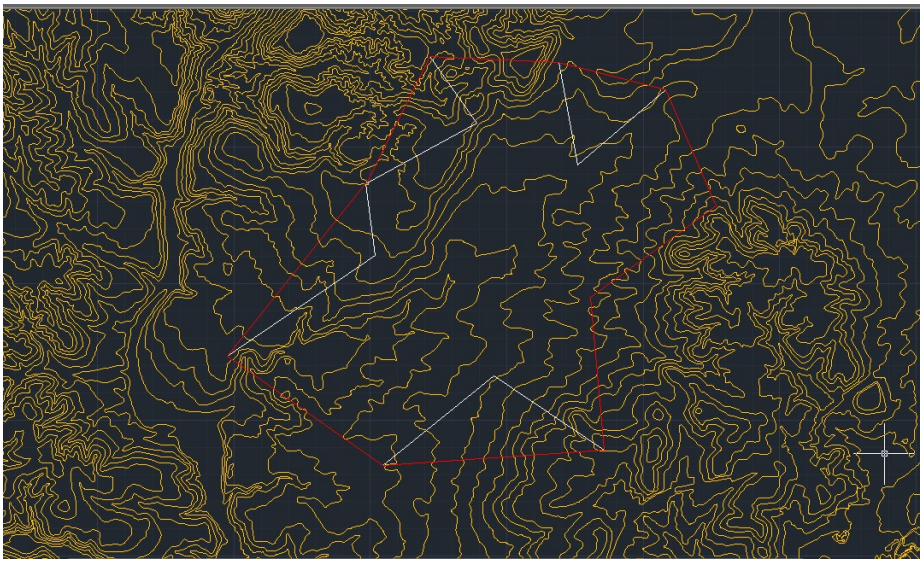


Image 4. Example of simplified polyline.

10. PREVIOUS STUDY DEVELOPMENT

In this section we describe the process for making a previous study. To give the user an easier understanding, we are going to show an example:

The stretch of road B-131 in its section Villa Ana – Pueblo Viejo is part of the corridor of the Valley Río Sur and is 60 km length. Currently it is a single carriageway road and its geometric features are acceptable. However, it has some limitations: 10% of heavy traffic using this carriageway, roads that pass through the village or others very close to town centres and industrial sites; or the presence of several level intersections with complementary-network carriageways and provincial-roads. These limitations greatly affect the operability of its itinerary. More importantly, if we take into account that this road works as a corridor associated to the structuring network (toll road network that is useful as support to long routes and main outside connections).

Currently, this stretch has 9800 v/d as ADT and a 4% growth per year. Its current average speed is 90 km/h. Its death rate is 84 and the hazardousness is 3. Therefore, an alternative road of high capacity is tto be implemented.

In order to check the technical viability of designing this new road, we make a previous study with Software TADIL. TADIL studies have two main blocks perfectly defined: TDB and TDI. TDB is the database module, where every single determining factor is loaded regardless its nature. These determining factors will be detailed all along this user's guide. The TDI, after introducing some determining factors, is a module mainly aimed at calculating design and editing solutions as well as lists. A previous study does not need a database, since it mainly checks the technical viability, that is, the capacity of the land to provide space for infrastructures with the indicated features.

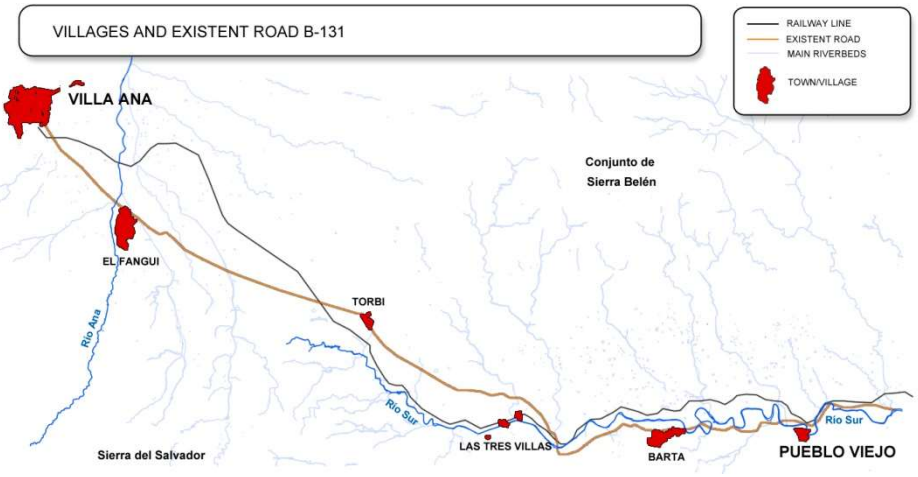


Image 5. Villages and existent road B-131.

10.1. TDI Implementation

Once the software is activated, we make the following:

10.1.1. Load the TDI

To load the TDI menu, we just need to write "TDI" in the Command Bar of AutoCAD.

In the tab "File" from the loading window TDI, we select the option "New Previous Study". We name the file and, then, save it.

10.1.2. Settings

10.1.2.1. File paths

The first thing the software must know which regulations we are going to follow. TADIL comes by default with the Spanish Regulations but the user will be able to enter the convenient regulations at any time.

In our example, we will use the default one. Therefore, we push the "Select" button. Then, a window opens and, in the Software Folder we open the folder "dat". Finally, we open the folder "regulations", select the regulation and save.

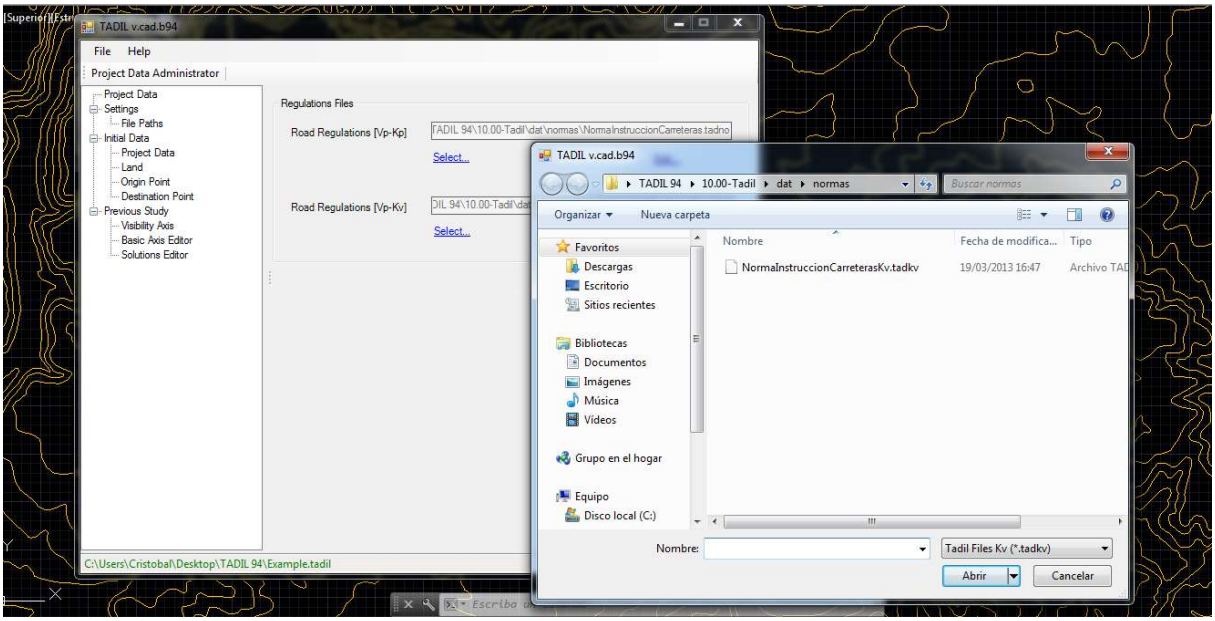


Image 6. Selection of regulation.

- **Edit regulation**

If we opt for a different regulation, the process will be the same as described previously. By clicking on "Edit", we can modify the values of units in the tables. We can modify them directly or just by clicking on the secondary button and clicking on "Add Record" or "Remove Record". To save the modified data, we must click on "File" and select "Save".

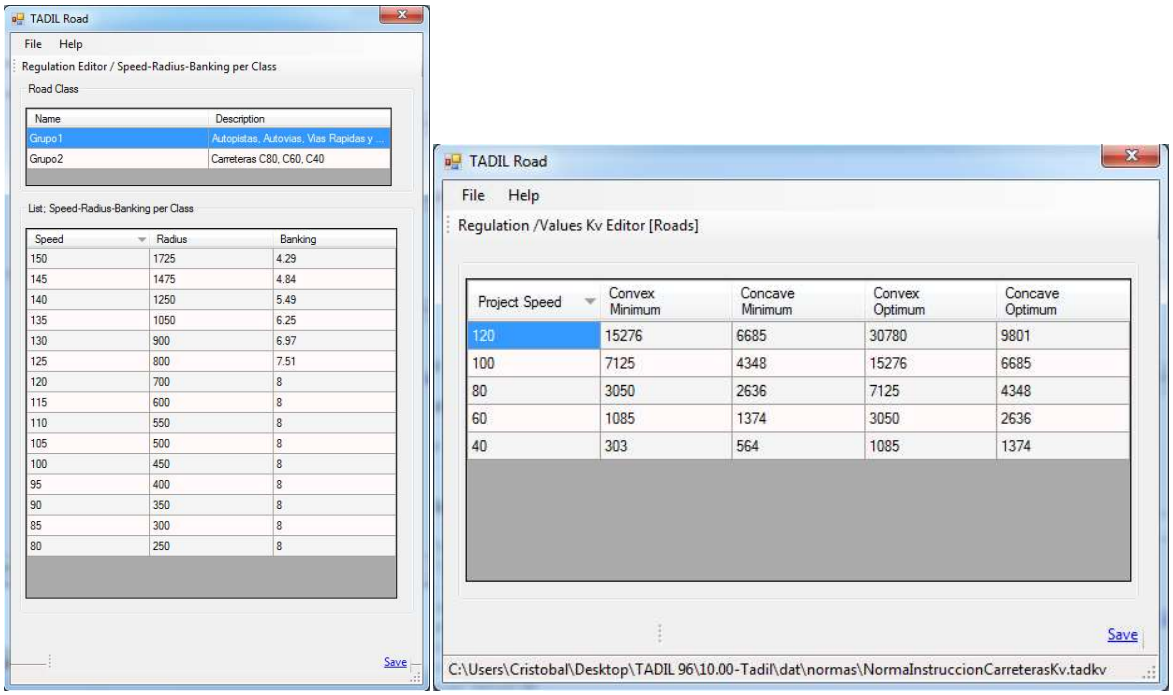


Image 7. Editing the regulation.

10.1.3. Initial data

10.1.3.1. Project data

In this section we define the project name and its description, finally we save it.

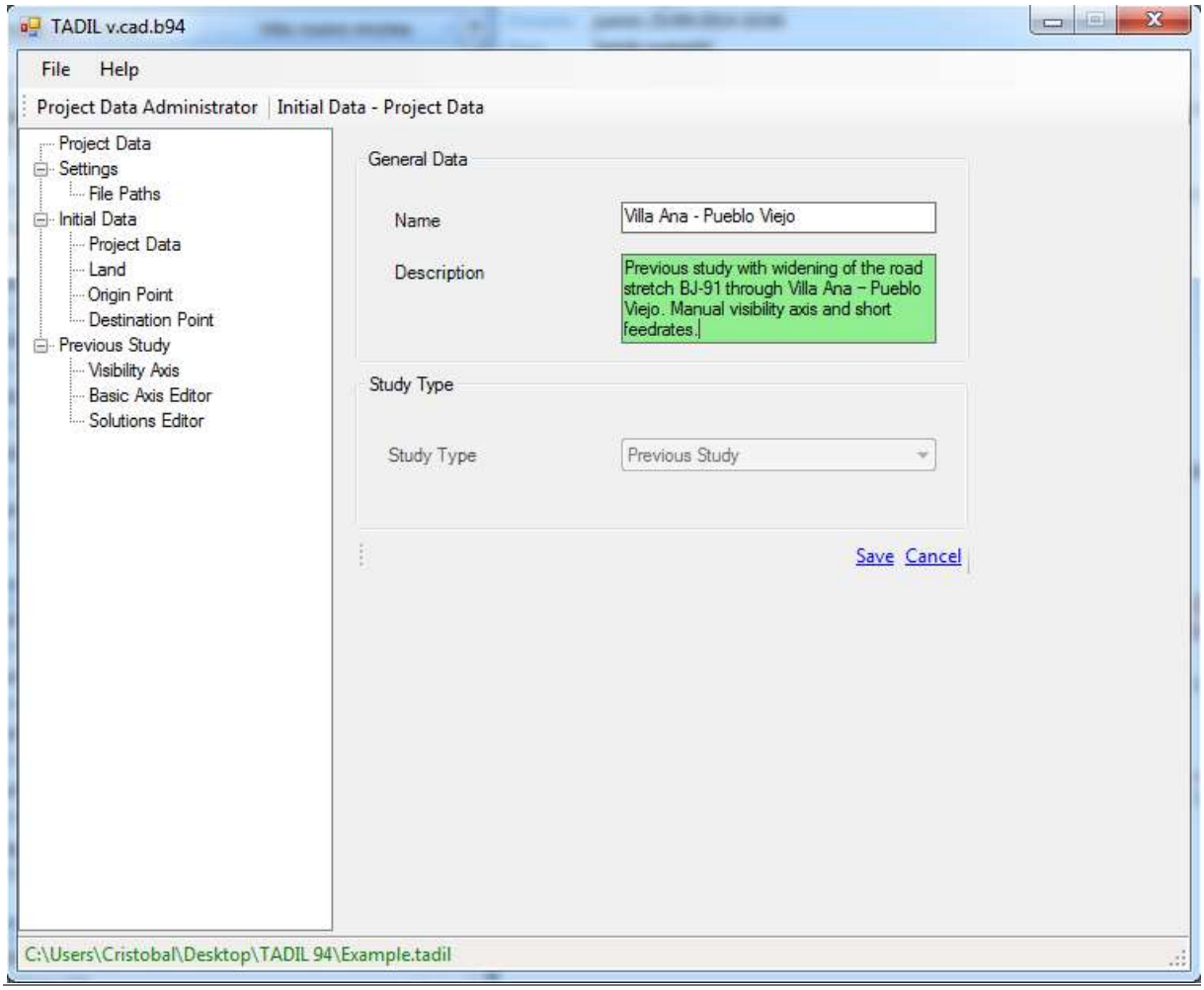


Image 8. Name and description of the previous study.

10.1.3.2. Land

Next we define the land TADIL is going to work with, In the drop-down "Name", it will appear the land's name of the cartography TADIL is going to work with. We select it and push "Save".

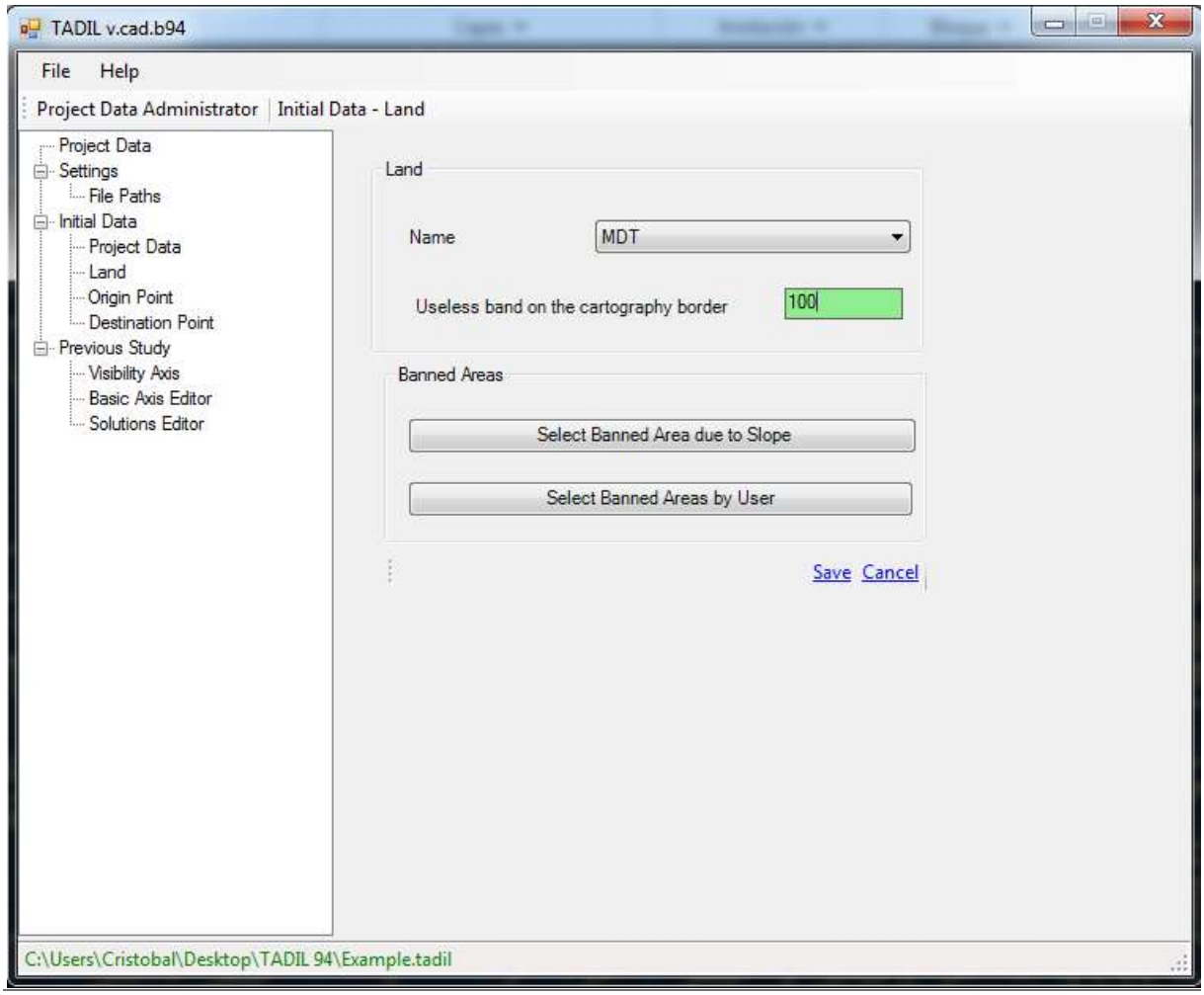


Image 9. Land selection.

- **Useless band on the cartography border**

The useless band on the cartography border is a value that the user must enter in meters. TADIL, in order to avoid calculations out of the cartography, will establish a security perimeter as banned area around the border of the MDT. This banned area will have the same width as the band the user had defined.

- **Banned areas**

  - **Banned areas due to slope:** Along with the TDM, a maximum slope was created as well as a layer (_Tadil_AnalisisPendiente) with polygons which delimited the TDM with areas whose slope was equal or higher than the maximum.

    In this menu, we can select the polygons whose slope is higher than the maximum and mark them as banned areas. We can select all or just those affecting to the study. We suggest selecting only those affecting to the study, since the calculation time for the visibility axis will be greatly influenced by the amount of banned areas we had previously defined.

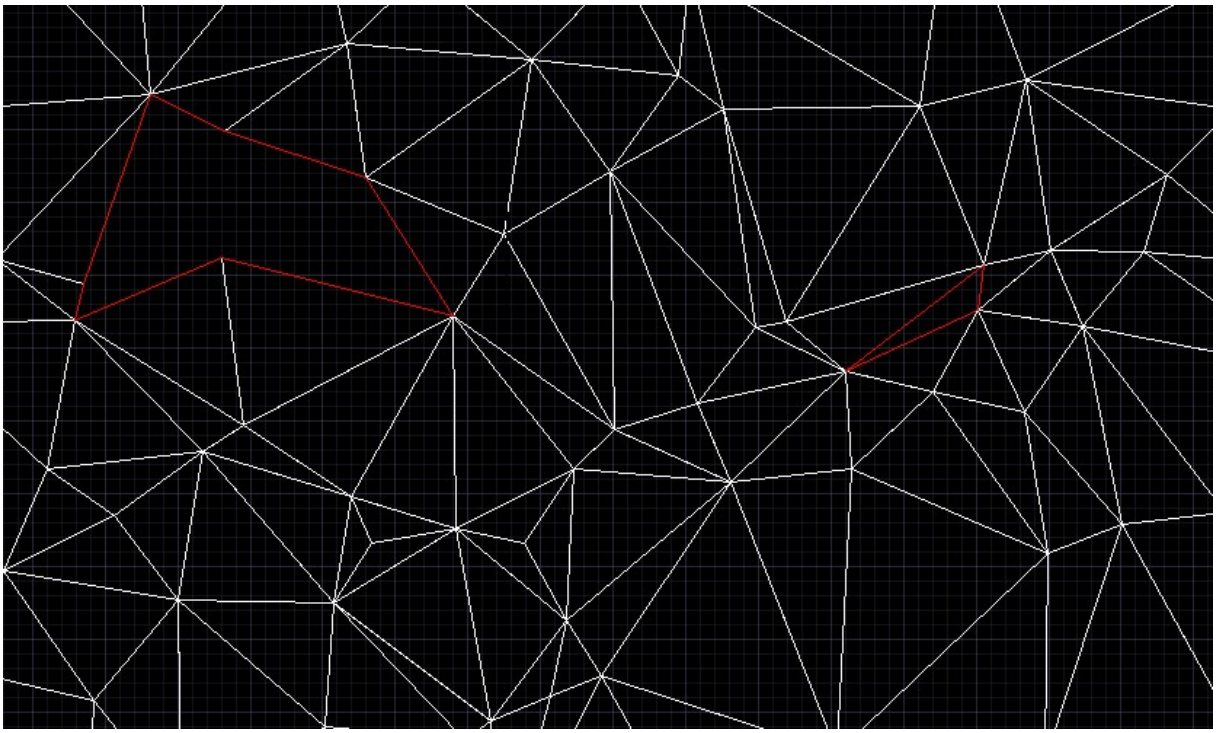


Image 10. Triangulation which TADIL makes for higher slopes than defined.

- **Banned areas defined by the user:** In this case we are allowed to delimit banned areas at will. As for our example, we just mark the city centres as banned areas. Likewise, we draw polylines around the city centre, we push "Banned Areas by User" and TADIL will avoid crossing these sectors.

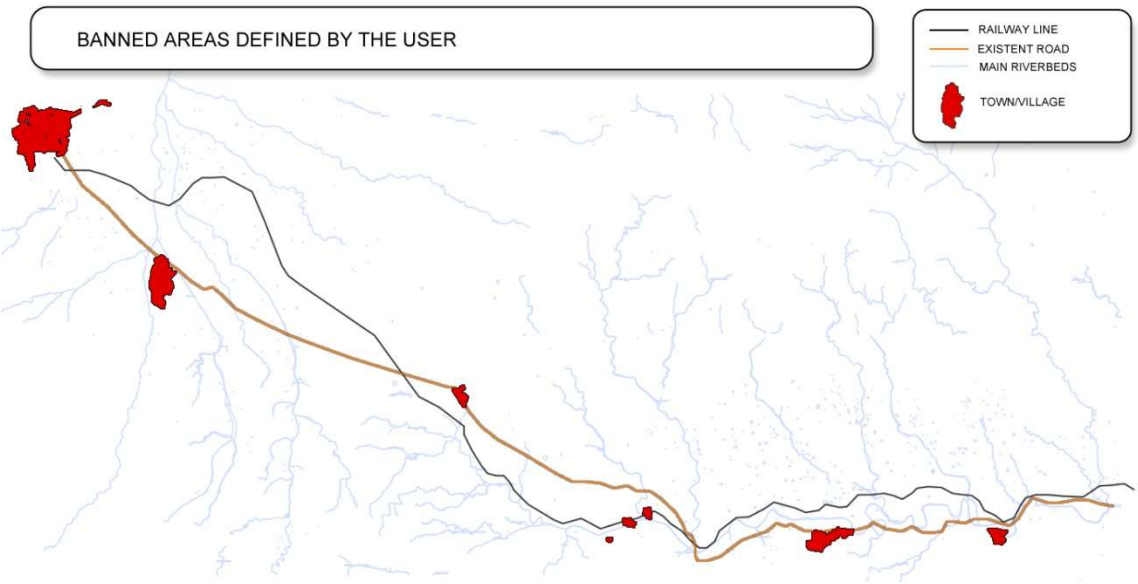


Image 11. Banned areas defined by the user.

10.1.3.3. Origin point

The biggest advantage of TADIL is its straightforwardness and speed of design calculation. Therefore, if we define an origin point and a destination point, the software will analyse the determining factors introduced and will select the best design option.

We can define the origin point directly over the surface of our .dwg (pushing "Specify Point on Surface" and clicking any point of the cartography) or we can introduce its coordinates manually (pushing "Specify Point with Coordinates…").

For our example, we will select an origin point over the surface. We will locate this origin point near the town Villa Ana.

- **Define azimuth**
  Pushing "Define Azimuth", we will be able to determine an azimuth of origin for the future road.

- **Define length**
  With TADIL we can also specify a length of origin at will pushing the box "Define length". This option is applicable when our connection must start from an existing road, whose length is known. When we mark this option, we must also stablish the azimuth.

- **Define slope**
  Likewise, we can also make the future design start with a fixed slope. If the slope is positive, this will be ascending and vice versa. This option can be marked in "Define slope". Just as in the previous section, this option is useful when we have an origin or destination point connected with an existing road.
  As for out study, we have determined an azimuth of origin of 120°, a length of origin of 1600 m and a slope of -0.5 %. The data are determined when we push "Save".

We must take into account that the origin length is conditioned by the class of road and speed. Therefore, having defined this, we recommend checking this length fulfils the data given by TADIL before calculating the basic axis.

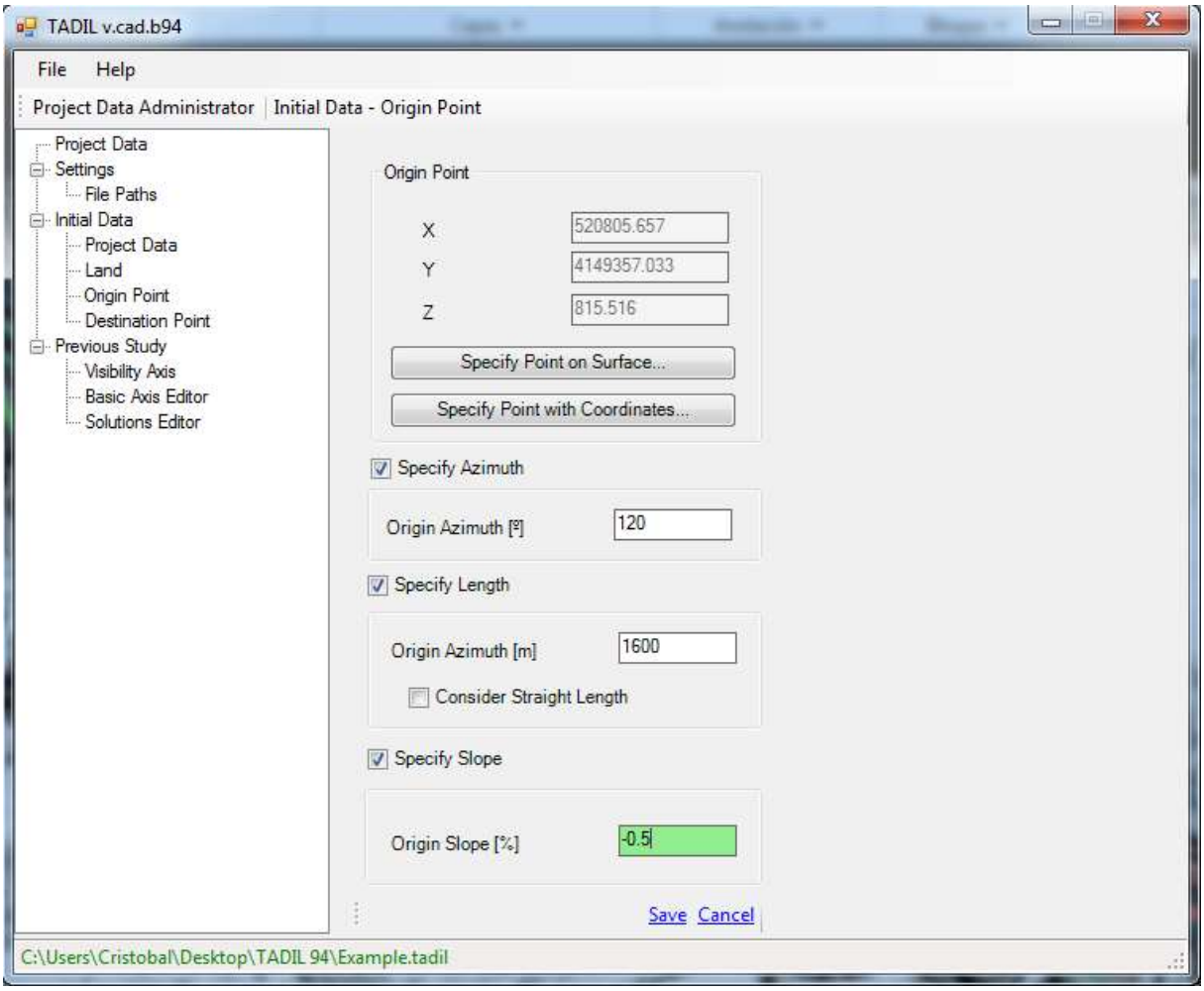


Image 12. Data for the origin point.

10.1.3.4. Destination Point

We establish the destination point like we established the origin point. We establish the destination point near Pueblo Viejo's town centre, with an azimuth of destination of 300°, a length of destination of 1650 m and a slope of destination of -1 %.

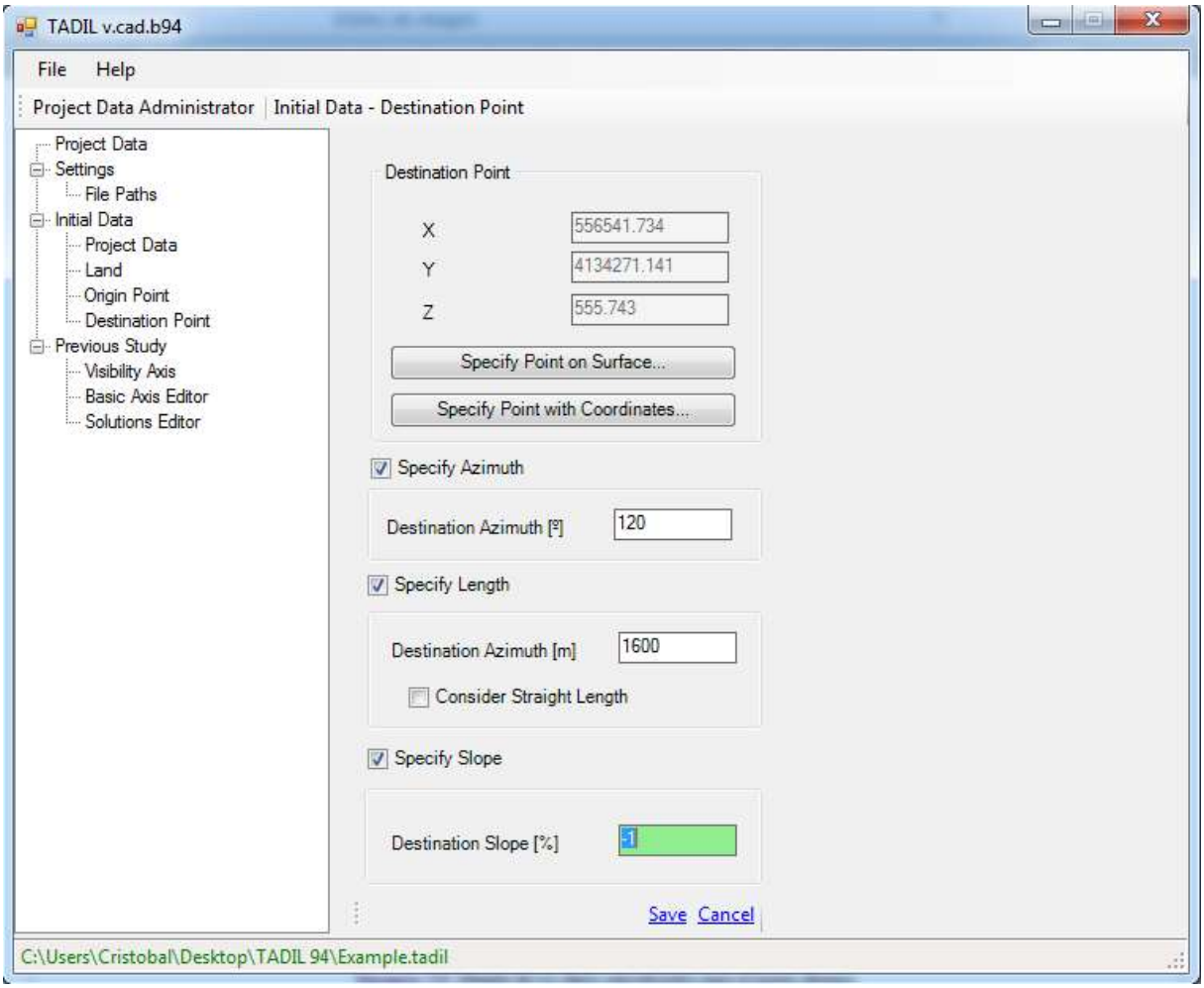


Image 13. Data for the destination point.

10.1.4. Previous study

10.1.4.1. Visibility axis

This allows creating a tracker polyline from the origin point to the destination point, which goes along the edge of the banned areas with the shortest possible length of the polyline, and defines, therefore, a tracker axis for the basic axis.

We can create the visibility axis in three ways:

- **Create the automatic visibility axis**

With this option, TADIL will calculate automatically the optimum visibility axis for our project, avoiding banned areas. In the event there is no banned area at all between the origin point and the destination point, the automatic visibility axis will be the straight line that joins them.

- **Select the visibility axis**

For this option, we need to have previously drawn a polyline in AutoCAD. The origin point and the destination point previously determined must be the same than the start and end of the polyline. Therefore, if we want to select a visibility axis from a polyline created by the user, we should mark the exact origin and destination point on the cartography so that we can draw the polyline afterwards.

For our example, we have selected a visibility axis previously created because, since it is a previous study, we have not enough data as to obtain great differences between alternatives of TADIL. The visibility axis was created close to several intermediate towns between Villa Ana and Pueblo Viejo.

- **Visibility axis created with corridors**

Nowadays, in a previous study, pre-analysing all the geographical corridors that could go towards our destination is a must.

From the middle point of the line joining the origin point with the destination point, and perpendicular to this one, TADIL will create points to a half way between them which the user had selected. These points join with the origin and destination point and create the corridors. The corridors crossing a banned area will be automatically dismissed.

For our example, we have selected a visibility axis previously created because, since it is a previous study, we have not enough data as to obtain great differences between alternatives of TADIL. The visibility axis was created close to several intermediate towns between Villa Ana and Pueblo Viejo.

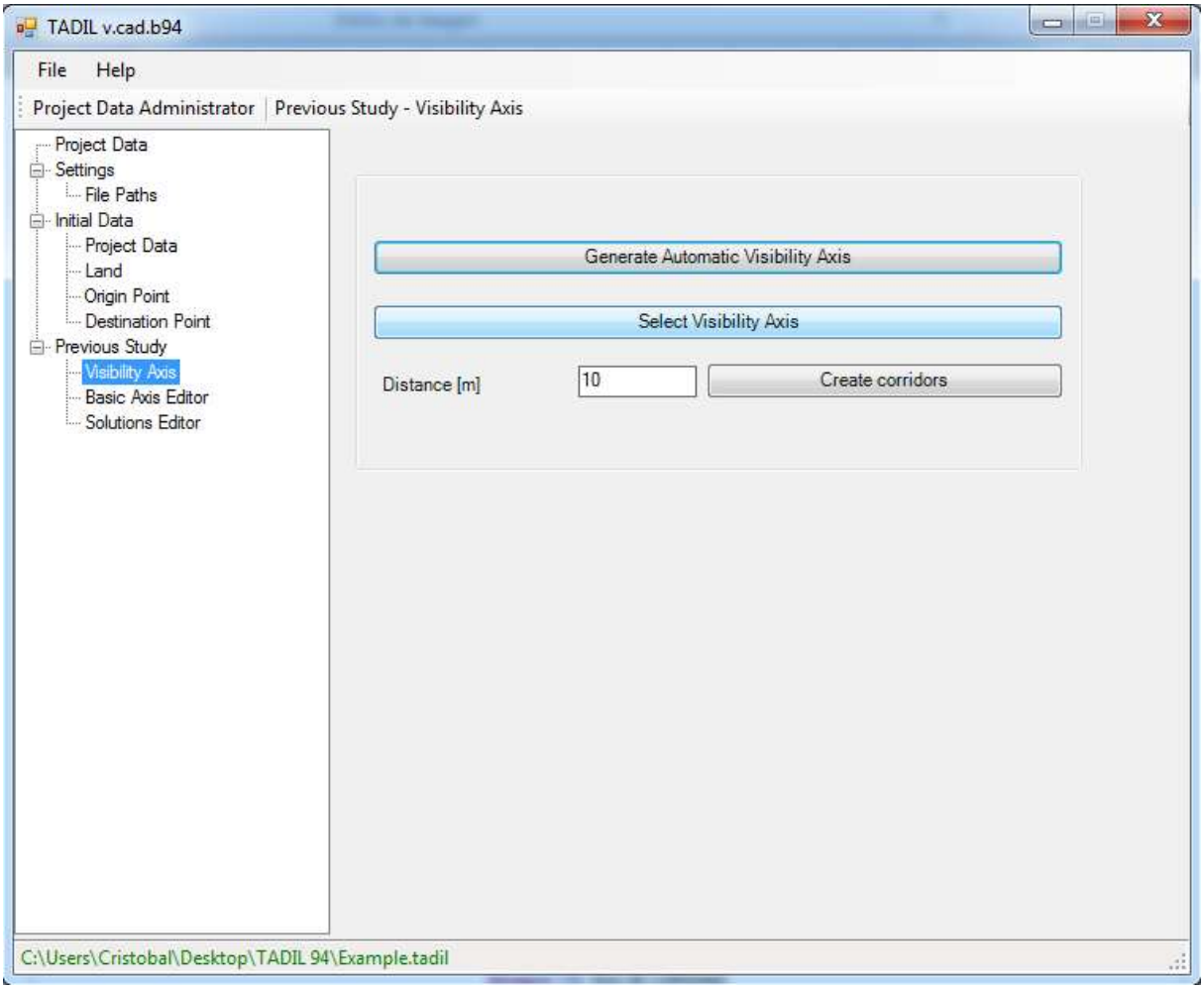


Image 14. Visibility axis.

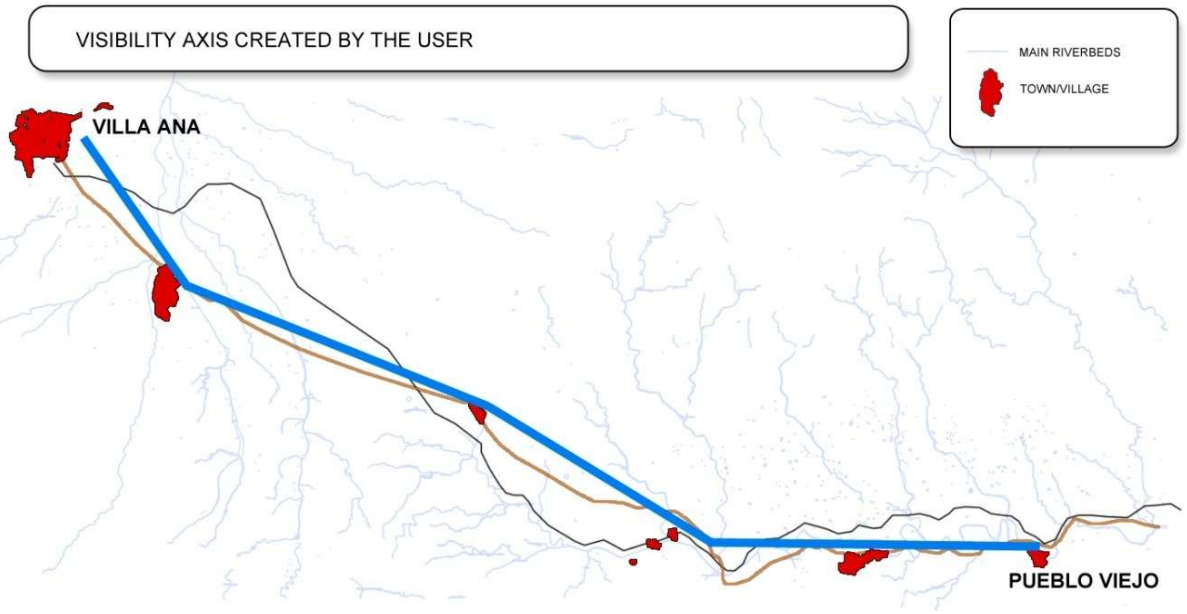


Image 15. Visibility axis created by the user.

10.1.4.2. Basic axis editor

The basic axis is a polyline which constitutes the skeleton of our design and has a geometry able to be turned into a conventional axis of design.

- **Road**

In this menu, the first thing to do is to select a road. We can select it by pushing the button and choosing the road in the sub-menu. For our design, we choose a road from group 1 with a speed of 120 km/h. Once we have selected the road, we automatically define the geometrical determining factors, according to the regulation previously loaded.

As for the design variables, we have to choose, according to our preferences, between rectilinear or curved alignments. The main differences between both studies are as follows:

- if we choose rectilinear alignments, we will look for inserting straight sections as long as possible according to the regulations and linked by sequences of symmetrical clothoid-curve-clothoid. When there are orientation changes, we will insert straight sections between the clothoids.
- if we choose curved S-alignments, we will insert S-clothoids with no straight intermediate sections when there are orientation changes. The curves will involve a greater development (the percentage of design in curve and clothoid is usually greater).

We can allow isolated speed reductions. These will make more versatile the search for itineraries with complex orography, where we should reduce the speed at some point in order to make the calculation of alternatives easier.

The planners are also free to choose between the minimum and desirable Kv for their design.

Once we know the available variables for this menu, in our example, we select straight sections, with not isolated speed reductions and minimum Kv.

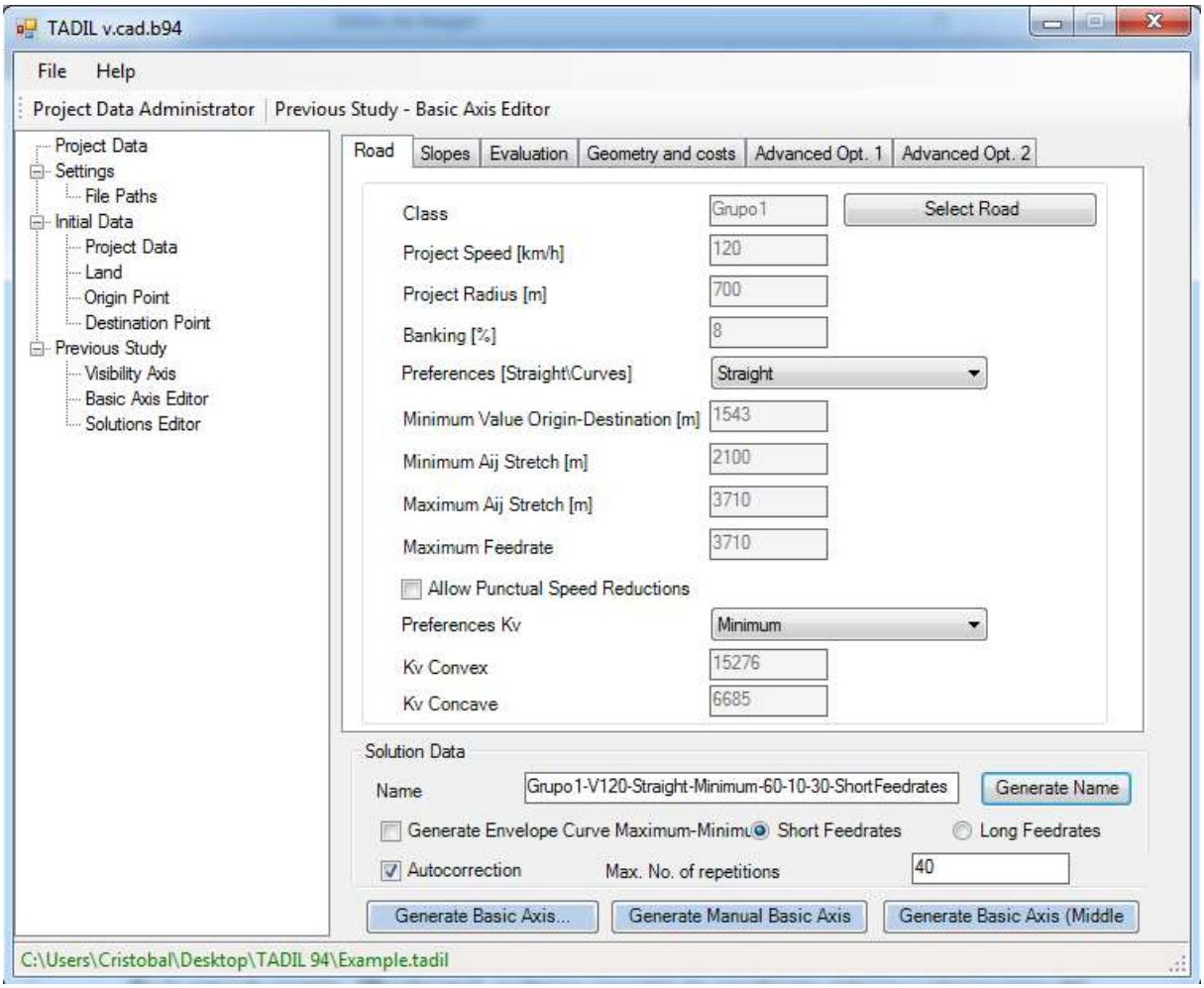


Image 16. Selecting the road.

- **Slopes**

In the second tab "Slopes", we can specify the maximum and minimum slope both for the design in general and for the structures and tunnels to be implemented. TADIL comes by default with some design values. For our example, we take these values but we will choose 7% maximum slopes for land works and 5% for structures.

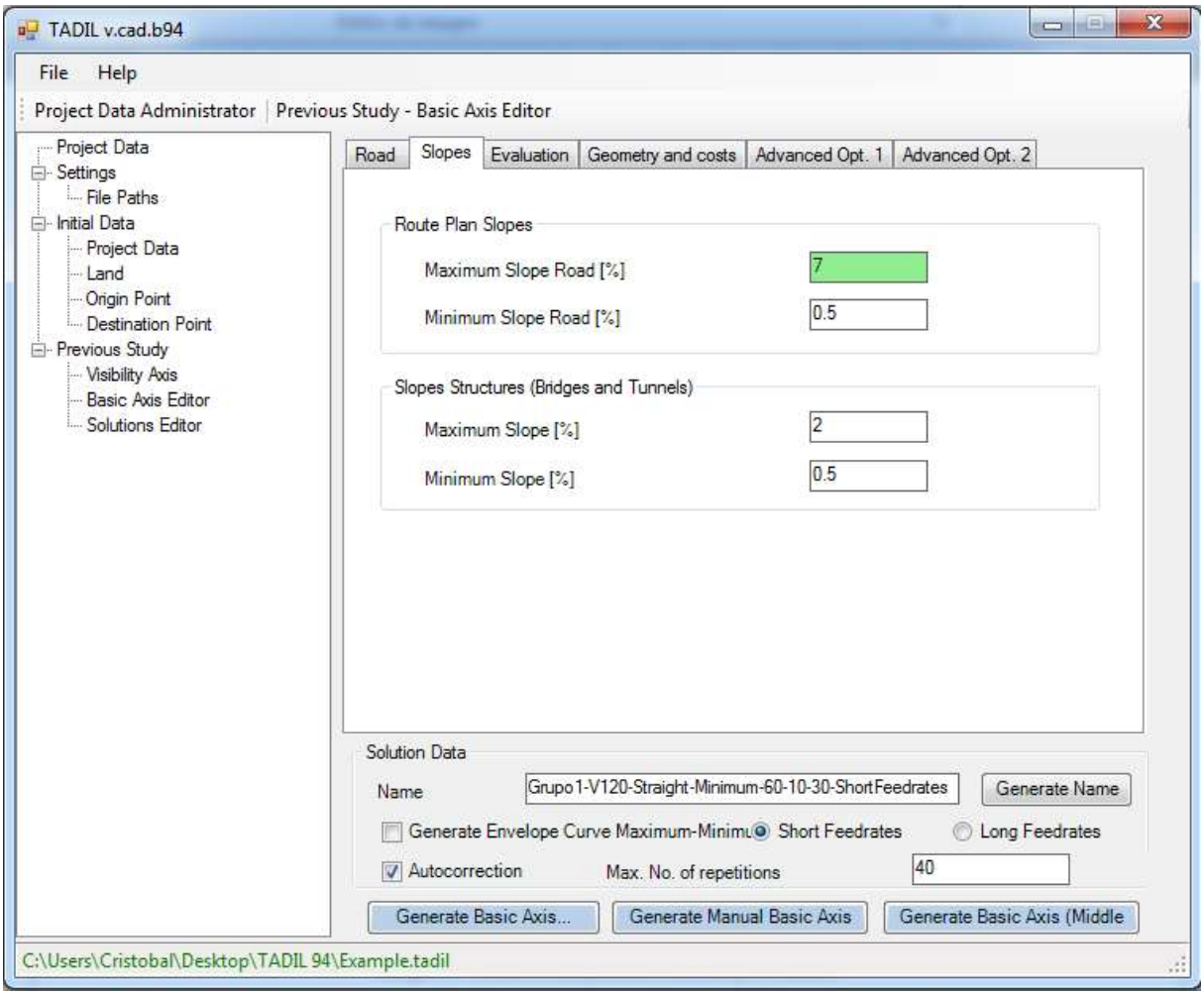


Image 17. Slopes defined by the user.

- **Evaluation**

In this section we specify our preferences of design, which will depend on the weighting values given to each essential variable: distance, orography and total cost. The addition of weighting percentages will be always 100%.

If we considered only the global cost as 100%, we would surely obtain a road of less volume of excavation. However, the road would be less direct than introducing an evaluation percentage regarding its proximity. In this case, the arrival to destination would not be the target, so the calculation would not be successful: TADIL would go into an endless loop, selecting always the cheapest itineraries.

If we considered only the proximity to the destination point as 100%, we would surely obtain a very direct design but more expensive to build. If we want to guarantee a successful calculation with TADIL, we should consider the percentages of the distance variable to be higher than 50%. Nevertheless, for a very complex orography, we can make iterations by reducing the percentage of distance evaluation and raising the orography and the cost of implementation until we get a solution.

Finally, introducing the orography variable allows more flat designs. If we combine this variable with banned areas due to great slope, we will obtain more "friendly" implementation areas, which will lead to an easier construction.

Anyway, this variable should not be weighed up more than 30% and values between 10% and 20% are suitable for obtaining quality design.

Modifying the percentages of the aforementioned variables, according to several hypothesis, we would obtain multiple alternatives too, improving the level and depth of the study.

TADIL offers some guiding values for these variables, which we use for our example.

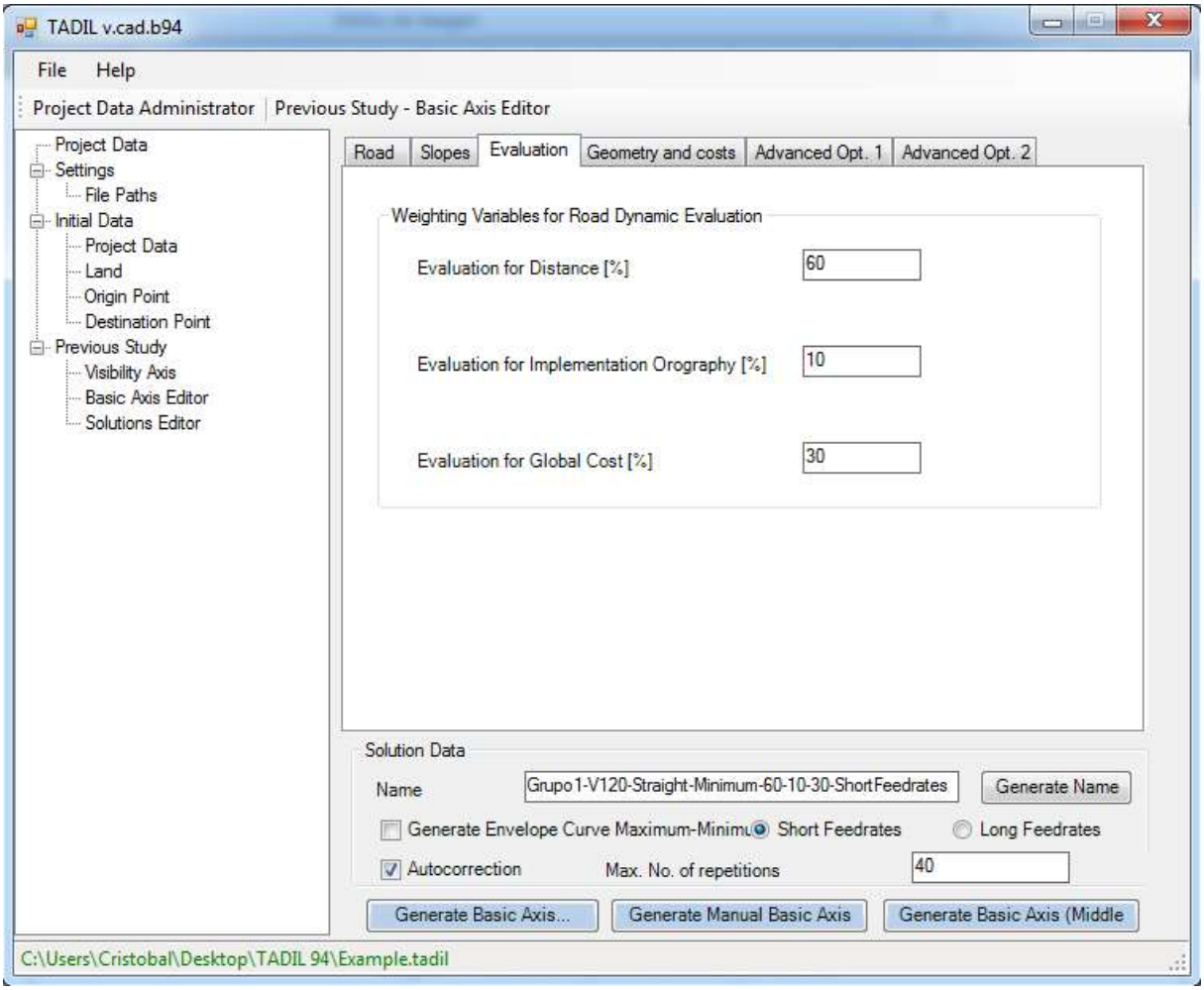


Image 18. Detail of given evaluations.

- **Geometries and costs**

This sections aims to specify data regarding road geometry and costs.

So, we must indicate the maximum height of cut section and embankment. The measures must be made over the route plan, the cut section slopes and embankment, and the platform width.

The most interesting thing in this section is the possibility of designing a road with/out structures and/or tunnels. By selecting the option "Generate bridges and viaducts", we can specify the maximum pier height for our project.

The cost of implementation is the guiding cost of our building work when executing the platform.

The cost of cut section includes the price of material from cut section (material to be used in work) and the price of material to landfill (material not to be used in works and to send to landfill). An average value between both costs is given.

We also establish the embankment cost by giving an average value between both the price of material from cut section (material from the work to be used in the same work) and materials from borrow pits (material not existing in the workplace due to its features and bought from near quarries).

The cost of bridges and viaducts is given by m^2 finished structure (deck). However, the tunnel cost is expressed in length of finished tunnel, in this case, in kilometres.

For our example, we leave the default data allowing the insertion of structures.

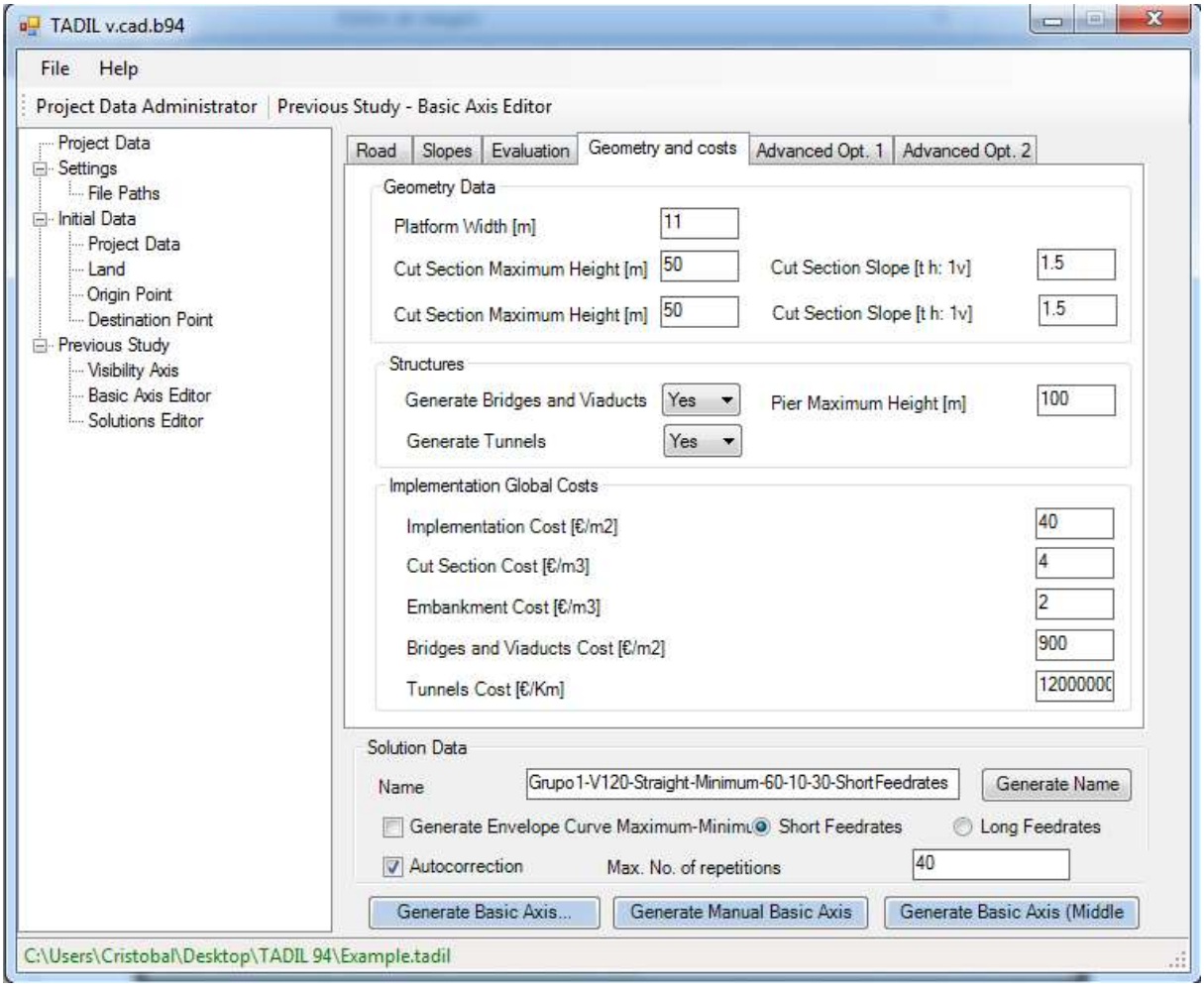


Image 19. Data from "Geometry and Costs".

- **Advanced options 1**

The dynamic evaluation of roads has to be with the data that the algorithm uses. These data are used for searching road itineraries. We recommend not modifying the default data.

Not using stretches with more length increases than indicated by the user is an option that allows segments of road to have harmonious lengths, so limiting specially the length increase of a straight alignment with regard to the preceding one.

Considering constant Aij requires every feedrate of the basic axis to have the same length. For calculating our informative study, we do not tick the box of constant Aij.

Tolerance towards the target point, we recommend using a percentage higher than 50%, since this percentage allows less winding and more direct roads. With this option we can bring forward the target points of the visibility axis.

The total angle is the projection angle of design options in the local search algorithm.

Degrees discretization has to be with the division of pre-polylines in the algorithm of local search.

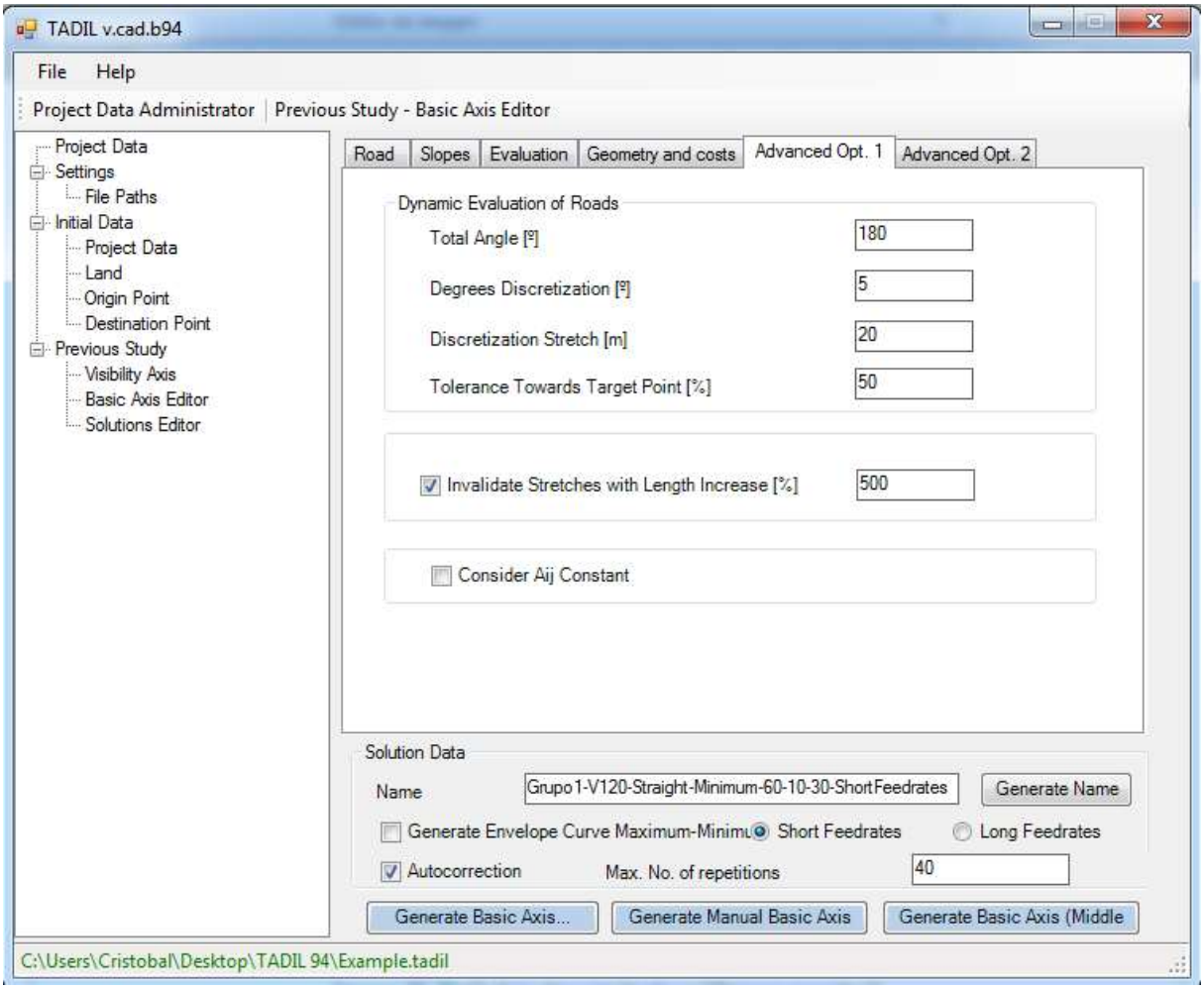


Image 20. Data from "Advanced options 1".

- **Advanced options 2**

We define coefficients of reduction. By modifying these coefficients we can obtain a wide and assorted range of alternatives. To obtain safer calculations, we must reduce the design slopes and structures as well as the maximum heights of cut sections, embankments and viaduct pier.

It must be highlighted that if we measure height of cut sections and embankments over the road axis, we may have a higher slope. So, just with the coefficient of reduction we would largely overcome this "excessive height".

We leave default values and continue with the calculation of the previous study.

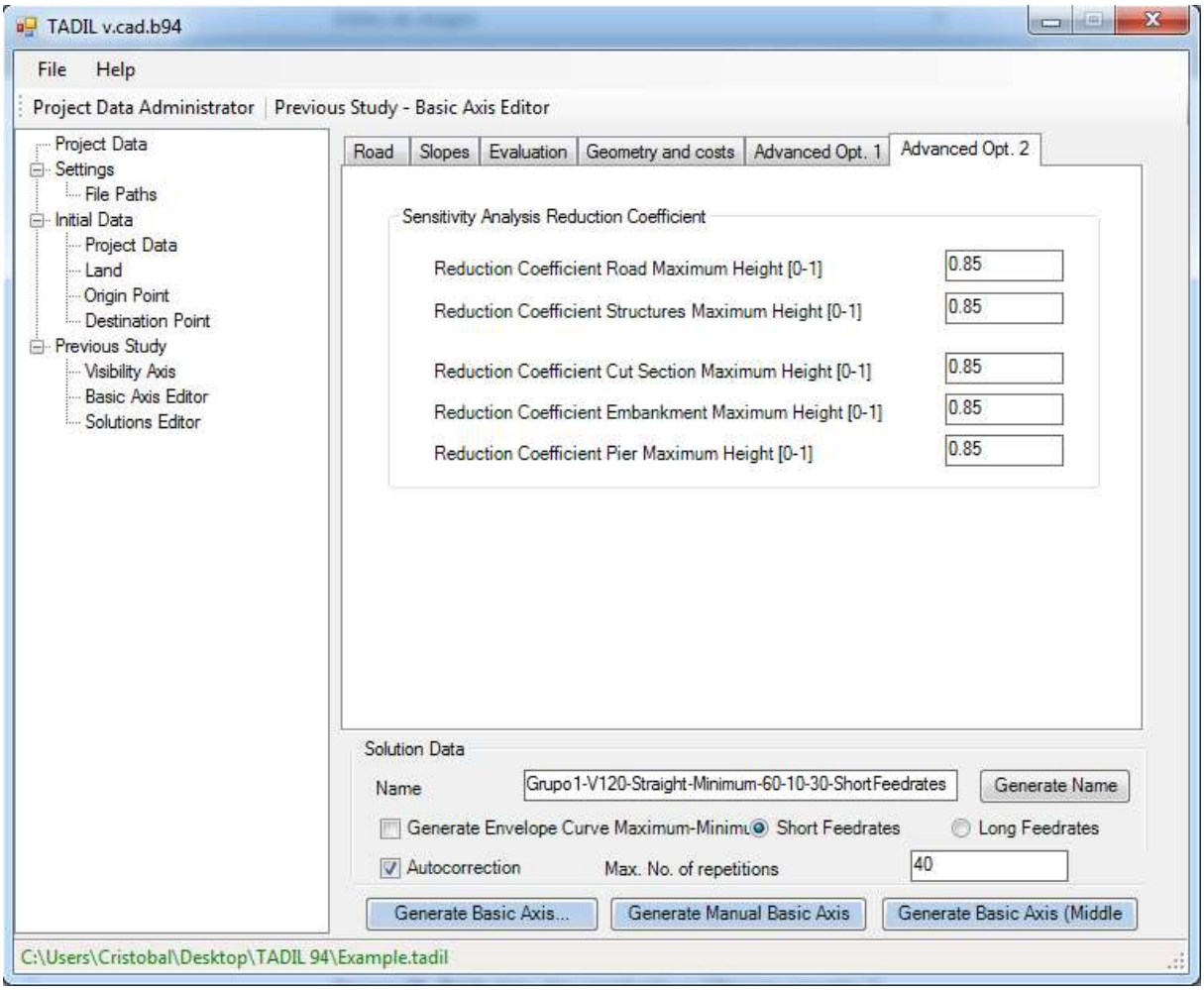


Image 21. Data from "Advanced options 2".

- **Solution data**

The first value we can define for this solution is its name. The name can be generated personally by the user or we can make TADIL generate one by clicking "Generate name". TADIL generated a name for each solution and indicated the class of road, the speed, the preference for straight or curves design, the preference for Kv, the evaluation given to distance, orography and infrastructure cost as well as the preference for short or long feedrates. For our example, we make TADIL generate the name.

By using short feedrates we obtain alignments better adaptable to land whose length is according to the considered regulation.

Instead, by using long feedrates we obtain simpler alignments with the maximum length established by regulation. For speeds from 80 km/h on, it makes no sense to include long federates since regulation does not allow making alignments that long.

For both feedrates, once the alternative is calculated, we can obtain sub-variables (minimum and maximum envelope curves).

In both sub-variables we obtain the points of envelope curves from the original alternative's basic axis. The sub-variable of the maximum envelope curve is obtained by directing the itineraries towards these maximum points. Likewise, the minimum envelope curve is obtained by directing them towards the minimum points.

By using these procedures (short and long feedrates) and by obtaining the envelope curves (maximum and minimum), we can obtain three sub-variables per original alternative.

To avoid the problem of self-closing, when in a point of feedrate, every visual of the fan are infeasible (very steep areas, with escarpment in the limit of an area of low slope or plain areas where the feasibility of the elevated link to the final alignment is not taken into account, etc.), we have the option to auto-correct the basic tracker polyline. That is, if in a fan, every visual is infeasible, TADIL will consider that area as a banned area, mark it and calculate again the visibility axis and, therefore, the basic axis. TADIL will auto-correct as many times as number of repetitions entered in the menu by the user.

If we do not want auto-corrections, we just need to indicate 0 in the maximum number of corrections. At this point, we need to highlight that it could be areas where a solution is physically impossible with the data entered. So, if the number of auto-corrections is high, TADIL could take long in calculating. If the user decides not to enter the data for that route and instead, stop the process, just push "Escape" on the keyboard.

Auto-correction is designed only to create the basic axis automatically; therefore the user has to unselect "Auto-correction" for generating a basic axis manually or to the middle point.

There are three possibilities to create the basic axis:

- Create Basic Axis: From the origin point to the destination point and in the direction of the visibility axis, TADIL selects the alignments for the basic axis.
- Create Basic Axis manually: From the origin point to the destination point and in the direction of the visibility axis, the user selects the alignment of each stretch until completing the basic axis.
- Create basic axis (middle point): One way to optimize the creation of basic axis is to make the basic axis itself and the visibility axis coincide. Then, we have two "origin point" following the primary visibility axis within the first alignments to make sure a proper start, from there each alignment goes in the direction of the destination point of the alignment in the opposite side. When both are less than 2*Amin close, possible connecting itineraries made up of two alignments are calculated. The basic axis to middle point is designed to improve the adaptation of land. Therefore, it can be only used with short feedrates, it is not available for long feedrates.

For our previous study, we choose short feedrates and we make TADIL generate maximum and minimum envelope curves.

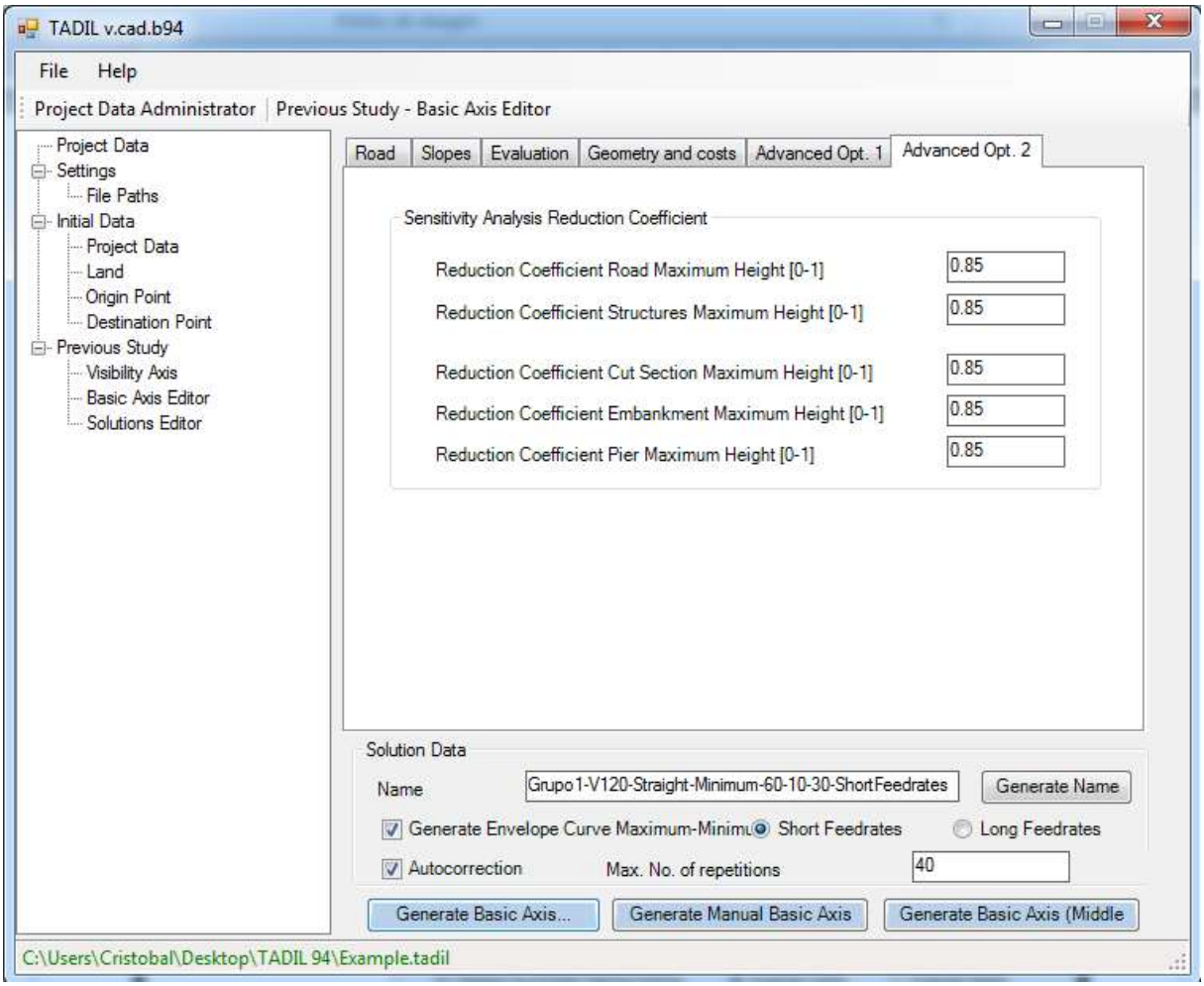


Image 22. Data from "Solution Data".

Finally, after entering these values, we can generate the basic axis by clicking on the button of the same name. As we have made TADIL generate both maximum and minimum envelope curves, we obtain three solutions.

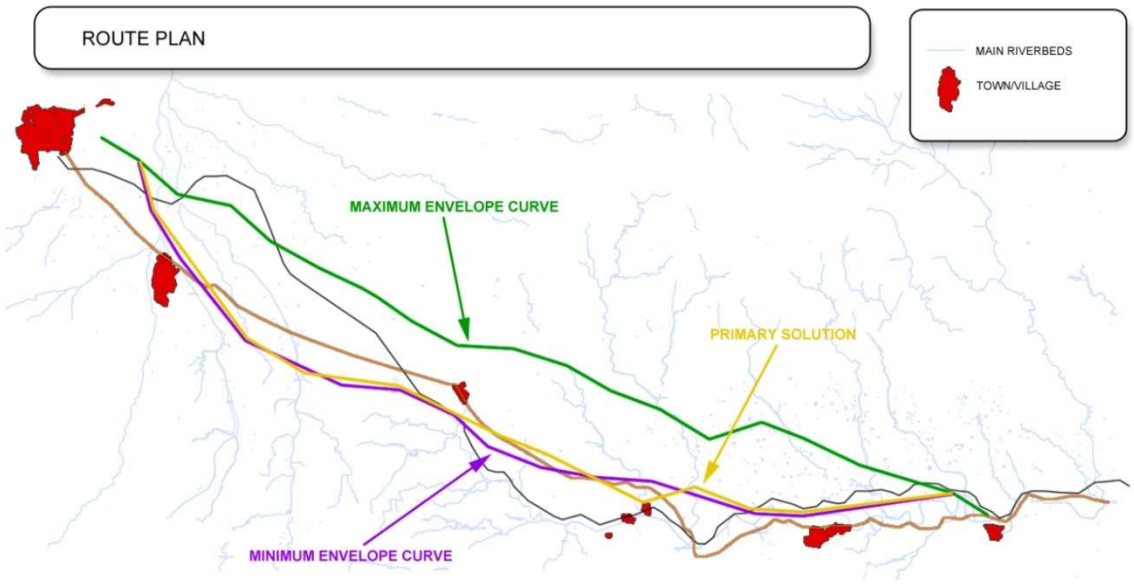


Image 23. Route plan.

10.1.4.3. Solutions editor

In this tab we can see the solutions that TADIL has generated for our example.

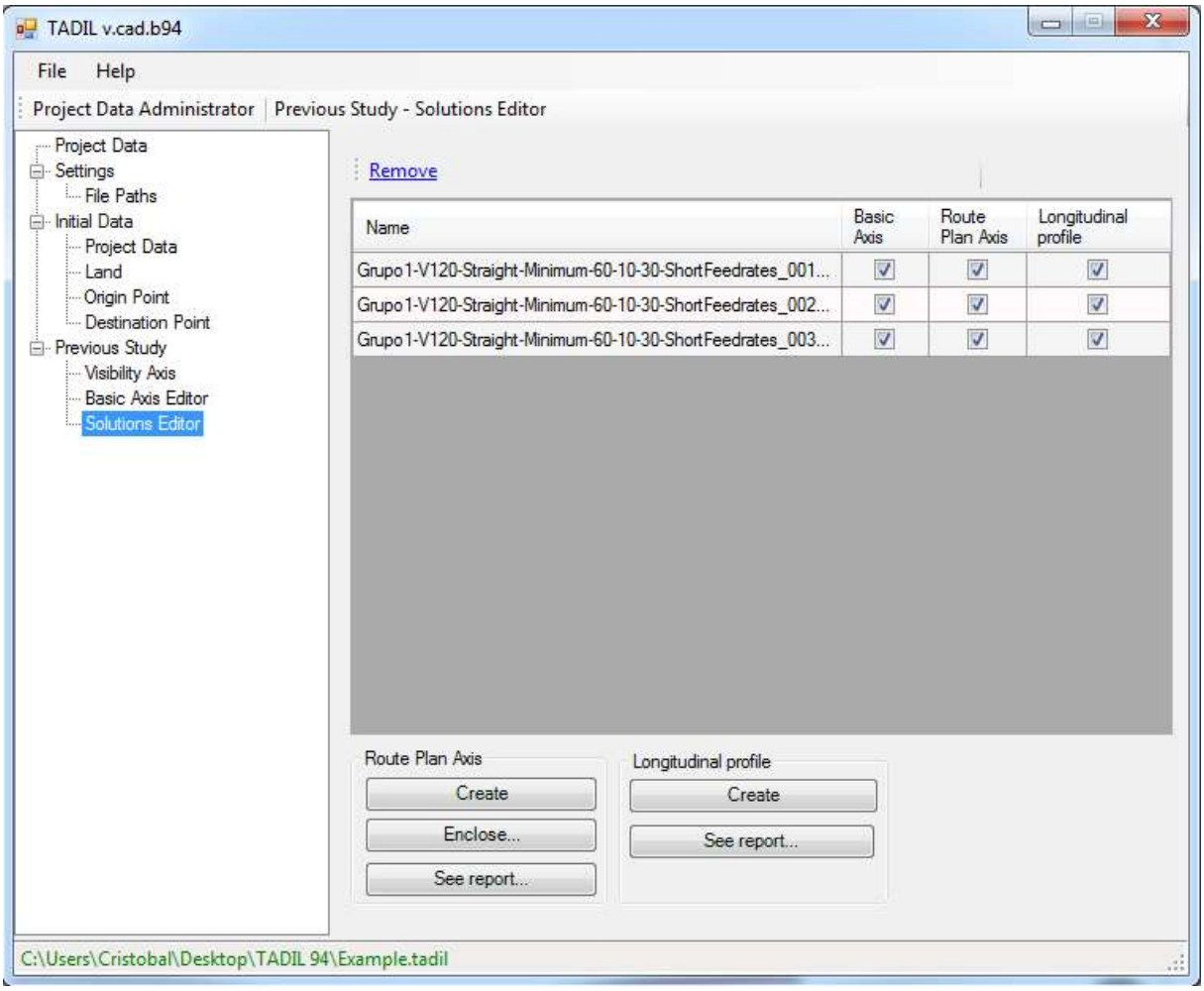


Image 24. "Solutions Editor".

This solution matches the first solution TADIL had calculated previously. The second solution is the maximum envelope curve and the third one is the minimum envelope curve.

- **Route plan axis**

The route plan axis is a conventional axis including straight sections, curves and track transition curves - clothoids.

If we click on one of the solutions and we push the button "Route plan axis", TADIL draws the route axis of the aforesaid solution. Therefore, for our example, we select the route plan axis of the first solution.

Once the route plan axis is drawn, we can enclose it so that the pk will be in different colours. We see the straight alignments are in red, the track transition curves (clothoids) are in green and the circular curves are in yellow.

TADIL offers the possibility to create and see the route axis report where we can see its geometric characteristics.

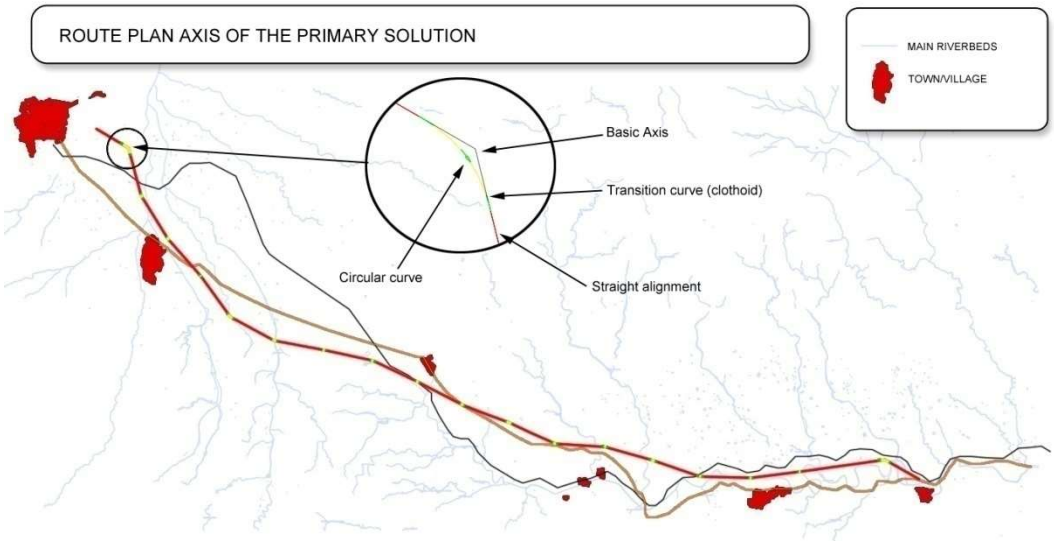


Image 25. Route plan axis of the primary solution.

- **Longitudinal profile**

The longitudinal profile supposes defining the grade line of the plan axis obtained.

We create the longitudinal profile as we have created the the route plan axis. For our example, once selected the first solution, we click "Longitudinal Profile". Then, TADIL ask us to insert a point. We click on any point of the .dwg and we draw the longitudinal profile.

In this solution we can see three lines. The grade line is in yellow, the land profile is in white and the basic axis is in red.

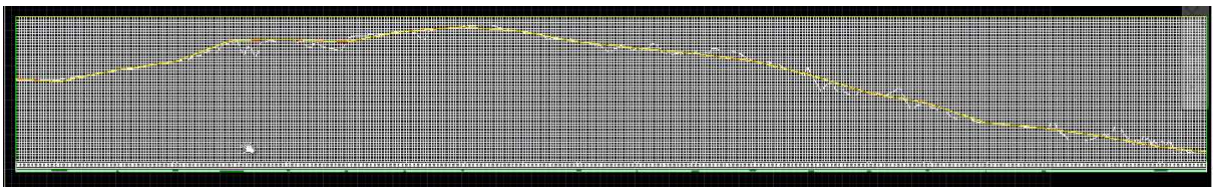


Image 26. Longitudinal profile of the first solution.

Likewise, TADIL offers the possibility to create and see the longitudinal profile report where we can see the geometric characteristics of the alignments.

These reports can be exported as spreadsheets.

Once we know how TADIL works, we obtain the following three solutions of our example.

- Route plan

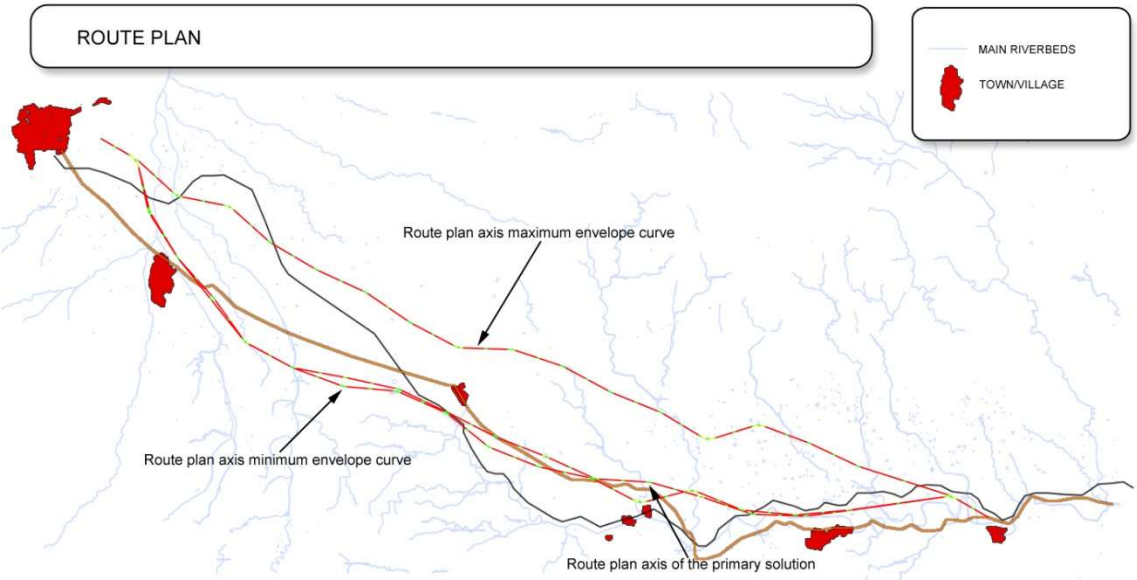


Image 27. Route axis plan of the three solutions.

- Longitudinal profile of the maximum envelope curve

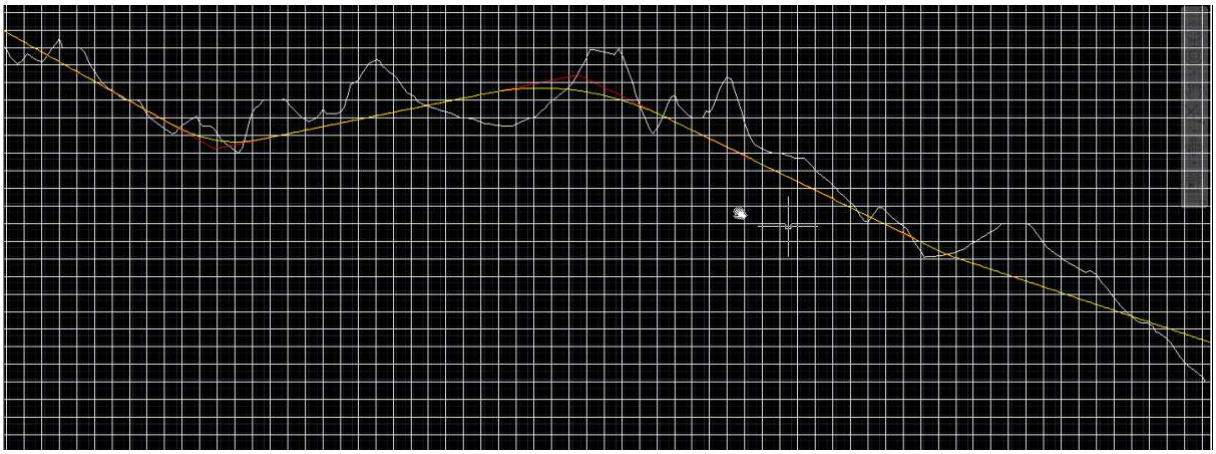


Image 28. Longitudinal profile of the maximum envelope curve.

- Longitudinal profile of the minimum envelope curve

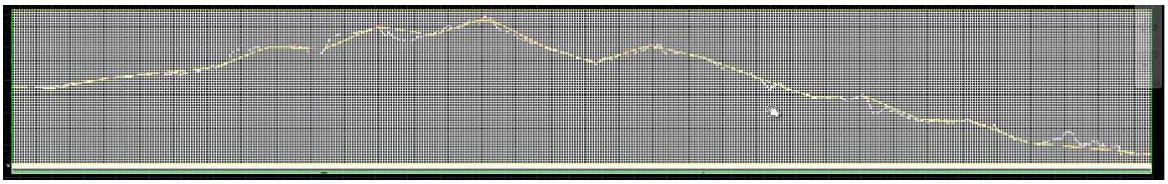


Image 29. Longitudinal profile of the minimum envelope curve.

10.2. Adding more alternatives to the previous study

To give variety to the previous study, we add three more alternatives to those we obtained in the previous section, one solution given by the automatic visibility axis, one with long federates and its two envelopes.

These three alternatives start from the same origin and destination points as defined in the previous section. Moreover, the previous conditions remain.

10.2.1. Example with the automatic visibility axis and long feedrates

The difference between this variable with regard to those of the previous example has to be mainly with two aspects:

- **Automatic visibility axis**

In this case, we make TADIL calculate the visibility axis automatically.

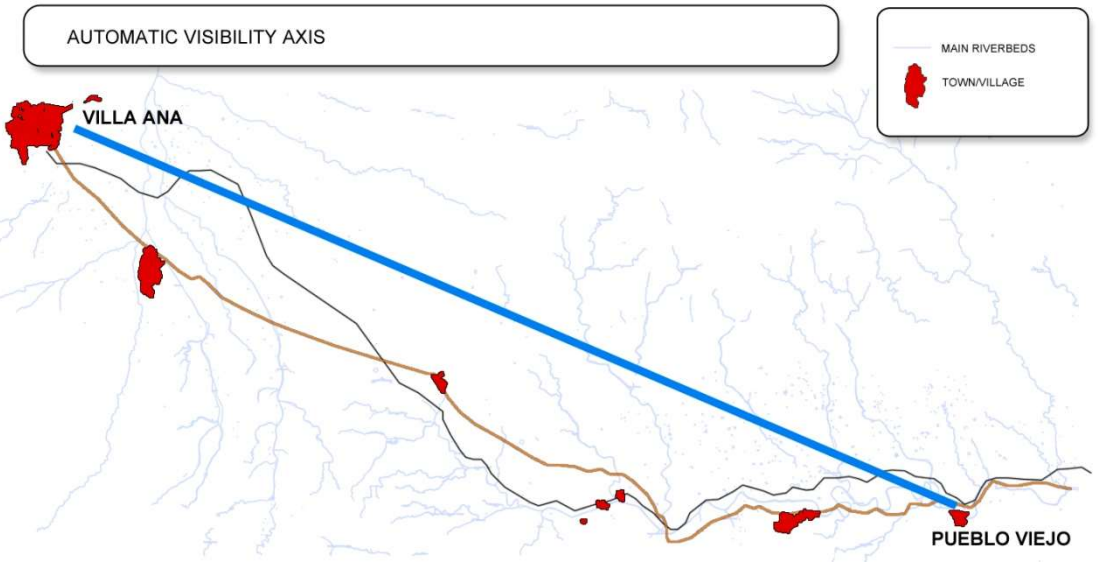


Image 30. Automatic visibility axis.

As there is not banned areas between the origin and the destination point, the automatic visibility axis is the straight line that joins them.

- **Long feedrates**

Unlike the previous example, now we choose long feedrates for the design. We obtain simpler alignments with the maximum length established by regulation. The long federates project with lengths multiple of $A_{mín}$ and they have always the maximum value of rate $A_{máx}$. This value $A_{máx}$ depends directly on the project speed of the route, hence with speed $V_p = 80\ km/h$ it does not make sense to talk about long feedrates since value $A_{máx}$ is always

lower than $2 \cdot A_{mín}$ and the long feedrates will have $1 \cdot A_{mín}$ long (equal to short feedrates). Therefore, for this example we have chosen $V_p = 60\ km/h$.

For further information about long feedrates adjustments, please go to the Methodological Application Guide.

Once we have selected the box "Long feedrates", we click on "Generate name" and we click on "Generate basic axis".

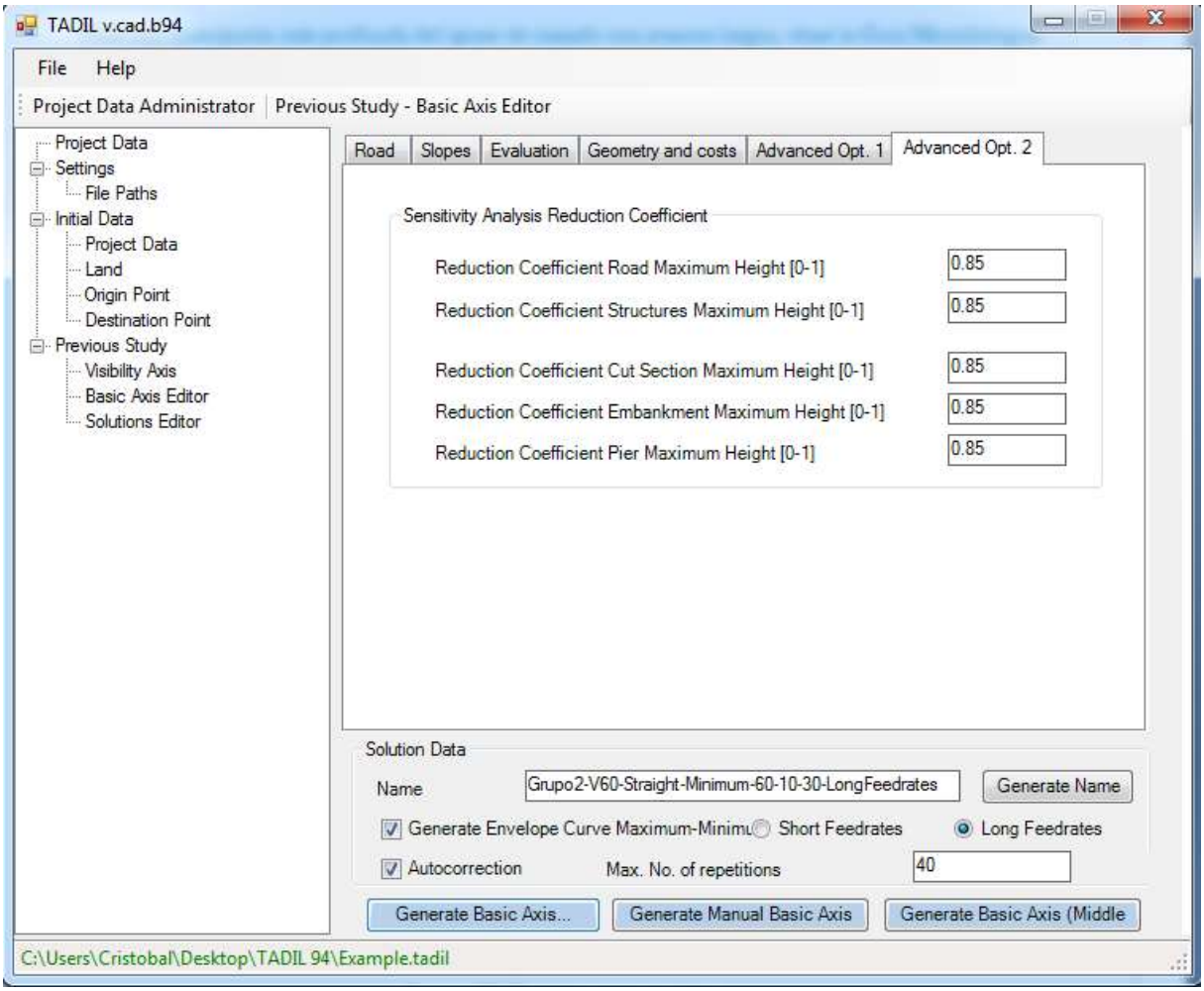


Image 31. Example with long feedrates.

- **Basic axis with long feedrates**

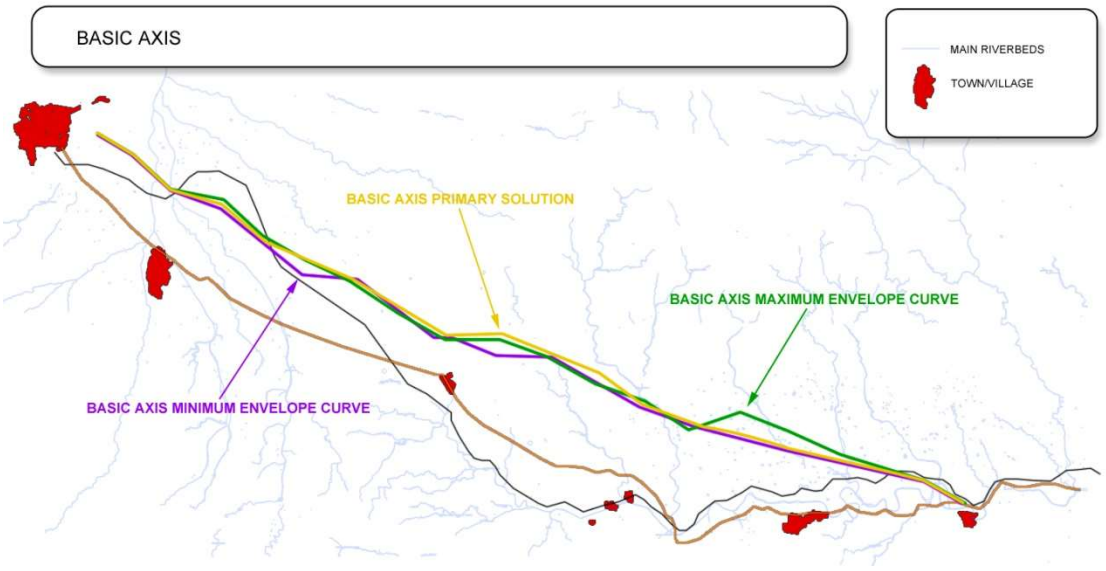


Image 32. Basic axis from the example with long federates.

- **Route plan**

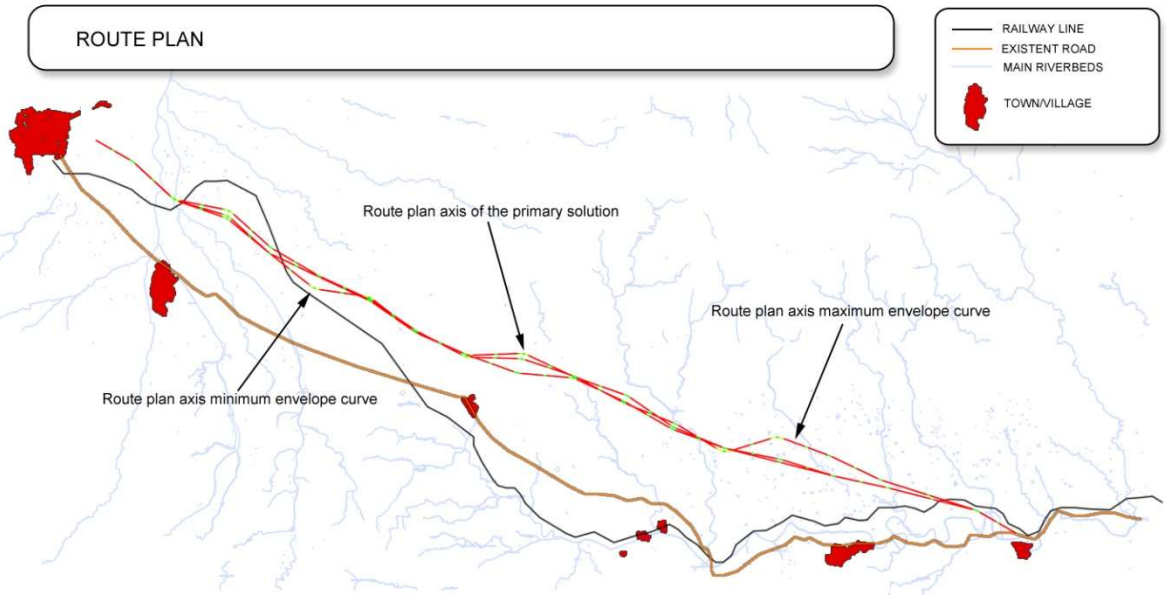


Image 33. Route plan axis from the example with long federates.

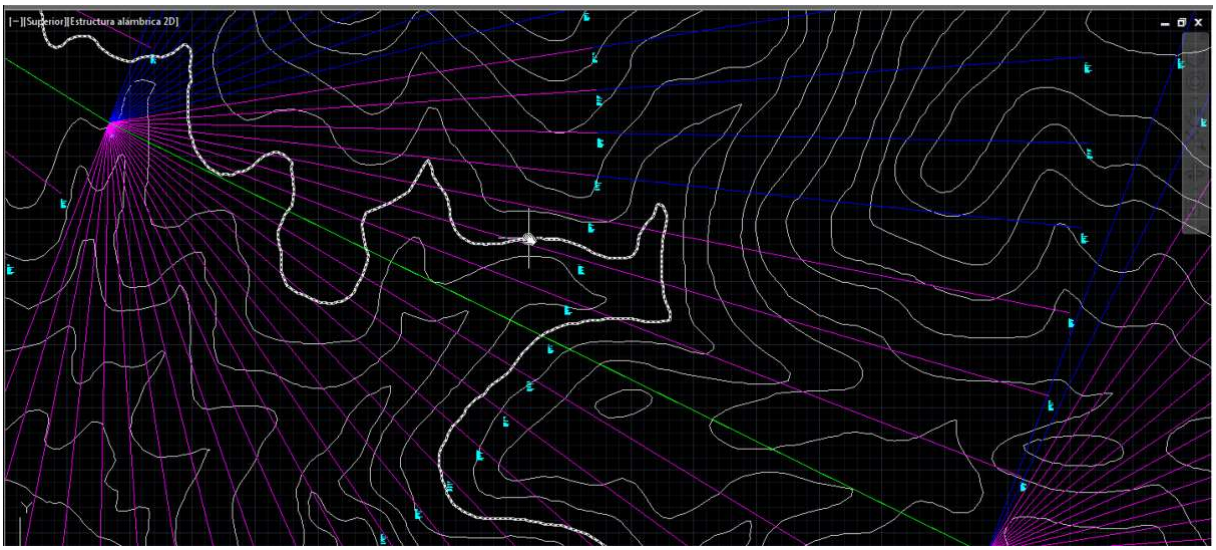


Image 34. Detail of long feedrate.

- **Longitudinal profile**

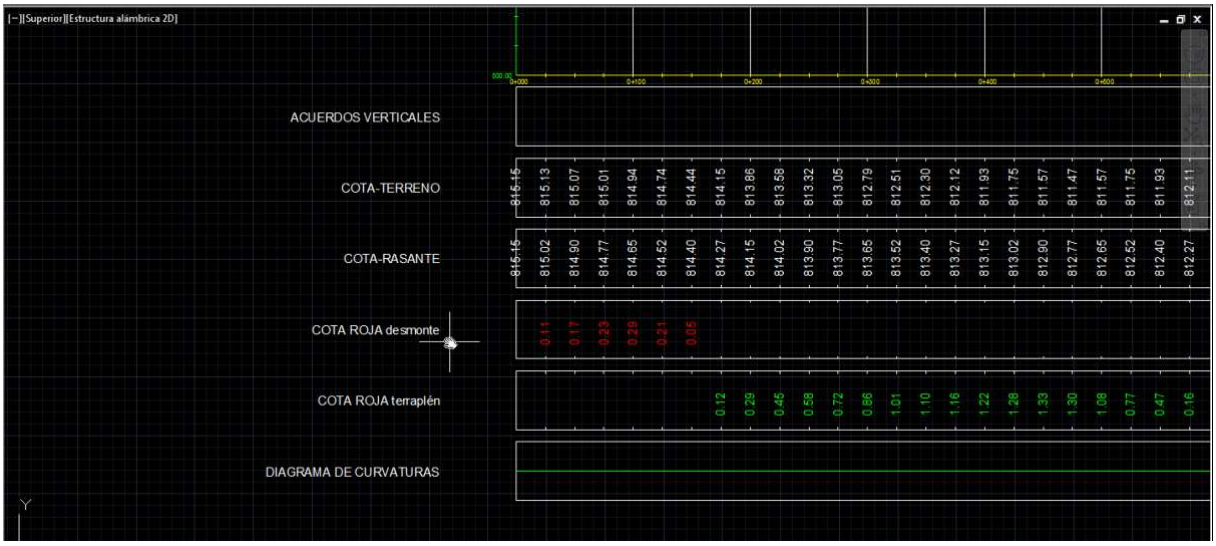


Image 35. Detail of longitudinal profile values calculated for the primary axis of the example with long feedrates.

10.2.2. Example of visibility axis with corridors and curves preference

We will calculate an alternative without envelopes for each of the two selected corridors.

- **Visibility axis with corridors**

In this case, we make TADIL calculate the visibility axis with corridors.

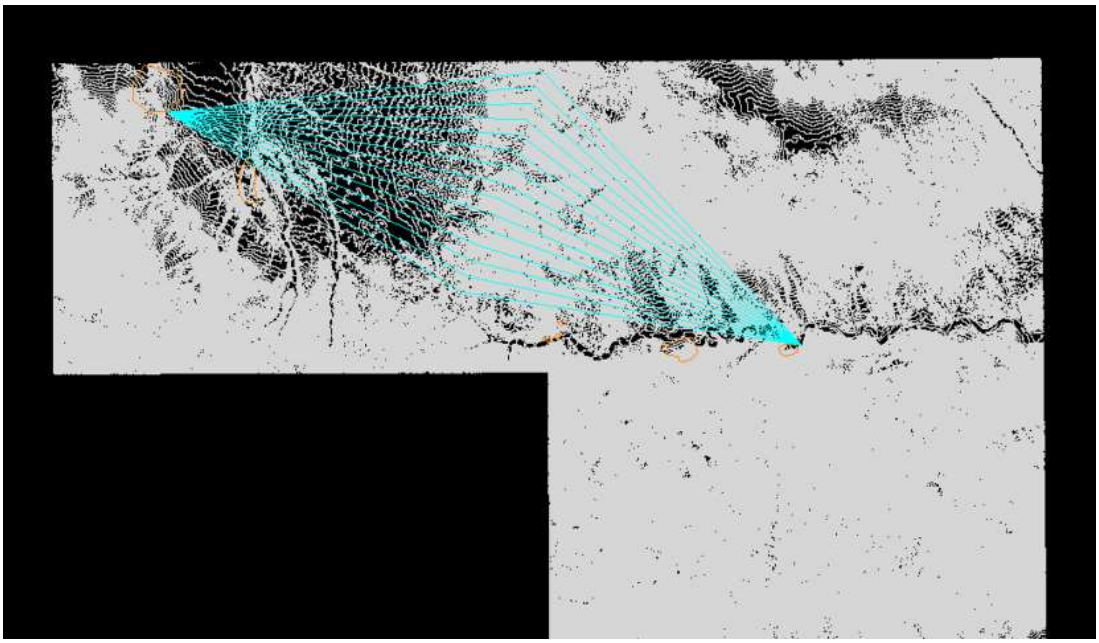


Image 36. Corridors created every 1000 m.

- **Curves preference**

Unlike the previous example, now we choose curves for the design. So, we will insert S-clothoids with no straight intermediate sections when there are orientation changes. Curves will be more developed.

Once we have selected the box "Curves", we click on "Generate name" and we click on "Generate basic axis)".

We select three visibility axis out of all we obtained with corridors, and we obtain three different solutions.

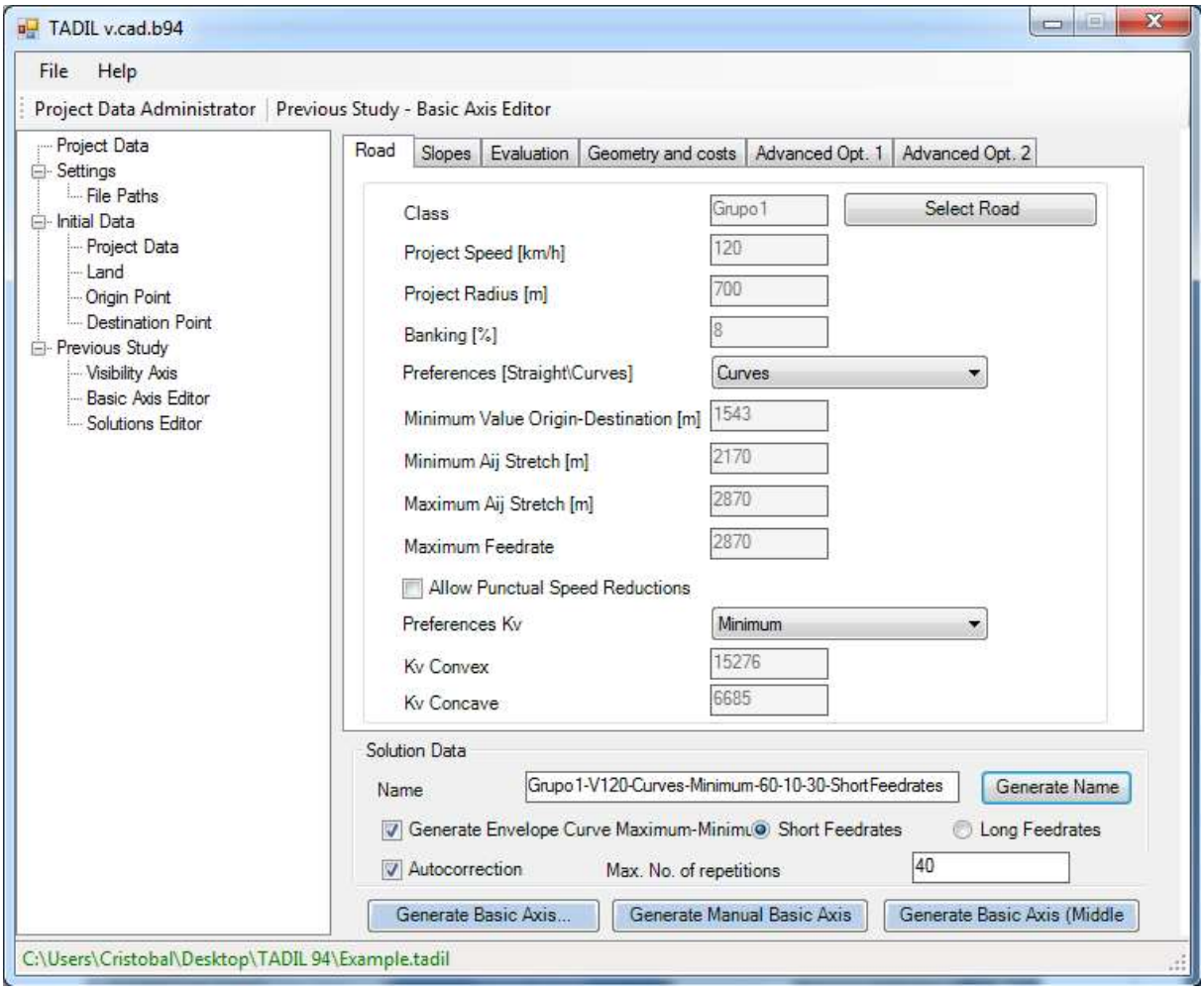


Image 37. Example curves preference.

- **Route Plan**

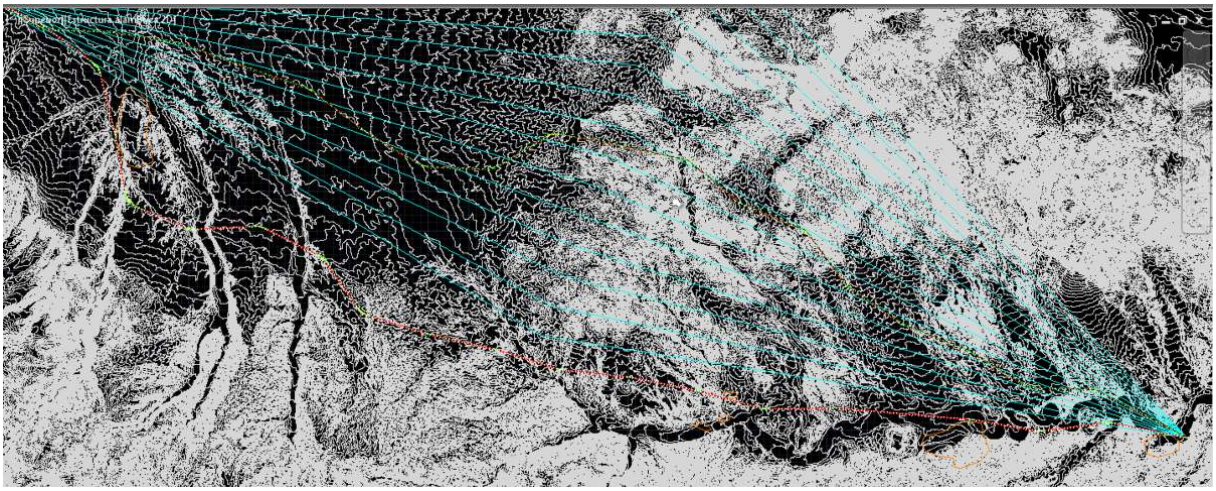


Image 38. Detail of the enclosed route plan axis.

- **Longitudinal Profile**

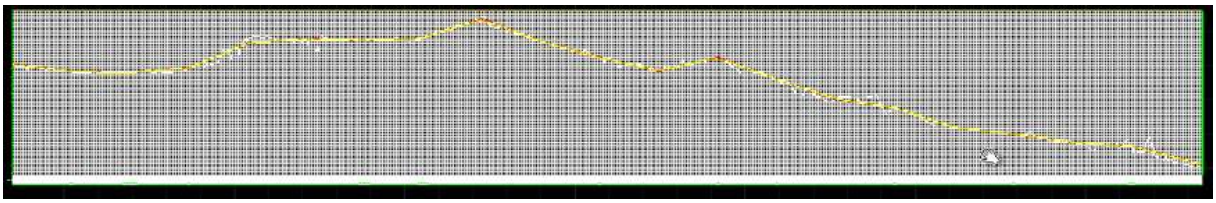


Image 39. Longitudinal profile of the first solution.

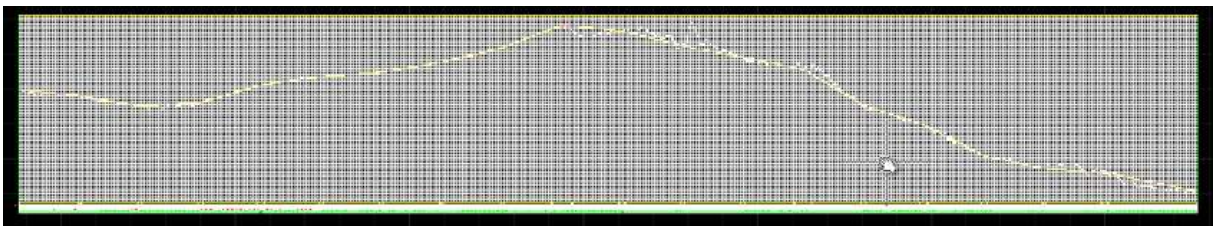


Image 40. Longitudinal profile of the second solution.

11. DEVELOPMENT OF AN INFORMATIVE STUDY

An informative study develops a complete study including all the land variables.

To better understand the informative study, we will solve the same case as in the previous study. We will carry out the informative study with widening of the road stretch Villa Ana – Pueblo Viejo.

11.1. Load the software

TADIL is a software that works inside the software AutoCAD. Therefore, first of all, we must open the cartography in (.dwg) format.

After that, we load TADIL. For doing that, we need to write "netload" in the Command Bar. Then, when the dialogue box "Select .NET Assembly" will open, we select the folder where TADIL is in our system, we select the folder "app" and the "acTadill.dll" opens.

11.2. Load data base (TDB)

To load the TDB menu, we just need to write "TDB" in the Command Bar of AutoCAD.

We must highlight that the same TDB serves to any work and cartography. So, we recommend entering many data and alternatives in the TDB and charging the required data specifically for each project. The TDB is also feeding when we make and edit different informative studies.

The TDB is divided into four big blocks: Construction units and prices, Geographic Information System, Macro prices and Sections.

11.2.1. Construction units and prices

In this first section we define the construction units we have and their prices. Entering data is almost the same in every construction unit. We specify how to enter these data next:

11.2.1.1. Units

- **Monetary unit**

We can define the monetary unit we want to use for measuring our informative study.

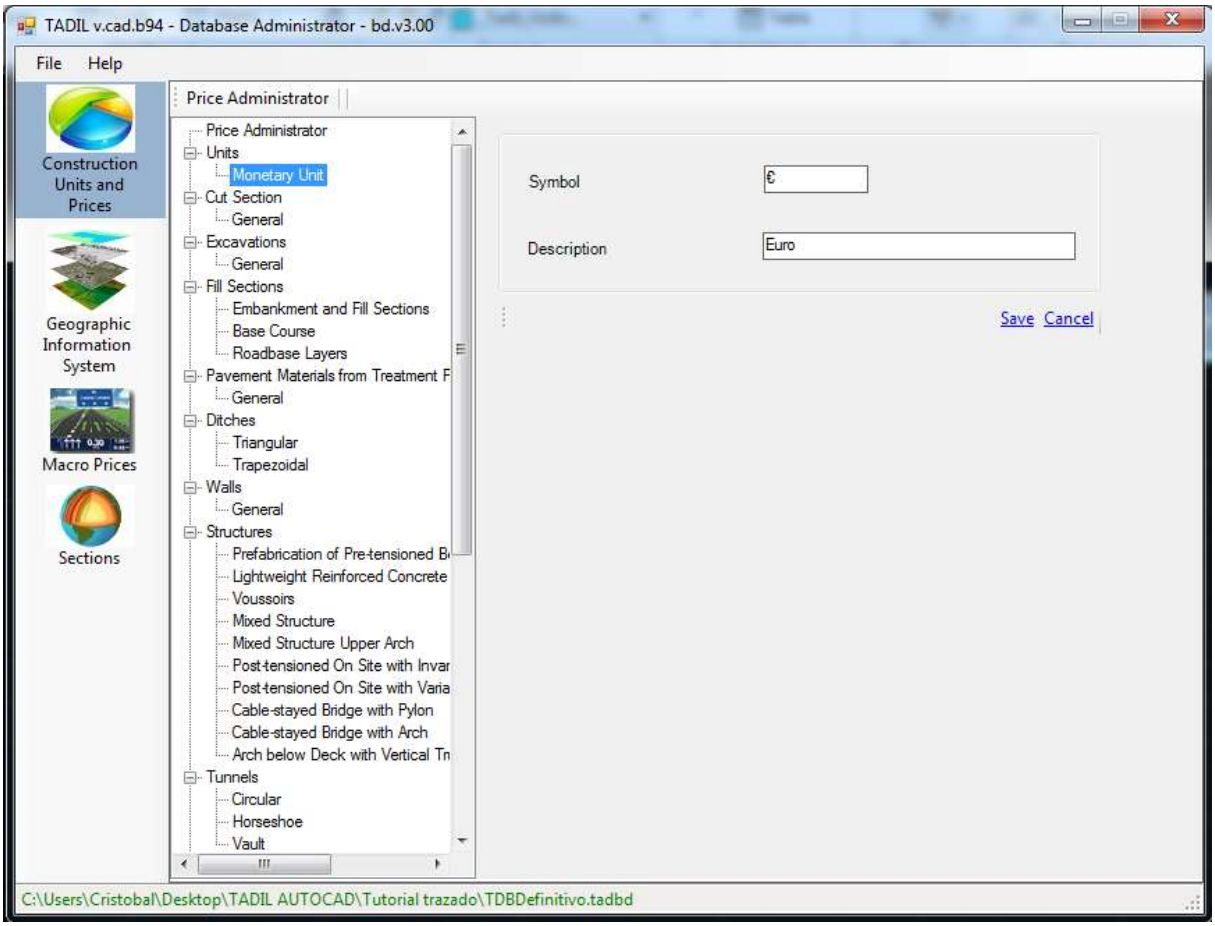


Image 41. Entering monetary unit data.

11.2.1.2. Cut sections

- **General**

The first box is the measurement units. We define the monetary unit before entering data into the TDB and this monetary unit remains like that the whole project. The measurement units are constant in each section and we can see which units are used for measuring each construction unit.

For creating a unit of cut section, click on "New", then we see the menu "Detail". We finish the construction unit by filling the gap and clicking "Save". Once created, construction units can be edited and removed by selecting "Edit" and "Remove".

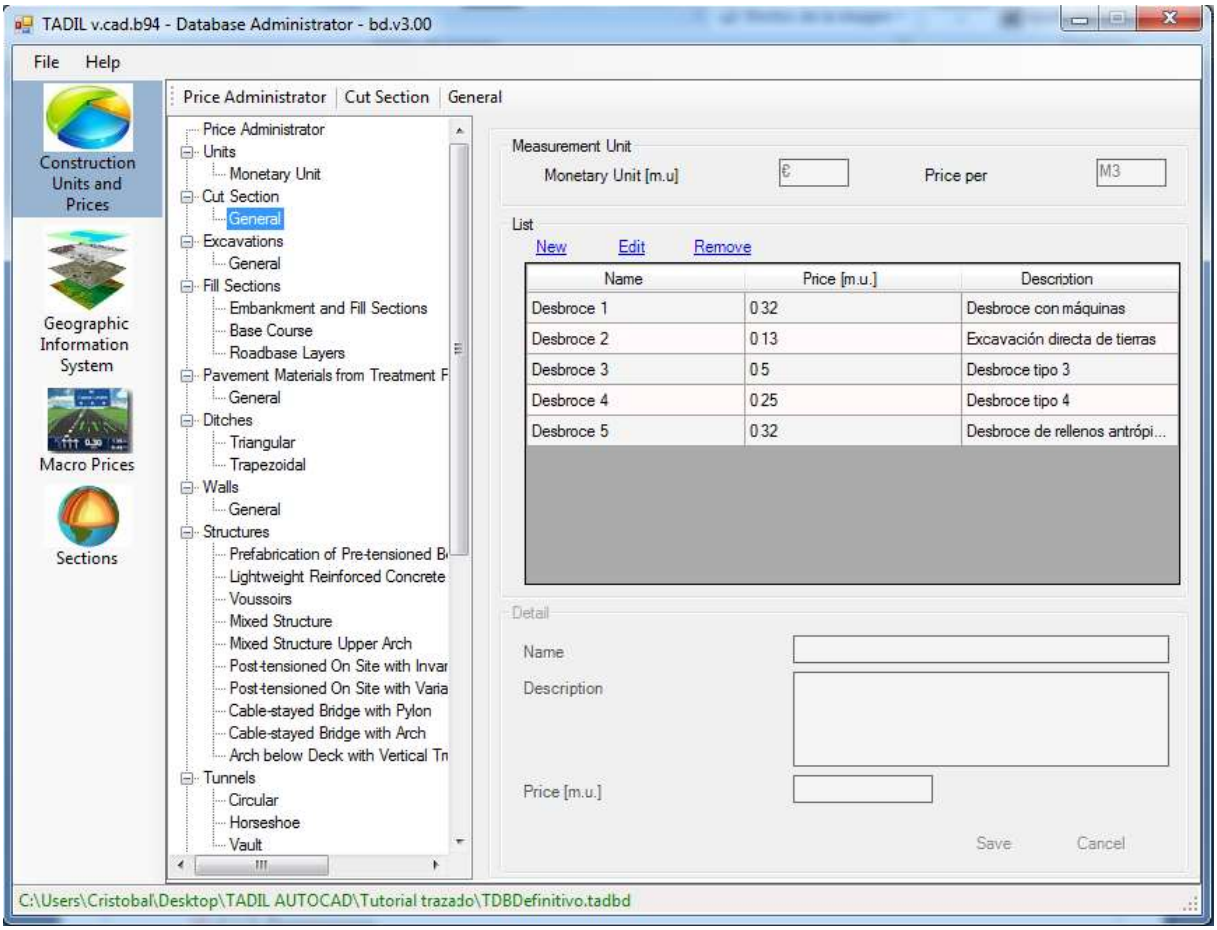


Image 42. Entering cut section data.

11.2.1.3. Excavations

- **General**

Entering data here is very similar to the aforementioned way. But, at this point, we enter two different variables:

- Price of the embankment material: The price we must pay for excavating and using the material from the workplace.
- Price of landfill: The price we must pay for excavating and driving the material from the workplace to a landfill because it is not suitable for the workplace or because we have surplus of this material.

We must take into account that in this section we must enter data according to the type of material from the geotechnical zone so that we are consistent with the area study.

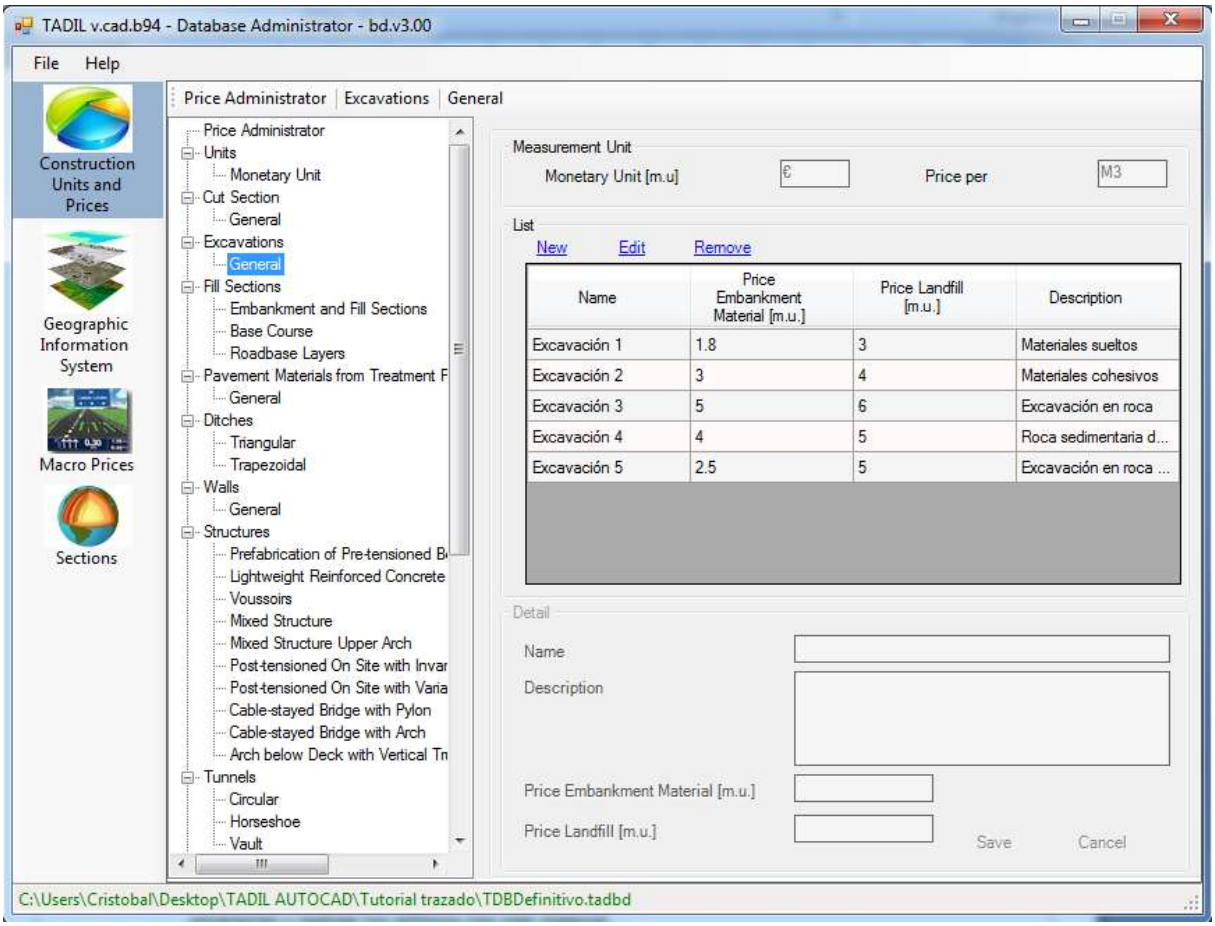


Image 43. Entering excavation data.

11.2.1.4. Fill sections

We follow the same steps as in the section "Excavation" but with two slight nuances:

- Price of the embankment material: The price we must pay for using material from the workplace and making fill section with it.
- Price of the borrowed material: The price we must pay for buying material from near quarrying exploitations and driving it to the workplace.

Therefore, we can see how to enter data in "Embankments and Fill sections" and, in the same way, in "Basecourse Layers" and "Roadbase Layers".

Just like in the previous section, the filling material has to be consistent with the excavation material from the workplace itself as well as with the geotechnical study carried out.

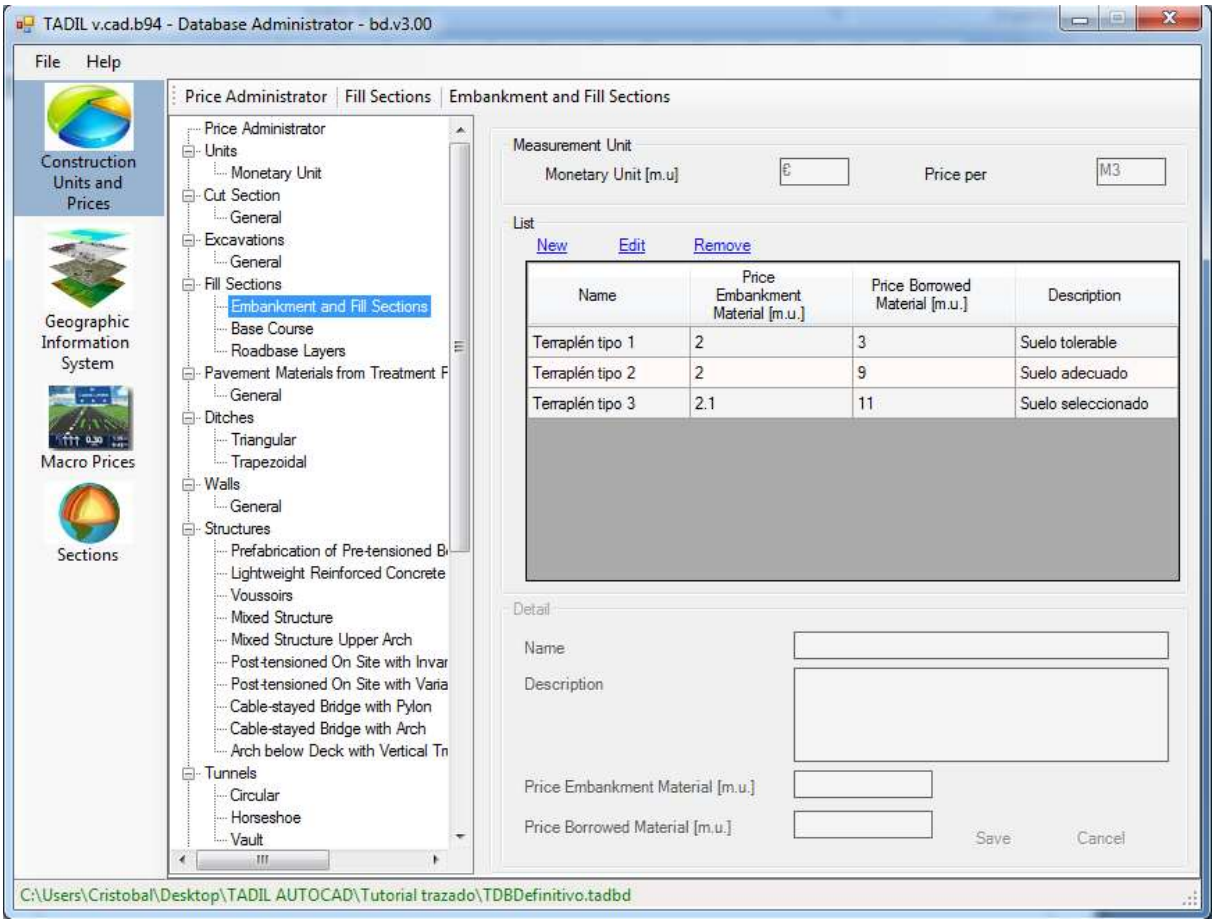


Image 44. Entering fill section data.

11.2.1.5. Pavement materials from treatment plants

- **General**

We make it in the same way.

We use the pavement materials from treatment plants to make the roadbase layer. To choose one material or another for making the roadbase layer may vary according to the conditions and needs of the future road. The most common materials are the asphalt mixes and concrete.

The price we confer to the units of pavement materials from treatment plants can significantly vary depending on the location of the treatment plant as it can be fixed (around the workplace) or inside the workplace itself.

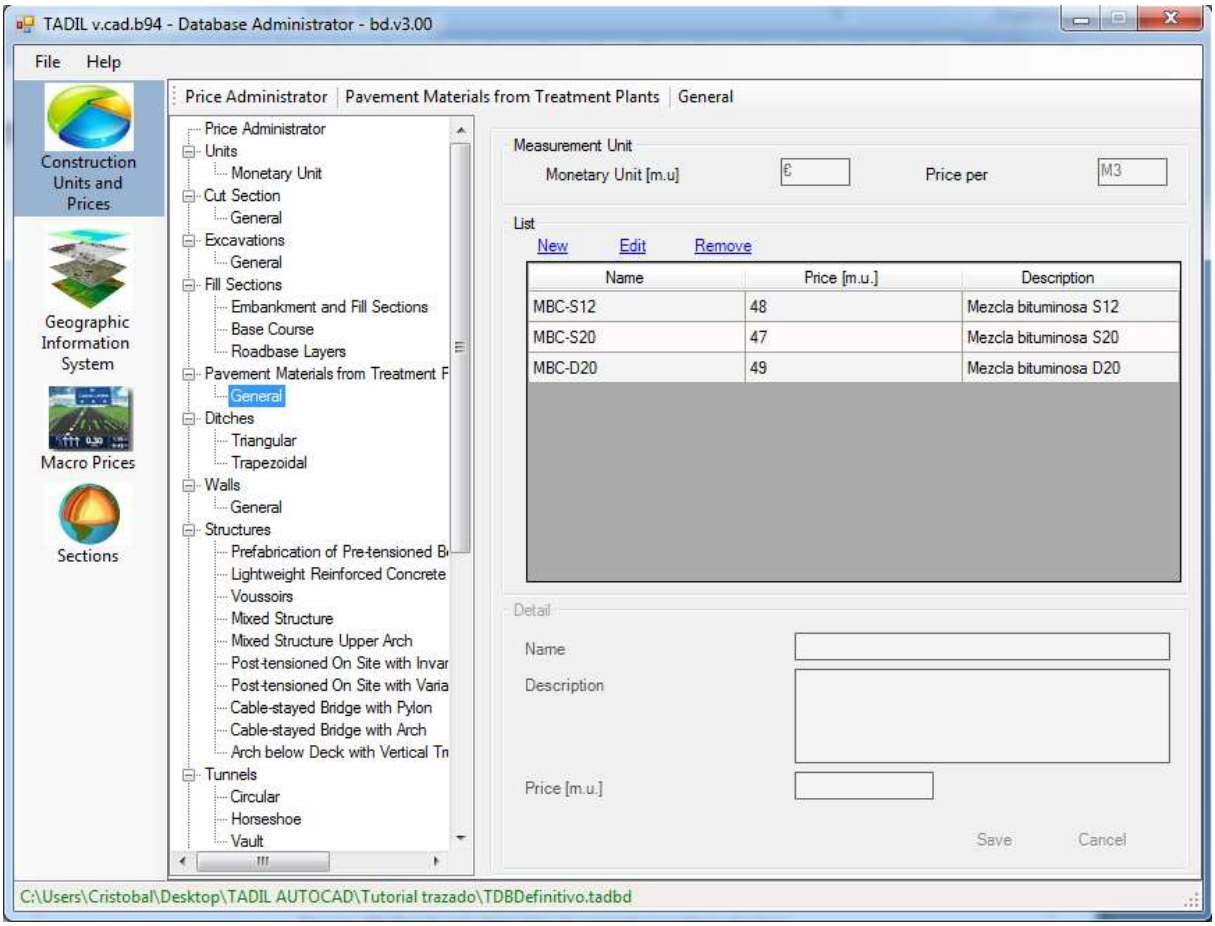


Image 45. Entering data of materials from treatment plants.

11.2.1.6. Ditches

As an example, we enter triangular ditches.

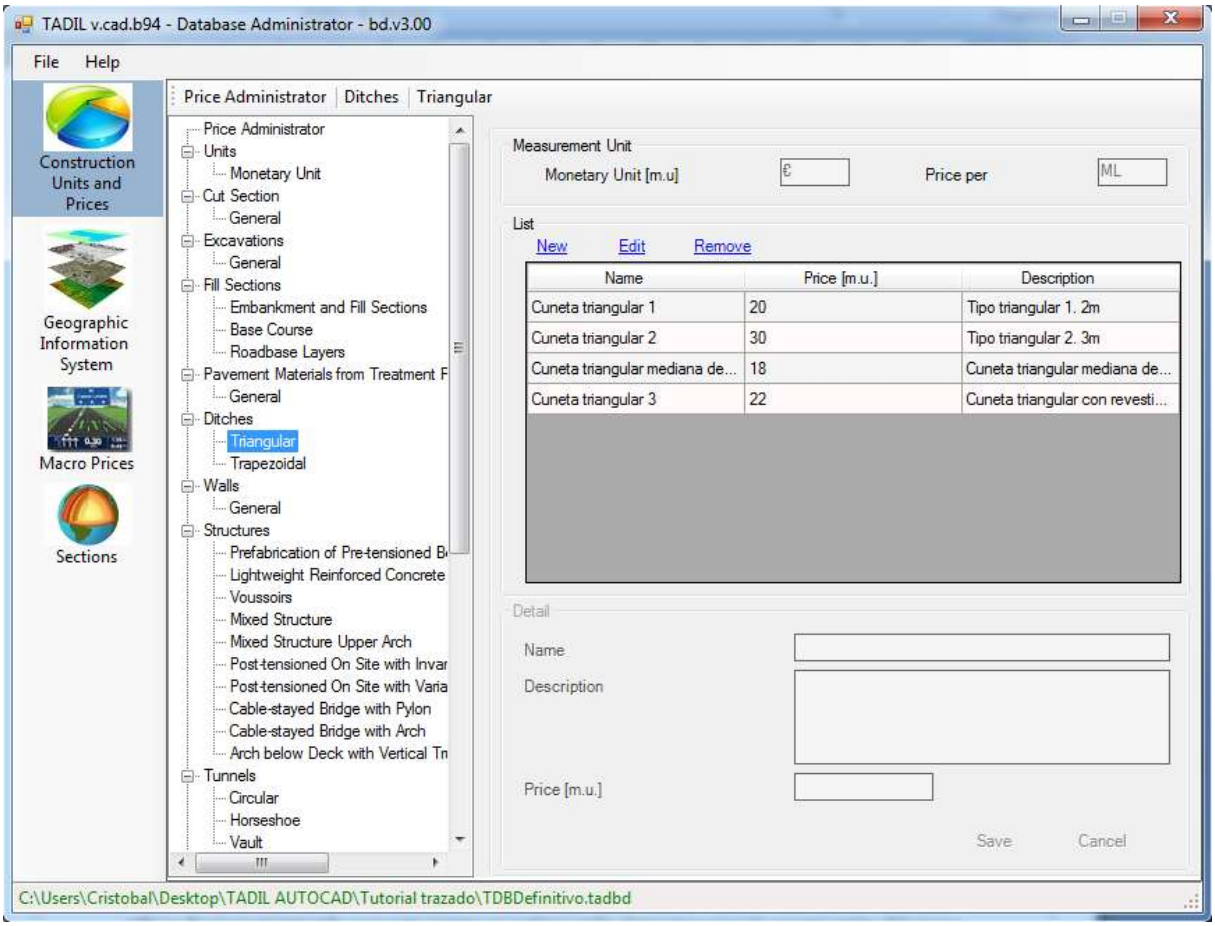


Image 46. Entering ditch data.

We make the same for the remaining construction units in the menu.

11.2.1.7. Walls

When we calculate the wall cost, we must take into account that this costs is given by cubic metre and this price also includes the whole wall construction process. For example, for a reinforced concrete wall, we would include concrete, steel, formwork, the staff… and for a breakwater wall we would include the material itself, the machinery, etc.

11.2.1.8. Structures

It is important to highlight that in this section, the price we enter is given by square metre of finished deck. For obtaining the deck price we have to take into account all the conditions to the construction. For example, the pier height and the building way so that the higher the prefabricated deck's pier is, the more expensive. Another important aspect we pay attention is the lightened area between piers since the bigger lightened area, the more deck's edge we will need.

11.2.1.9. Tunnels

In contrast, the tunnels price is given by kilometre of finished tunnel and we must to consider all the process costs such as special treatments, tunnel entrance, bolting, forepole umbrellas in tunnels, etc.

11.2.2. Geographic Information System (GIS)

The GIS is an information system able to include, store, edit, analyse, share and show the information geographically referenced. That means it is a tool we can use for holding on interactive consults, analysing spatial information, edit data, maps and show the results from all of these.

The GIS works as a database with geographic information joined by an identifier which is common to the graphical objects of a digital map. Therefore, if we mark the object, we can know its attributes and, inversely, if we ask for a record in the database, we can know its location in the cartography.

11.2.2.1. Geotechnical variables

11.2.2.1.1. Earthwork

In this section, we define everything related to earthwork in the workplace, the generating process of cross sections, roadbase packets and esplanades. To see how this works in greater detail, we create a geotechnical area of earthwork. Once we have defined it, we can edit or remove clicking on the homonym buttons. By clicking on "New", we start defining our geotechnical area.

- **General data**

In "Lithological Group", we have to name that geotechnical area. We can also choose if we ban the passage or not in this area due to geotechnical risks. We can activate or deactivate this option in the box "Ban Passage" Geotechnical Risk Area". With the option select colour we just make TADIL assigns that colour to the lithological group in plan, once we have assigned the polyline (see below).

We select the cuts material, the UNS, the excavation material, the granular material, the roadbase layers material, the embankment material, the scaling embankment material and the scaling cut section material from a drop-down menu. This menu shows us the material we have previously defined in "Construction Units and Prices".

After selecting the material from the excavation, we move on to see how much material we can use in the workplace. For doing that, we begin with the upper layers, in particular, with the granular roadbase layers. We define the use percentage of the excavation material and the kind of material. Likewise, we define the basecourse layers and the embankment layers. At this point, we can understandably presume that the use percentage will rise from upper to lower layers, since it would be senseless using more materials for layers which need better materials than for layers which do not require high-quality materials. For more information, please see the Methodological Application Guide, in the section Earthwork Balance Generation.

We can also use TADIL for setting up the fill section and cut section scaling. Therefore, we must click on "Set up Scaling Fill Sections" and "Set up Scaling Cut Section". We must highlight that the maximum slope without step of the embankment refers to the maximum slope for that scaling so that the embankment is stable. If we have more slope than the defined, the embankment foundation is not stable and we have to carry out scaling with steps.

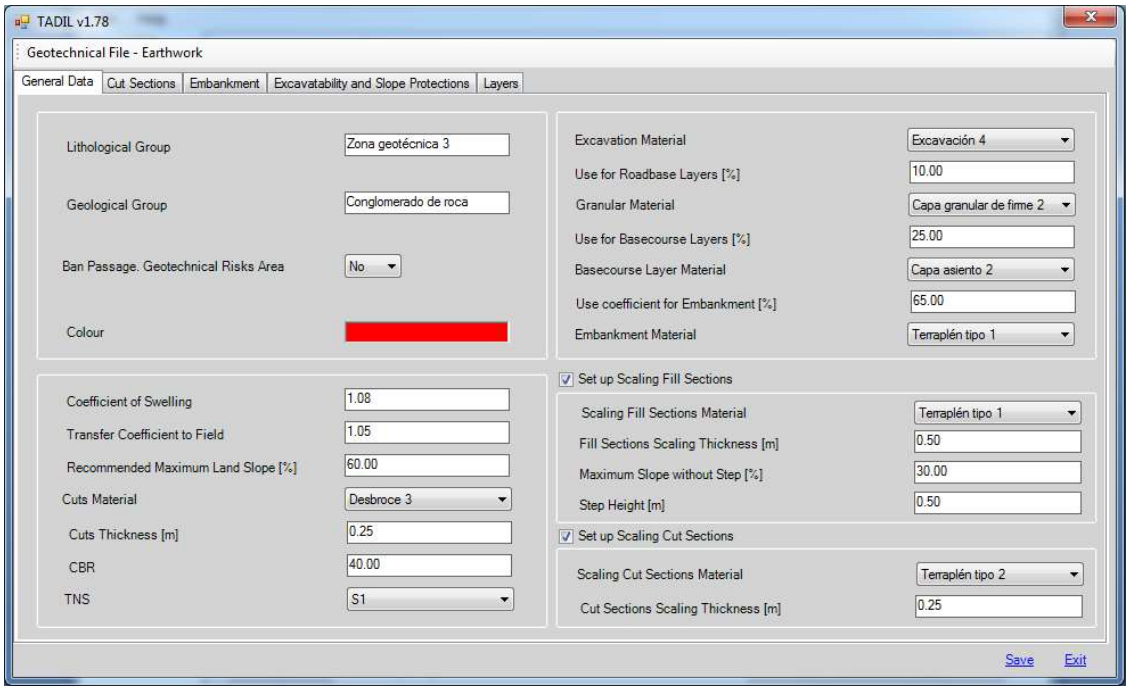


Image 47. Entering earthwork general data.

- **Cut sections**

We have three options: Carrying out the cut section with constant slope, with wall on the side or with slope with berms. TADIL carries out the kind of cut section we select among these three according to the geotechnical area. If we want to carry out a cut section with wall on the side, the wall material must be chosen among a list offered by TADIL depending on what kind of wall we have defined previously in "Construction Units and Prices".

Once we have specified the cut section in this lithological group, we click on "Save".

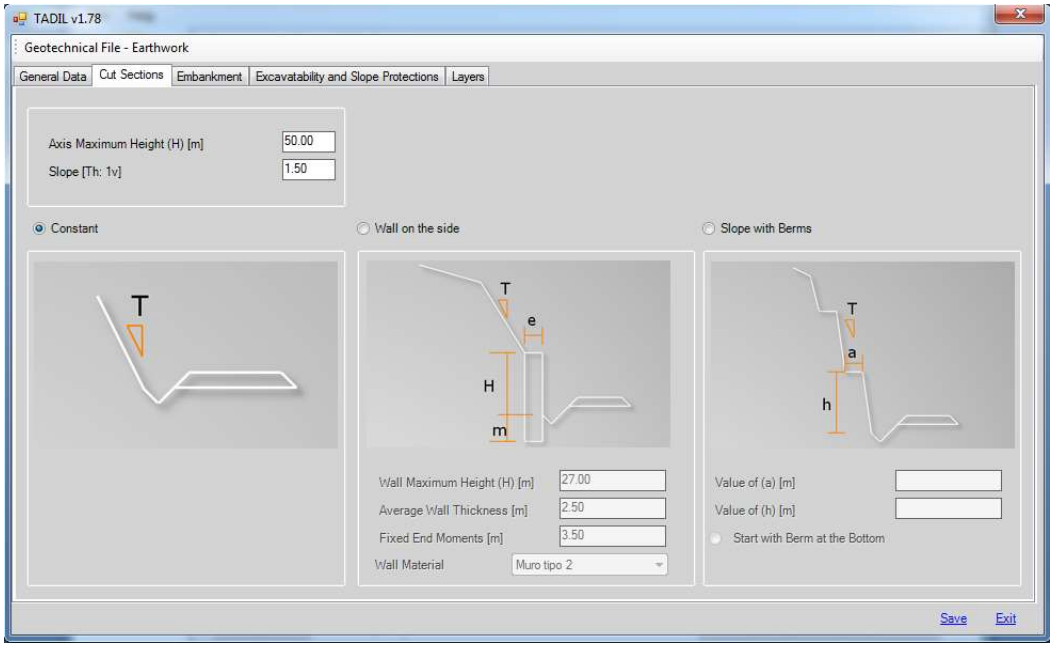


Image 48. Entering cut section scaling data.

- **Embankment**

We have also three possibilities when selecting the embankment: Embankment with constant slope, with slope over wall and with slope with berms. Likewise, by clicking on one of the three boxes, we can select the type of embankment desired according to the geotechnical area.

We can select the embankment material and the wall material from the drop-down menu offered by TADIL according to the data entered in "Construction Units and Prices".

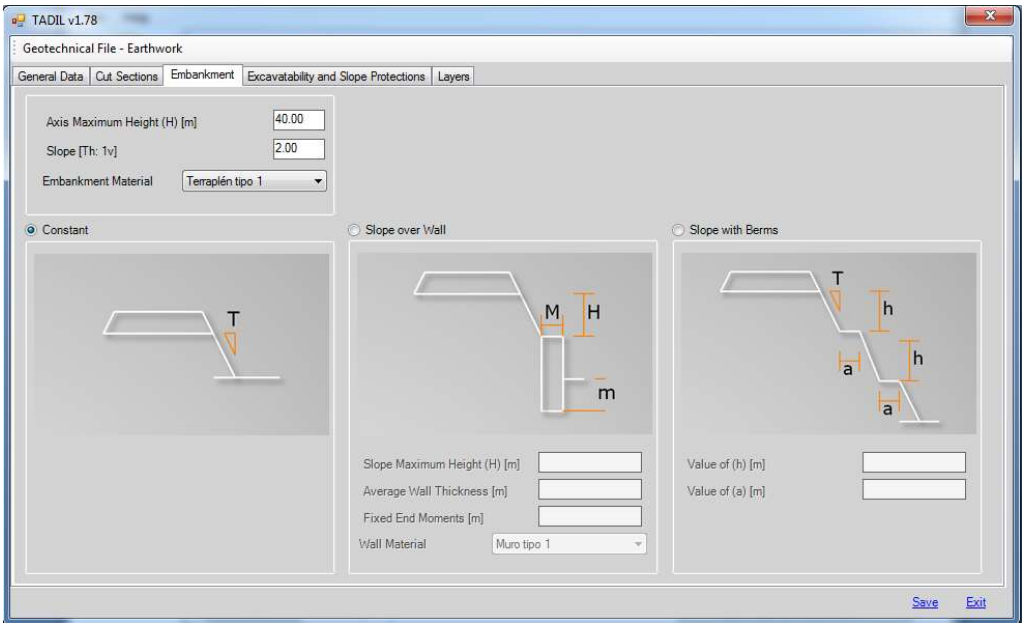


Image 49. Entering embankment data.

- **Excavatability and slope protection**

In this tab, we can assign percentages, from 0 to 100, to the different excavation methods and the slope protection depending on their adequacy to the geotechnical area. All the methods must add up to 100. The most adequate is the method, the highest must be the values. It is very important to take into account the geotechnical nature. Hence we must use mainly pneumatic hammer and/or blastings for rocky areas and depletion systems for areas of higher ground water level, and so on.

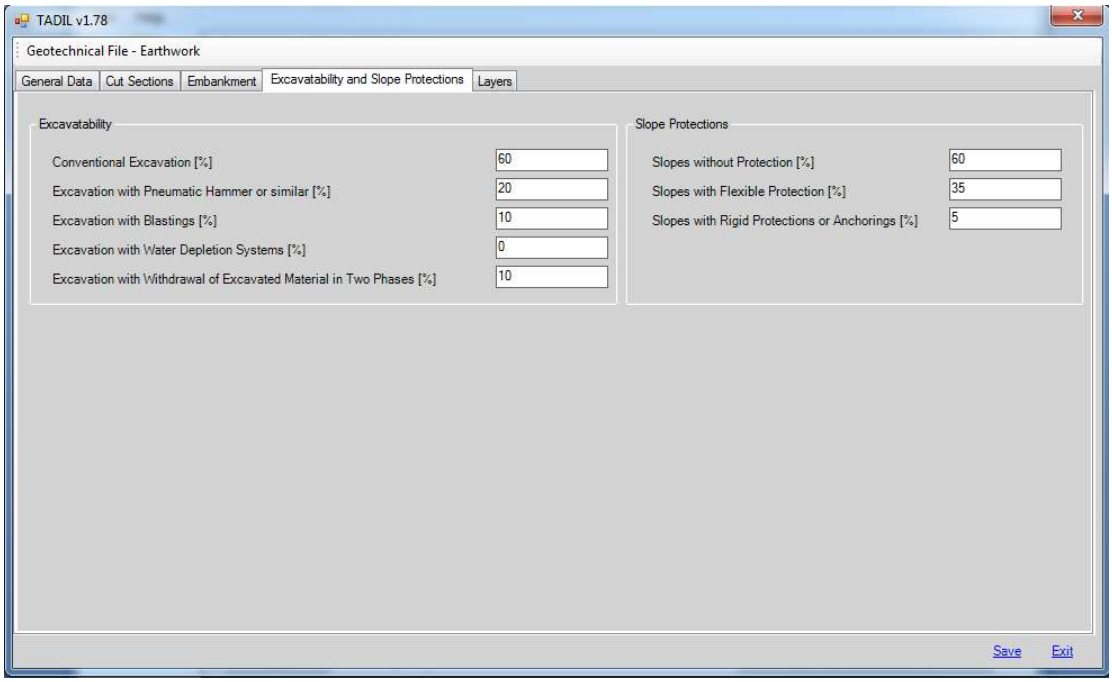


Image 50. Entering excavatability and slope protection data.

- **Layers**

Finally, we must specify the different layers our cross sections is going to consist of. First of all, we select the berm area in the drop-down menu. Every berm area has been created in "Construction Units and Prices". Once we have specified the berm area, we click on "Save" and we move on to specify the layers.

The first one is the roadbase layer. At this time, we must detail which layers, what thickness and what order we must follow to place its material. Materials have been previously defined in "Construction Units and Prices".

For the hard shoulder layers we have two options: entering data just as we have done with the roadbase layers or by clicking on "Copy Roadbase Layer to Hard Shoulder Layer".

We make the same for the basecourse layers.

We click on "Save" and we have fully defined this geotechnical area. This lithological group can be edit as many times as required or removed just by clicking on "Edit" or "Remove".

When any GIS record is to be removed, the user must also remove the shading linked by TADIL in AutoCAD. The same will be done for all GIS records that the user wants to remove.

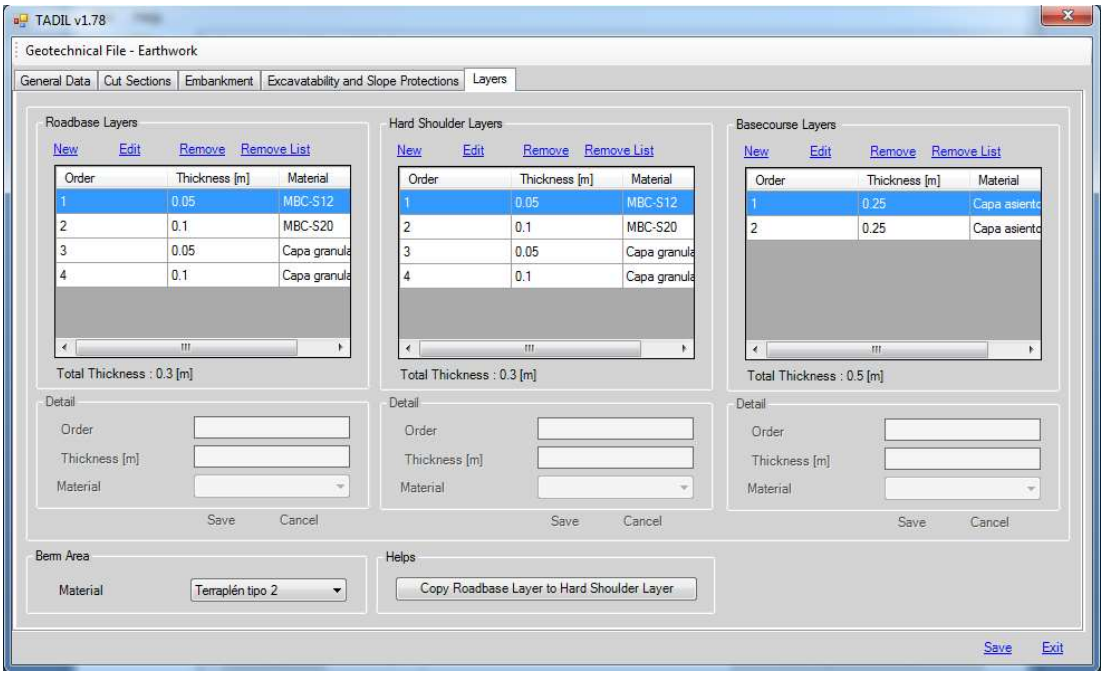


Image 51. Entering layers data.

- **Link polyline to GIS area**

Once we have fully defined the geotechnical area, we must associate it to the cartography. First of all, we must draw a polyline (closed) on the cartography. Then, we click on "Link Polyline to GIS area" and we select the polyline.

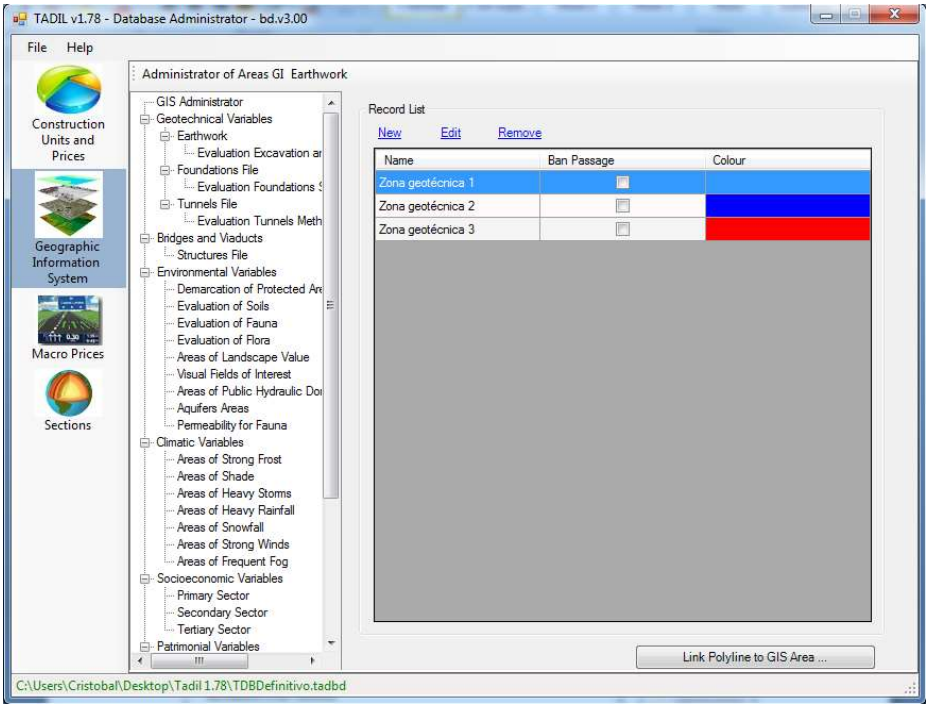


Image 52. Link polyline to GIS area.

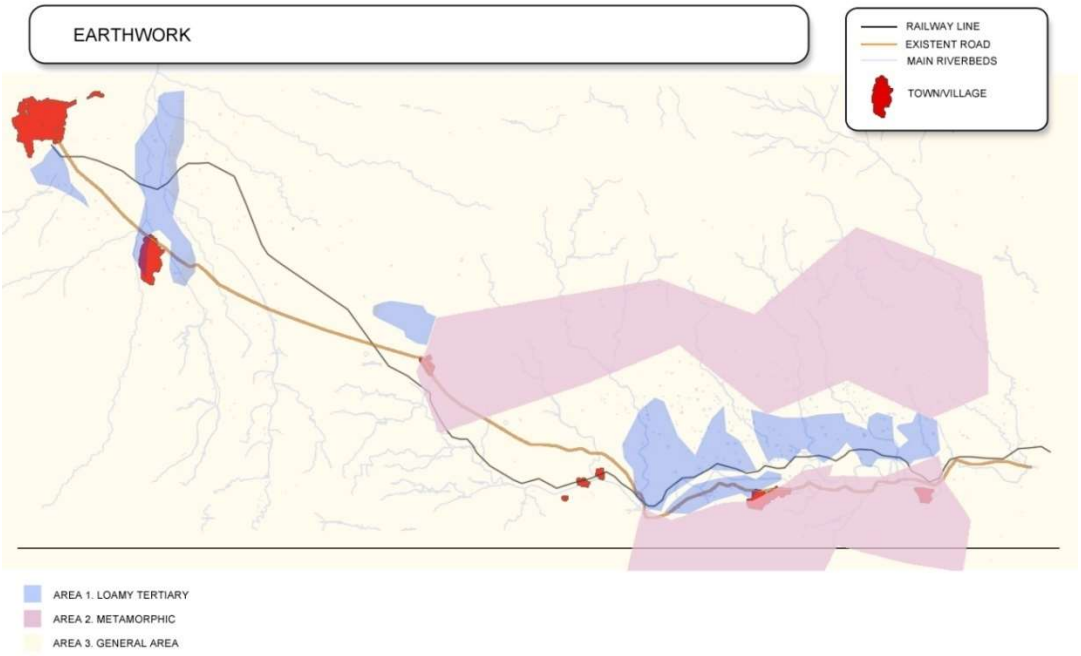


Image 53. Areas linked to the different geotechnical areas.

- **Evaluation of excavation and slope method**

In this section, we must enter a subjective evaluation of the excavation and slope methods. Zero is the most favourable value and ten is the least favourable. We save the values and move on to the next section.

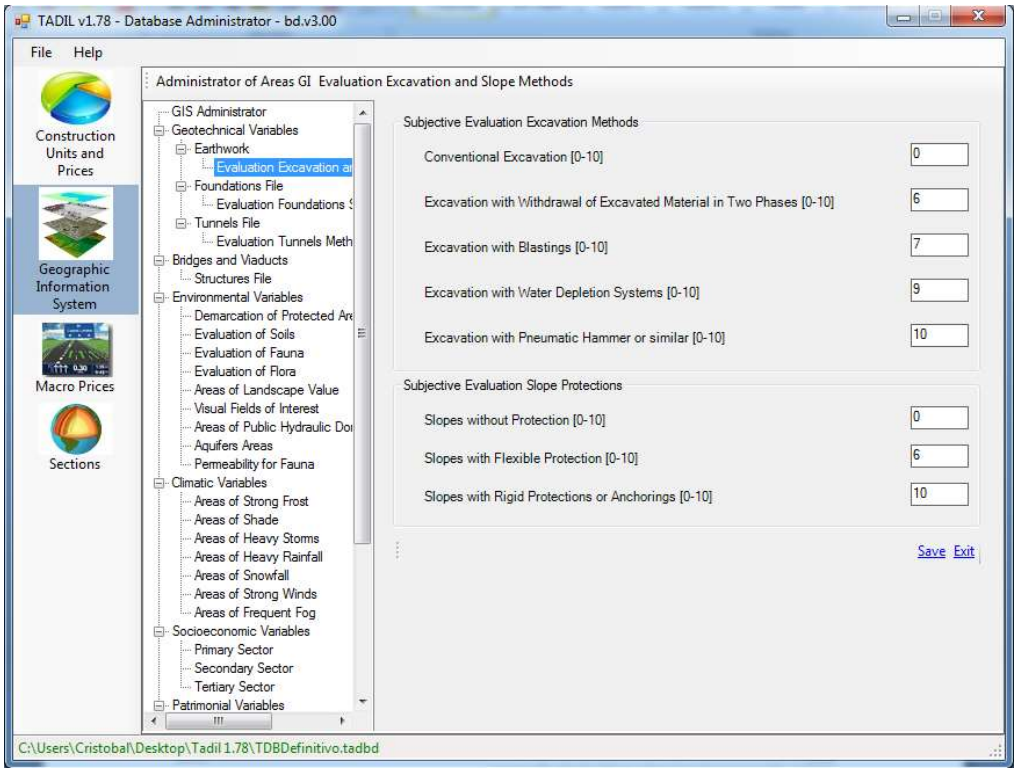


Image 54. Entering excavation and slope evaluations.

11.2.2.1.2. Structure Foundation File

In the foundation file we give the foundation features of a geotechnical area in particular. So, we must specify the typology of foundation in structures and crossing methods for each geotechnical area by filling the box "Geotechnical File, Foundation", just as we have done previously. Afterwards, we link the cartography and the polyline to the GIS area, as we have done in the previous section.

By clicking on "New" we can create new foundation areas, which can be edited and removed later by clicking on the homonym buttons.

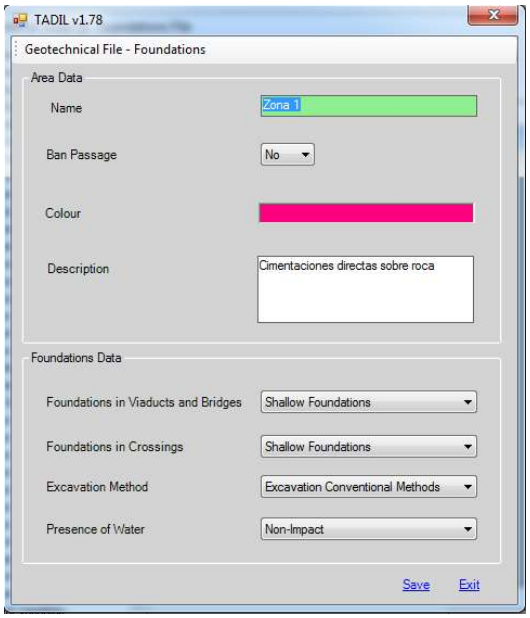


Image 55. Entering foundation data.

Next we show the different foundation areas created in our example.

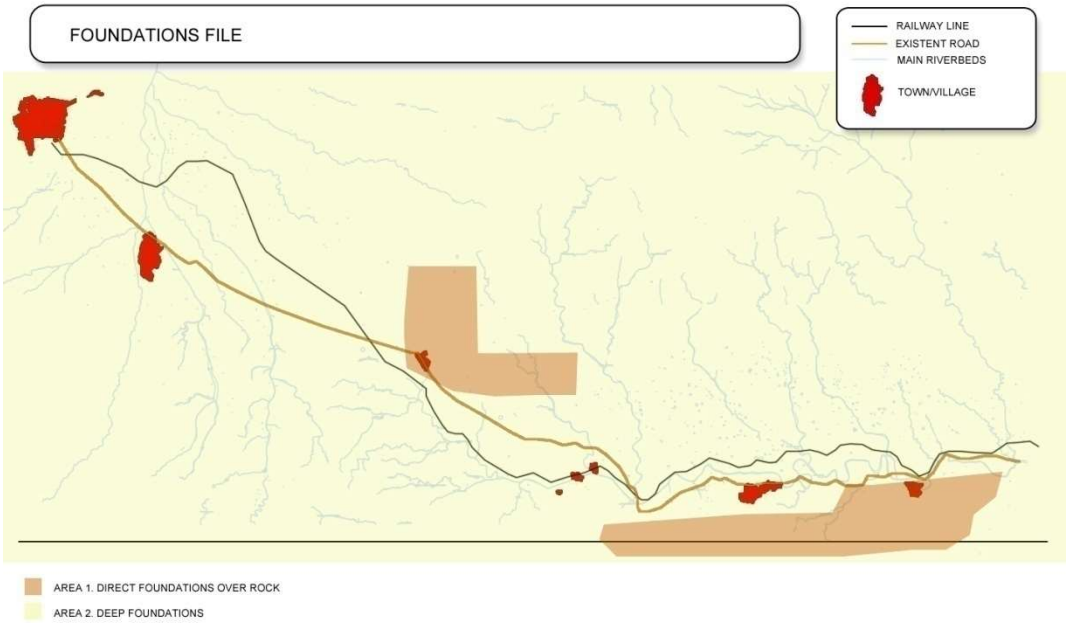


Image 56. Areas linked to the different foundation areas.

- **Evaluation of foundation, structures and walls**

Likewise, we must enter a subjective evaluation about structure foundation and crossings methods, and excavation and presence of water methods. Zero is the most favourable value and ten is the least favourable. Then we click on "Save".

11.2.2.1.3. Tunnels File

The first step is to specify if we allow or not tunnels for the draft in a particular area, by clicking on Yes or No in the box "Ban Tunnels".

As help, we can use the tab next to the entering data tab. There we can see, according to the RMR data (Beniawski 1989), data related to the setting up of support and actions in the tunnel section.

By filling the tunnel and clicking on "Search Section", TADIL selects from its database the tunnel complying with all the specified conditions.

We can also create our own tunnel sections in a .dwg file and load them into the software. To load our own sections, we must save the file into the same folder where the software is saved, by opening the folder "cad" (inside the folder "sec") and copying the file into the folder "tun".

We can also choose the tunnels construction methods and the specific treatments we need.

We save the data. We can modify them by clicking on "Edit" and removed with the button "Remove".

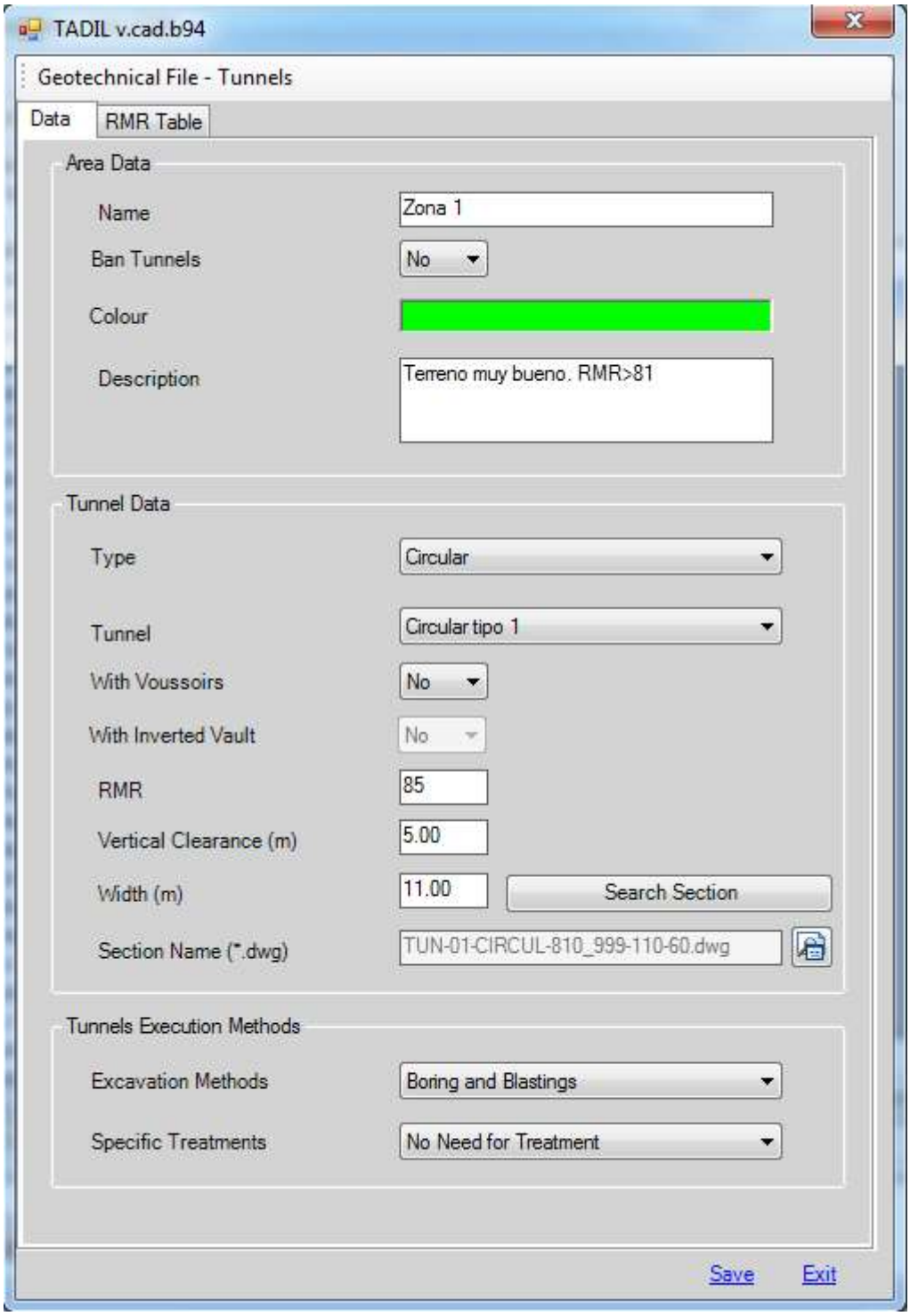


Image 57. Entering tunnels data.

To fully define the area, we also need to link a closed polyline on the cartography.

These are the areas we have specified in our study.

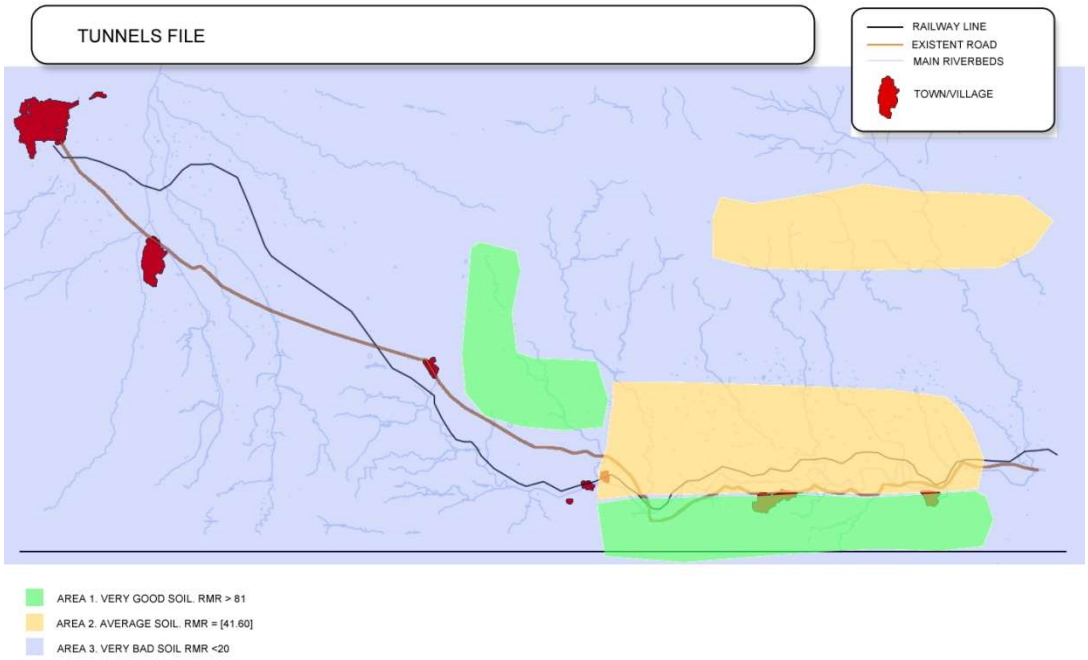


Image 58. Areas linked to the different tunnels areas.

- **Evaluation of tunnels method**

We evaluate the excavation methods and specific treatments used for building the tunnel from zero to ten, zero being the best and ten being the worst.

11.2.2.2. Bridges and viaducts

- **Structure File**

We make the same for the structure file. We name the area and we define if we ban or not the structures.

We can select the structure type and, inside the menu "Structure", we choose one of the prices defined in "Construction units and prices".

After having the typology, the maximum width of deck and the distance between piers, we click on "Search selection" and TADIL selects from the default sections the one that better fits to the conditions.

Just like in the tunnels file, we can enter our own bridges sections. To load our own sections, we must save the file into the same folder where the software is saved, by opening the folder "cad" (inside the folder "sec") and copying the file into the folder "tun".

Once we have filled out the required gaps, we click on "Save". We can also edit and remove any area previously defined.

Finally, we draw a closed polyline and we link it to the area by clicking on "Link polyline to GIS area". Like that, the structures file is totally defined.

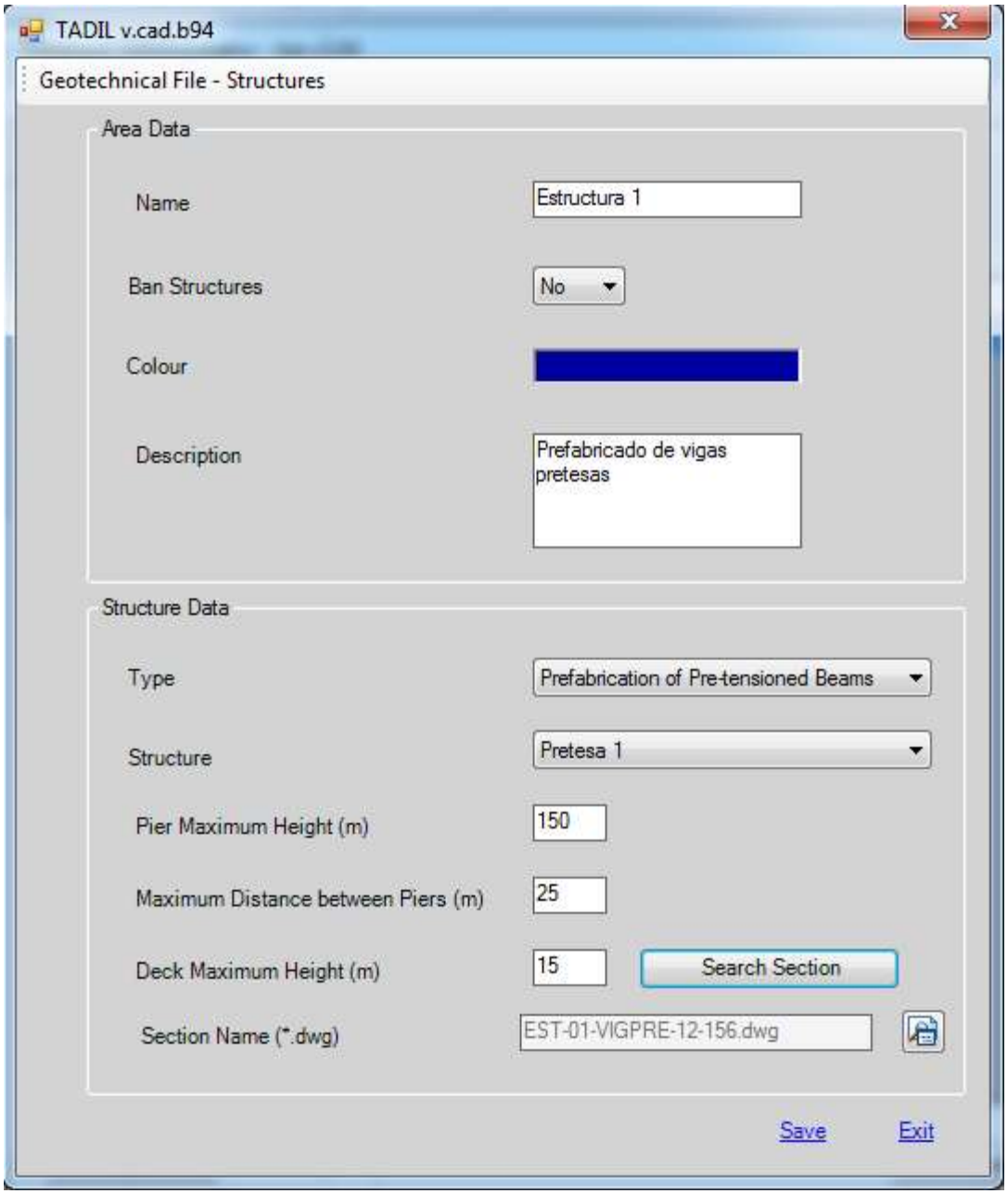


Image 59. Entering structure data.

11.2.2.3. Environmental variables

From this menu on, all the sub-menus are the same except for some aspect we explain independently. Therefore, once we explain one sub-menu, the remaining ones are also explained.

11.2.2.3.1. Evaluation of fauna

This menu is divided into two different parts: "Classifications" and "Records for Classifications".

For making the classifications we click on "New", we name the classification, we make a brief description and we save it. As always, we can edit or remove these values.

Next we develop out example. We make two classifications for the animal kingdom: lepidoptera and protected bird species. The records for classifications are the different species grouped under this classification. So, under the

lepidoptera classification, we have introduced the species parnassius apollo, and under the protected bird classification, the falco naumanni and the aquila chrysaetos.

For entering new records for classifications we need to click on "New", finally, we name and describe it. We can ban an area where these species live by activating the box "Ban Passage". We give an evaluation to the species depending on its importance. Zero is the biggest value and zero is the smallest.

We can link a photo to each record for classification. For that, we must have a file in .jpg format, save it into the same folder where the software is saved, open the folder "img" and copy our .jpg in the folder "gis".

Finally, we must link each record for classification to a polyline following the same steps as in previous sections.

When the record for classification is completely defined, we save it. This record can be edited or removed afterwards.

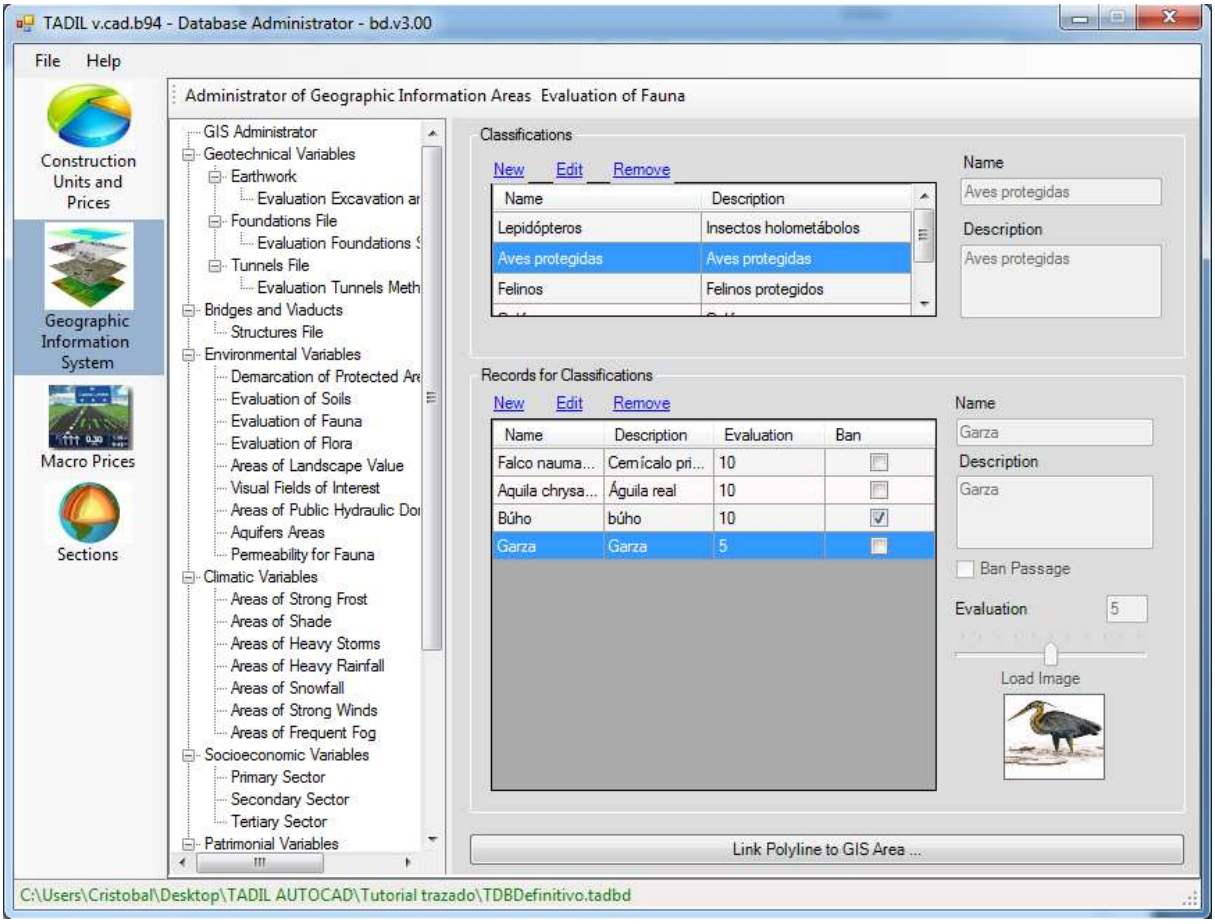


Image 60. Entering fauna data.

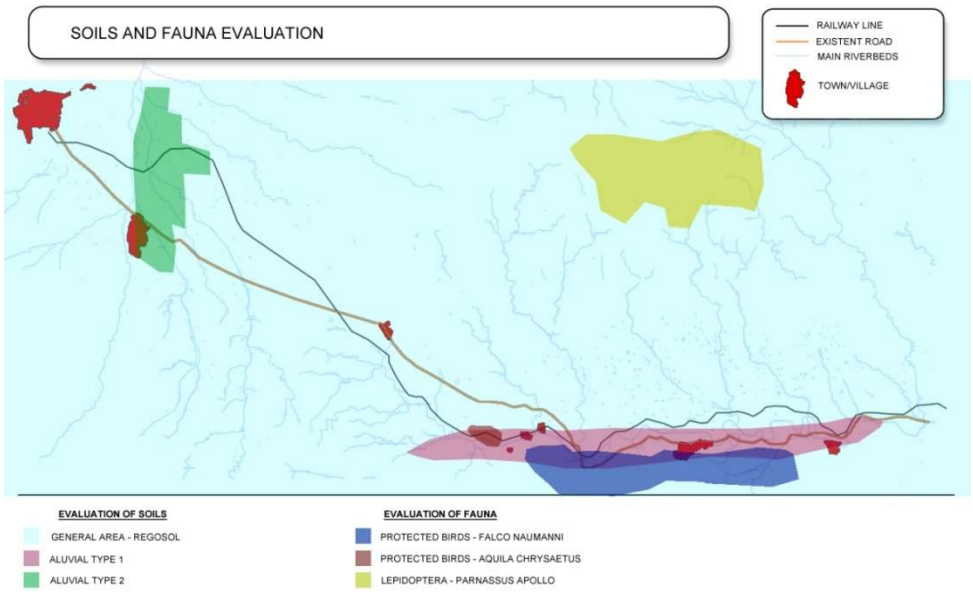


Image 61. Areas linked to the different fauna areas.

11.2.2.3.2. Areas of public hydraulic domain

In this section, we define the conditions for the different possible areas or public hydraulic domain in our cartography. We can create a new area by clicking on "New". Once we have named the area, the software must know if we want to ban the passage or not. After that, we must decide if this area passes with structure (we select "Yes") or not (we select "No").

Selecting structure not compulsorily passing with structure does not mean that there are no structures, but that passing with structure is not compulsory. Entering the clearance value will make TADIL check and correct if necessary that every point of the future road is at a minimum height equal to the grade line plus said clearance. TADIL starts checking in the borders of PHD of our infrastructure. In this aspect, there can be different situations where TADIL has to modify the grade line cutting the PHD in order to be able to meet this condition. In the Methodological Application Guide, the user will be able to get detailed information about said situations.

It can be possible that the origin point, the destination point and our whole study pass inside the PHD, not cutting between the road and the borders of the PHD. In these events, we recommend modifying the borders of the PHD in order to leave the start and/or end point out of the PHD (very closed to the border) so that TADIL can check the grade line on the border.

The evaluation, as in previous sections, determines if the area is considered as important or just modest. Zero would go with the least important ones and ten with the most important.

There is the possibility to allow or ban whole road stretches of the PHD. This way, if the user does not allow whole road stretches, TADIL will dismiss any possible solution of whole roads stretches inside the PHD.

When indicating a maximum crossing angle, we get to facilitate the drainage works or necessary structures for saving the watercourse and to limit the condition to the riverside.The user will be able to allow or not this possibility by selecting or deselecting on "Set up Angle". The angle we have entered gives us the permissible angles by which road and watercourse cut. This range will cover from the user's angle to its complementary.

Once we have saved these data, they can be modified by clicking on "Edit" or removed by clicking on "Remove". Just like we described previously, every time we want to remove a GIS area, the user must remove the shading linked to the polyline by TADIL.

Finally, we must link this area to the cartography. By selecting a closed polyline, this is linked automatically.

The watercourse is linked in a similar way, although for this case the polyline does not have to be closed.

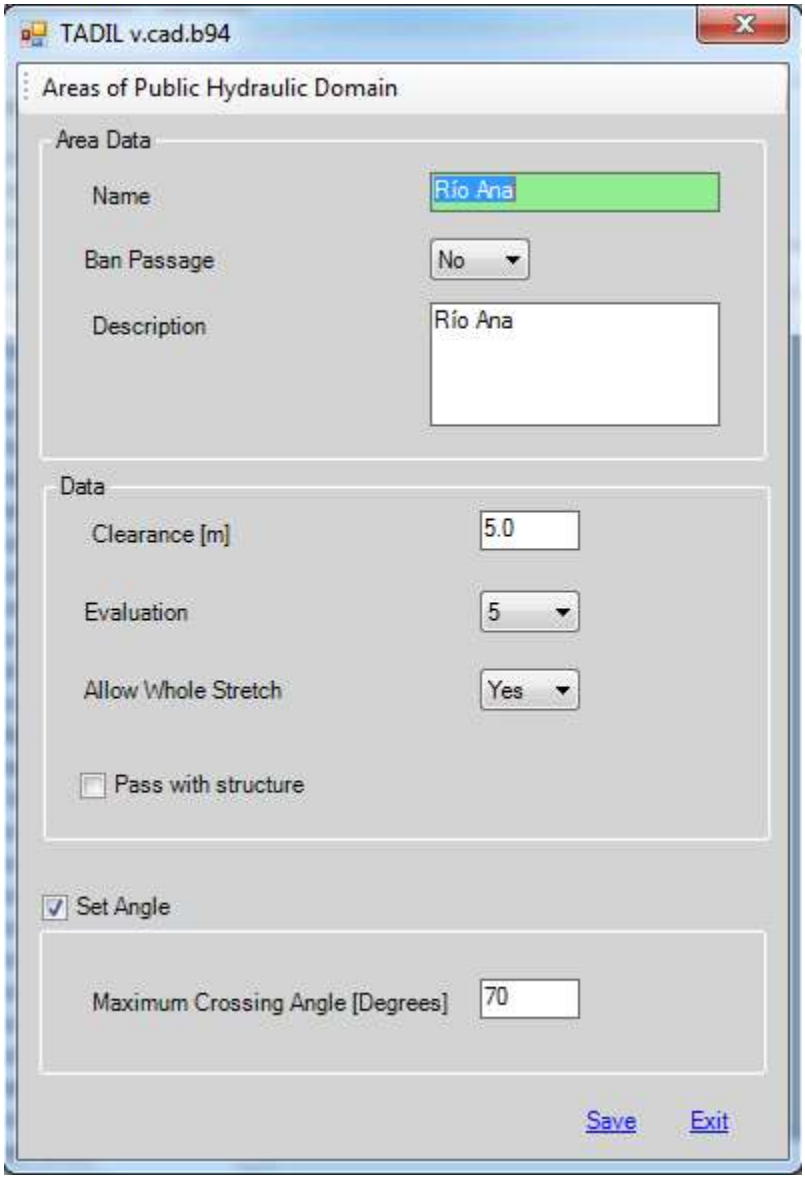


Image 62. Entering areas of public hydraulic domain data.

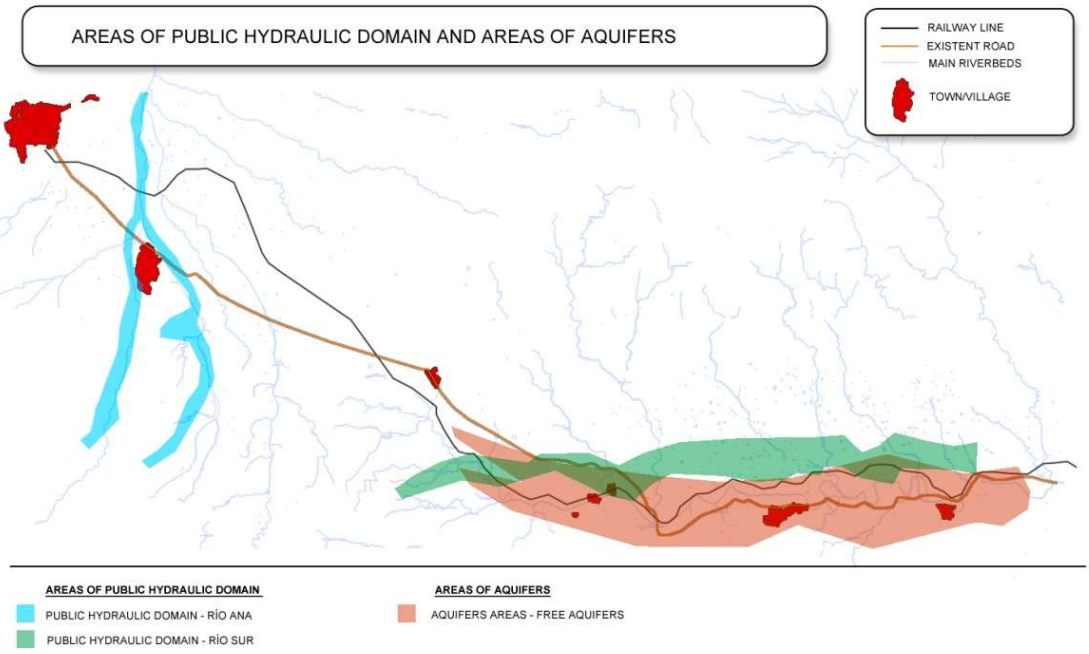


Image 63. Areas linked to the different areas of public hydraulic domain areas.

11.2.2.3.3. Example of widening of road stretch Villa Ana – Pueblo Viejo

Next we show the areas defined with TADIL when we link polylines to each environmental variables.

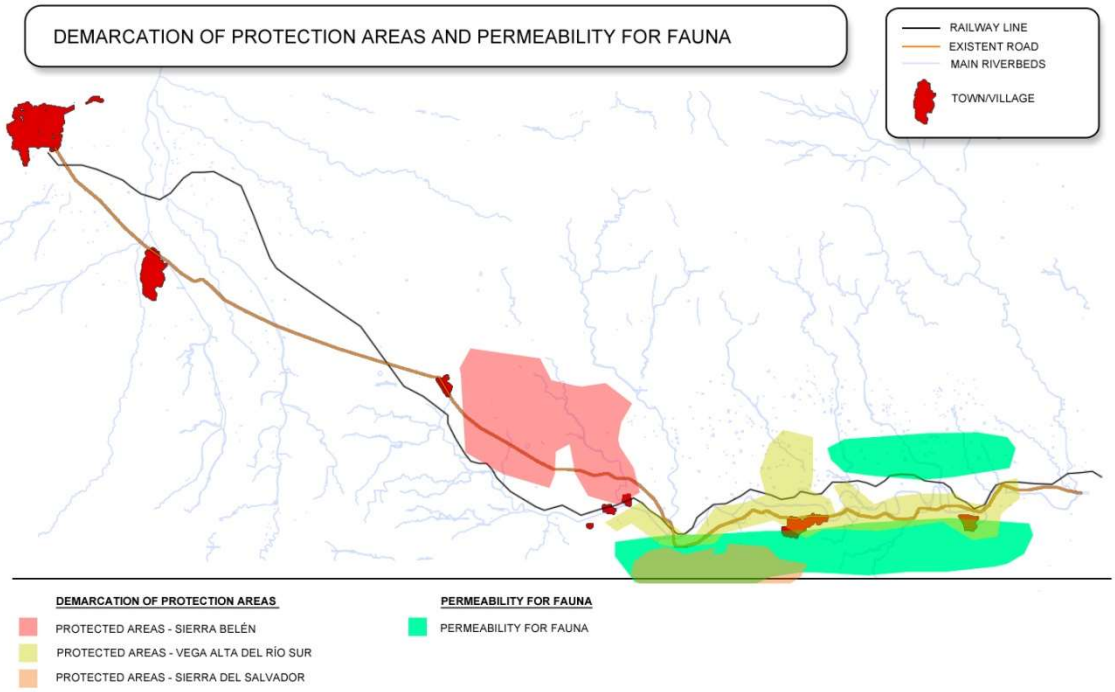


Image 64. Areas linked to the different protection and permeability for fauna areas.

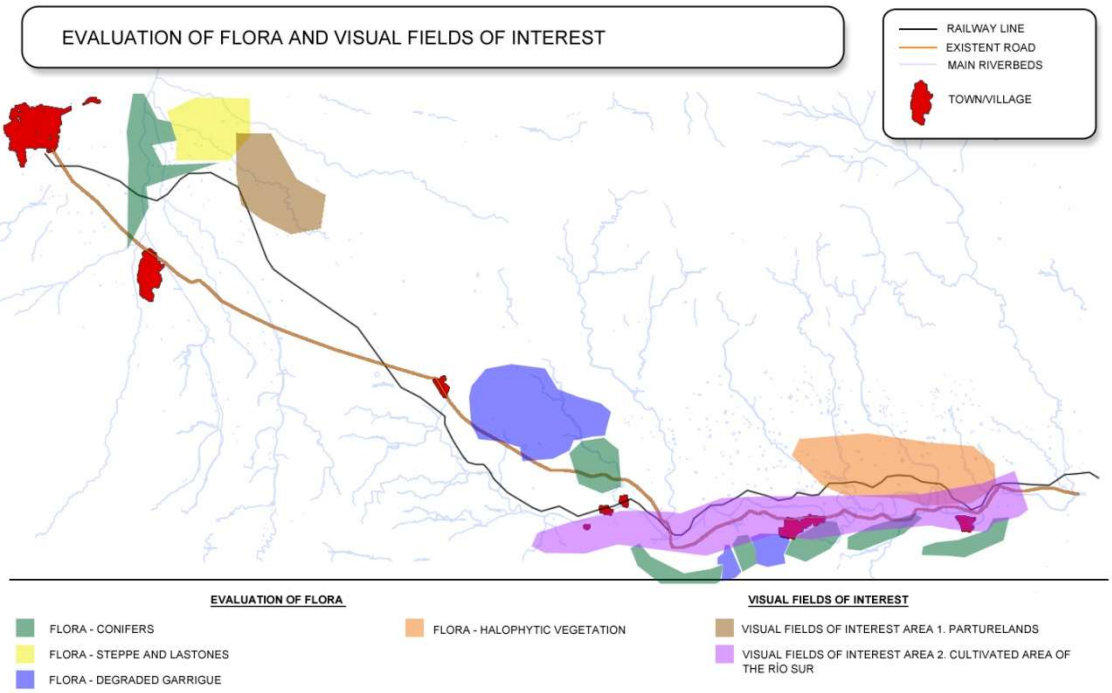


Image 65. Areas linked to the different flora and visual fields of interest areas.

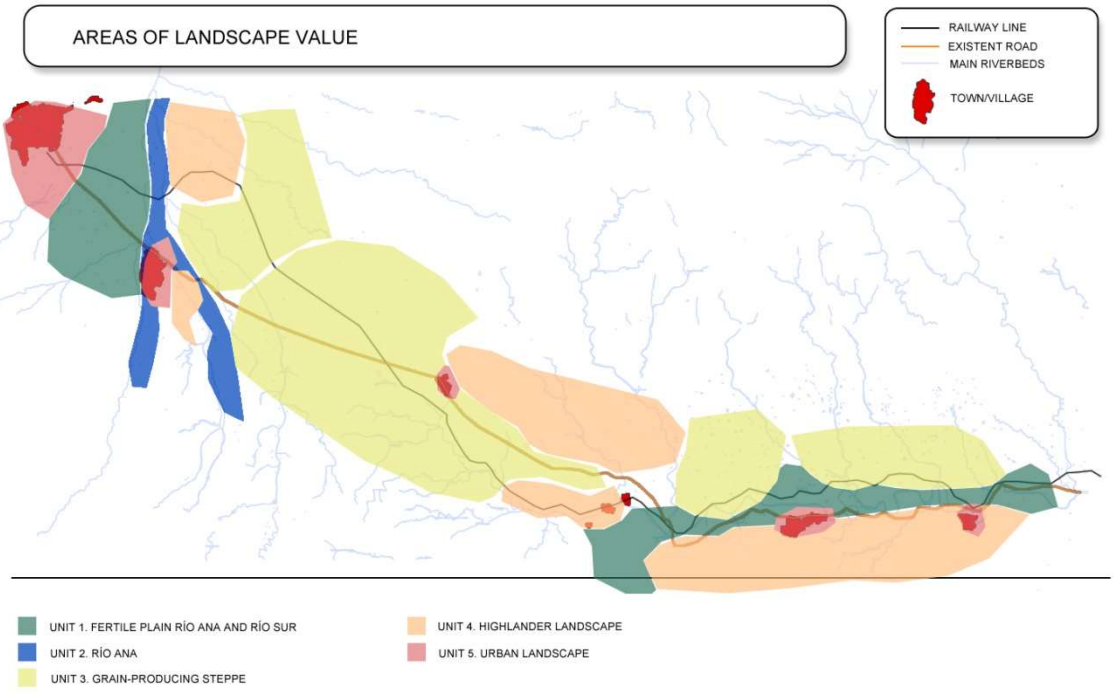


Image 66. Areas linked to the different landscape value areas.

11.2.2.4. Climatic variables

All these variables are defined as we did in the evaluation of fauna. Therefore, for our example, we enter the following GIS areas.

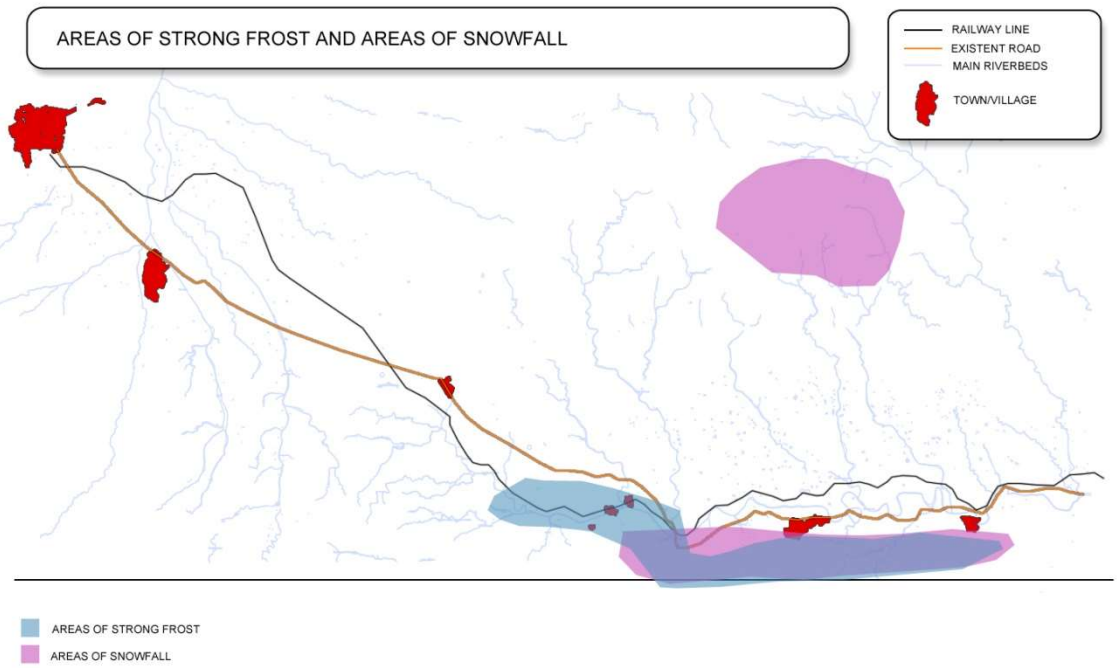


Image 67. Areas linked to the different strong frost and snowfall areas.

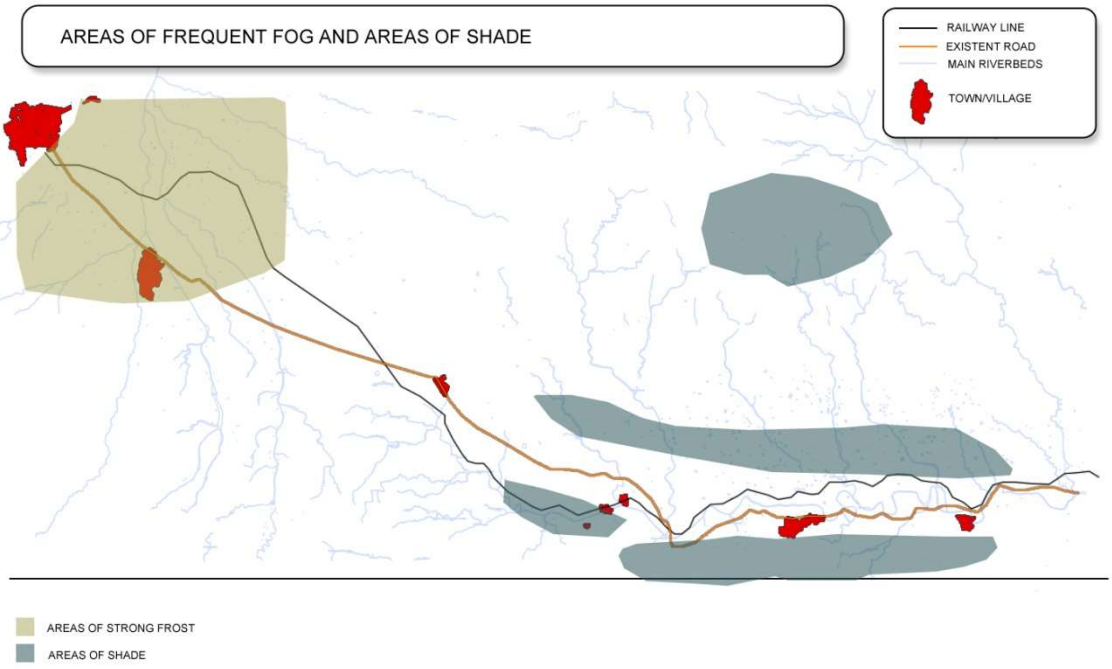


Image 68. Areas linked to the different strong snowfall and shade areas.

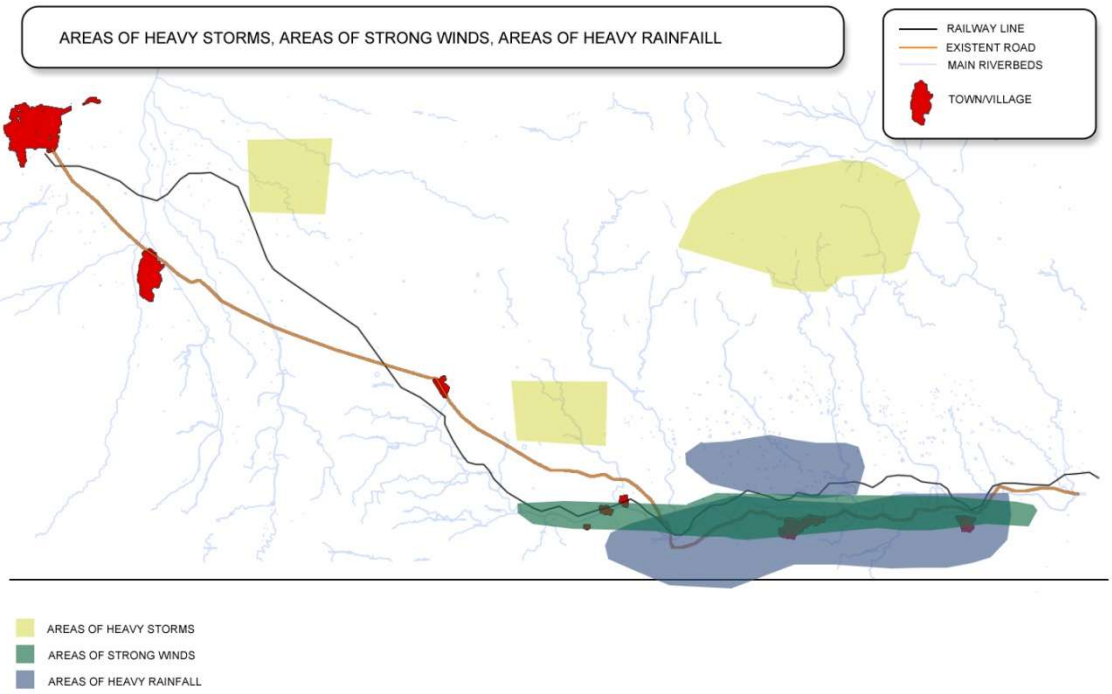


Image 69. Areas linked to the different heavy storms, strong winds and heavy rainfall areas.

11.2.2.5. Socioeconomic variables

The socioeconomic variables are defined in the same way as we did for the primary, secondary and tertiary sector (see below).

11.2.2.5.1. Primary sector

We click on "New" and we create an area corresponding to the primary sector. We choose between banning or not the passage in this sector. We make the area evaluation following the same criteria as followed previously. Finally, we select the evaluation of land production from the drop-down menu. This evaluation has to be with the price of economic performance of land. Previously, we have defined the different evaluations of land production offered by TADIL in "Construction units and prices". We save it and exit.

Finally, we need to link this area to a polyline of the cartography to totally delimit this area of the primary sector.

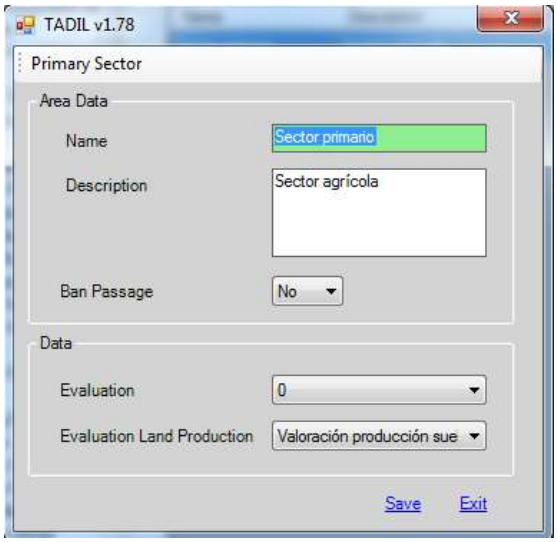


Image 70. Entering primary sector data.

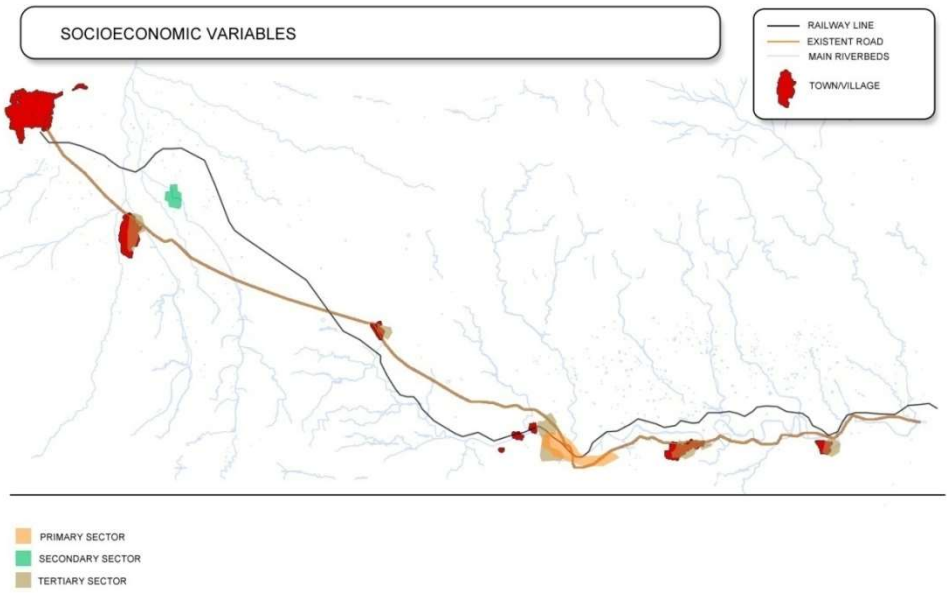


Image 71. Areas linked to the different socioeconomic sectors.

11.2.2.6. Patrimonial variables

All these variables are defined as we did in the evaluation of fauna, except for the following:

11.2.2.6.1. Building land

We make the same for building and non-building lands.

First we click on "New" to create a new entity of building land. We name and describe it. After that, we choose between banning or not the passage in this area. We make the evaluation just as we did in previous sections, giving higher evaluations to those areas of greater interest and vice versa.

In the drop-down menu "Patrimonial evaluation of land" we can select the type of expropriation that this area of building land is subject of. Previously we have defined in "Construction units and prices" both for the expropriations and prices. We save the data and exit.

We should highlight that when we ban an area, the basic axis is what will not go through this area but when creating the linear work, slopes of the cut section or embankments may go through it. Therefore, we recommend defining banned areas with a safety margin. This feature is included in TADIL in order to be able to calculate the expropriations for these cases.

Finally, we link this polyline to this new category of building land.

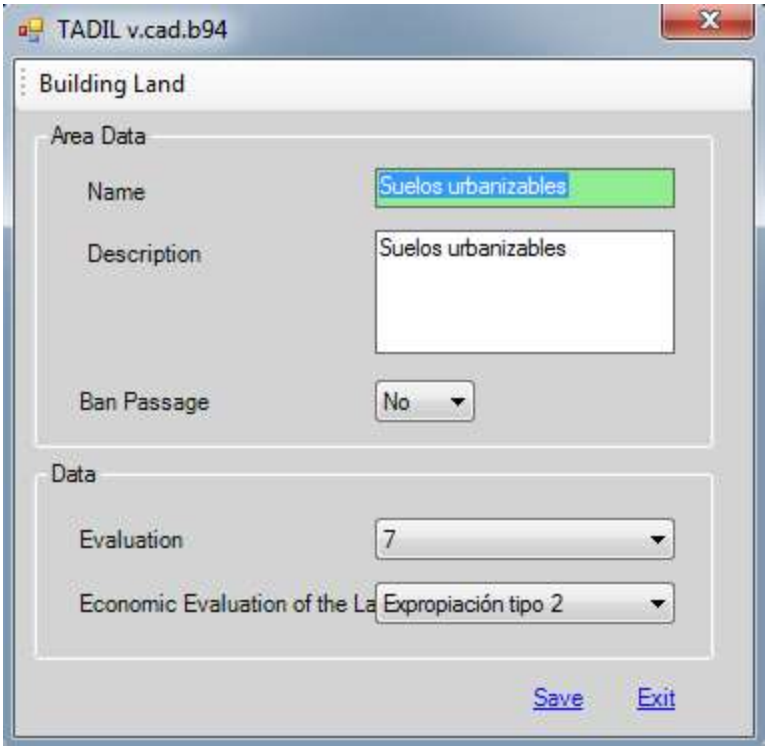


Image 72. Entering building land data.

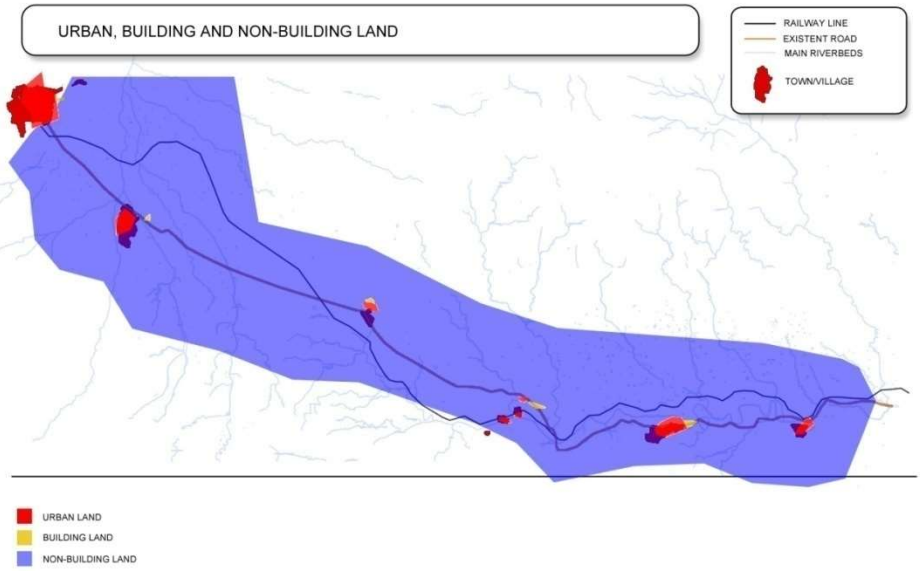


Image 73. Areas linked to the different urban, building and non-building land areas.

11.2.2.6.2. Crossing of linear infrastructures

For the study to be complete, we must take into account that a road is not an isolate entity by a part of a network and that this network will define in many aspects the geometry and the cost of the future road. Therefore, we have to specify the pre-existing linear infrastructures and how they affect our project.

We add linear infrastructures to our cartography by clicking on "New". We name them and specify if we ban or not the passage, just in case the infrastructures cross our own road. If we choose not to ban the passage, we should specify if they cross level or flyover. If we find ourselves before a high capacity road, we are expected to choose flyover and we must specify its vertical clearance.

The flyover passage can be made either over or under the previous linear infrastructure. TADIL checks out the grade lines of both infrastructures at the cutting point, so that if the new road has a bigger level number than the old one, this will pass over it, otherwise it will pass under it.

Logically, TADIL will make all the flyover passage of the crossings with linear infrastructures in structure. It will assign bridge or tunnel typology, according to the bridges area or tunnels area defined by the user.

In the event that public hydraulic domain areas cut off an area of crossing of infrastructures, this would be done over. To increase the level point of the grade line, TADIL calculates the one due to PHD and the one due to PID in the cutting points between the borders of PHD and PID, in the start and end points of the cut stretch and in the inner points of the PHD and PID that might exist. TADIL always selects the increase of maximum level of each aforementioned point, modifying therefore the grade line of the longitudinal profile. See the Methodological Application Guide.

We must evaluate the area that the pre-existing linear structure occupies and then, we save and exit.

Finally, we link a closed polyline to any linear infrastructure that can be crossed with our road.

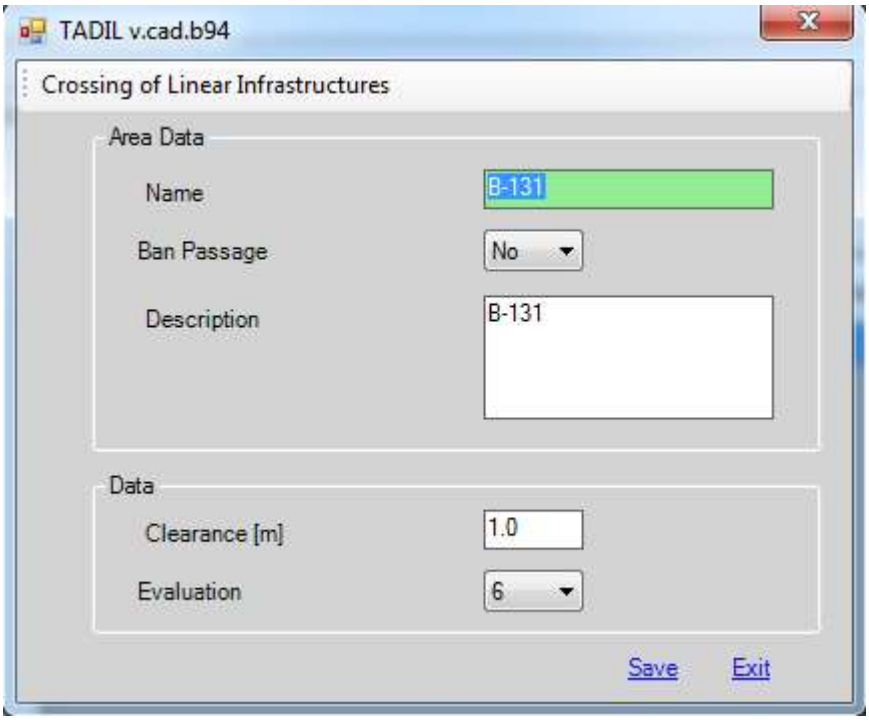


Image 74. Entering crossing of linear infrastructures data.

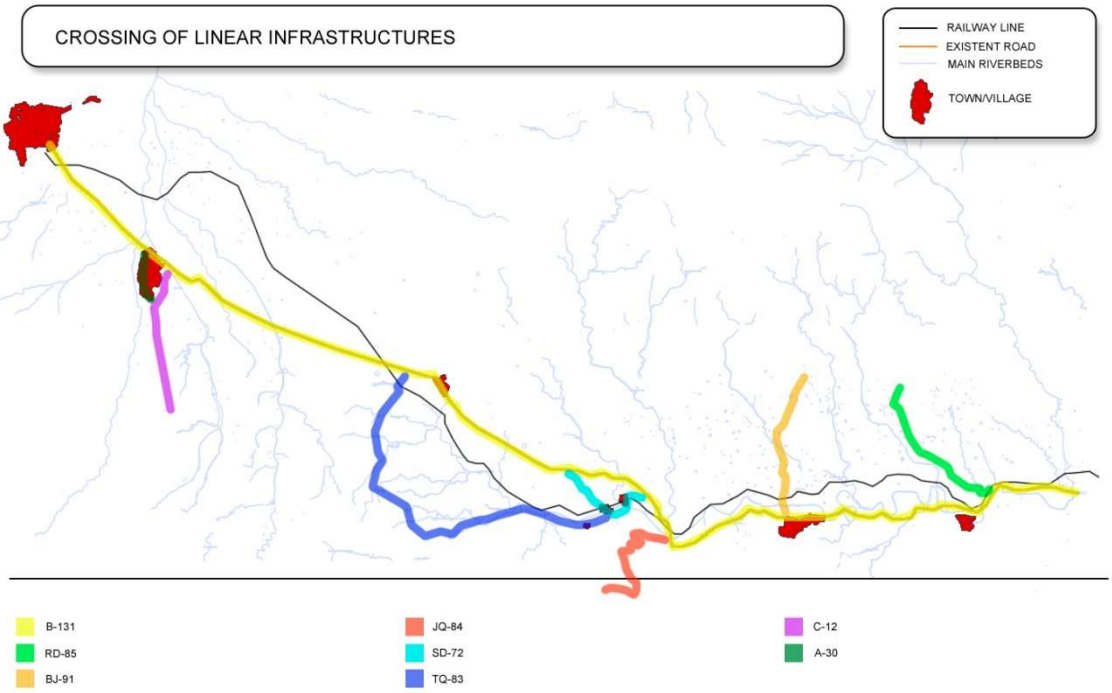


Image 75. Areas linked to the different crossing of linear infrastructures areas.

11.2.2.6.3. Example of widening of road stretch Villa Ana – Pueblo Viejo

Next we include the remaining patrimonial variables we have considered in our example.

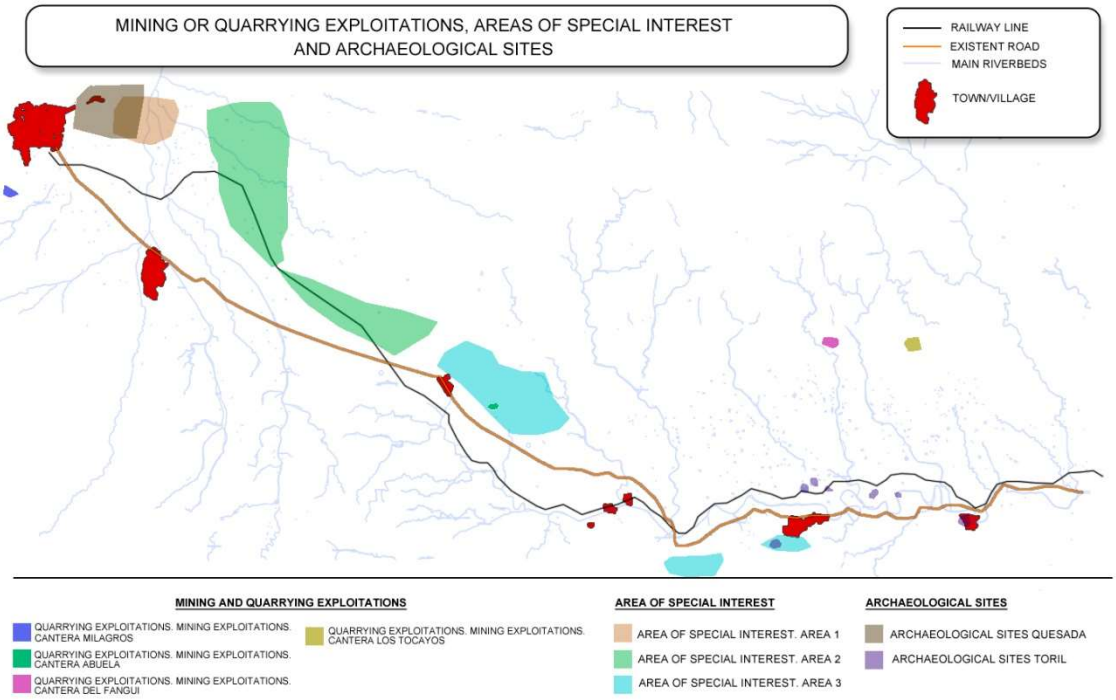


Image 76. Areas linked to the different mining or quarrying exploitations, special interest and archaeological sites areas.

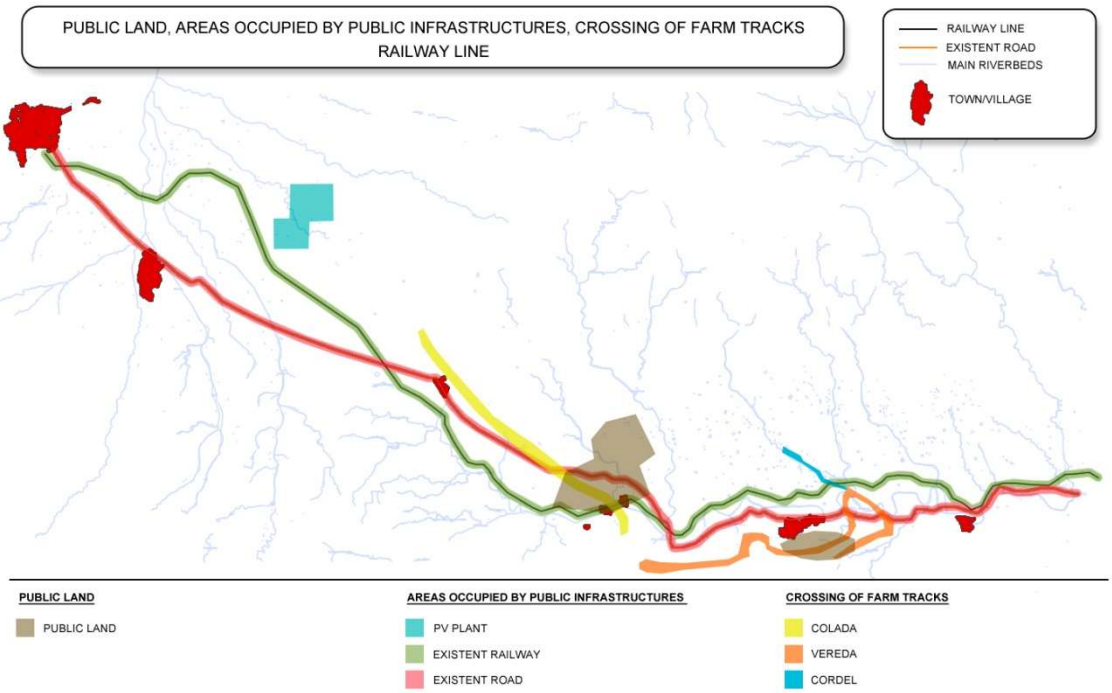


Image 77. Areas linked to public land, areas occupied by public infrastructures and crossing of farm tracks areas.

11.2.3. Macro prices

In this section we must specify the group of macro price of the type section of our road. As type section we can consider simple road or double road and under the category of double road, we can choose between dual carriageway, controlled-access motorway or dual carriageway without central reservation. In each section we can create different records of groups of macro-prices, according to the intrinsic features of the land. That is, each record is a combination of macro-prices which must be in line with the infrastructure type and the land features we have. So, for example, it will not be the same if we create a road in a very rainy area, where more important drainage works are required, than if we do that in a drier area.

It must be noted that the concept of macro-price includes every construction unit comprised in the corresponding section. In general, these prices are given by the draft length unit and we must confine ourselves to the experience in the project and construction of infrastructures to give these costs. The macro-price of Health and Safety is measured as a percentage in the budget of material execution of the work.

11.2.3.1. Macro-prices for simple road

- **General type**

To add a new record of macro-prices appropriate for the type section of simple road, we click on "New". Afterwards, we can edit or remove this record by clicking on "Edit" and "Remove".

Then, we move on to select the macro price of the longitudinal and transversal drainage, of the signalling, beacons and traffic barriers, of the replacement of services, of the geotechnical corrections, of the provisional diversions, of the complementary actions, of the corrective measures and of the health and safety. Previously we have defined the macro prices in "Construction units and prices". Once selected, we obtain a new record of macro-price. We click on "Save" and we exit.

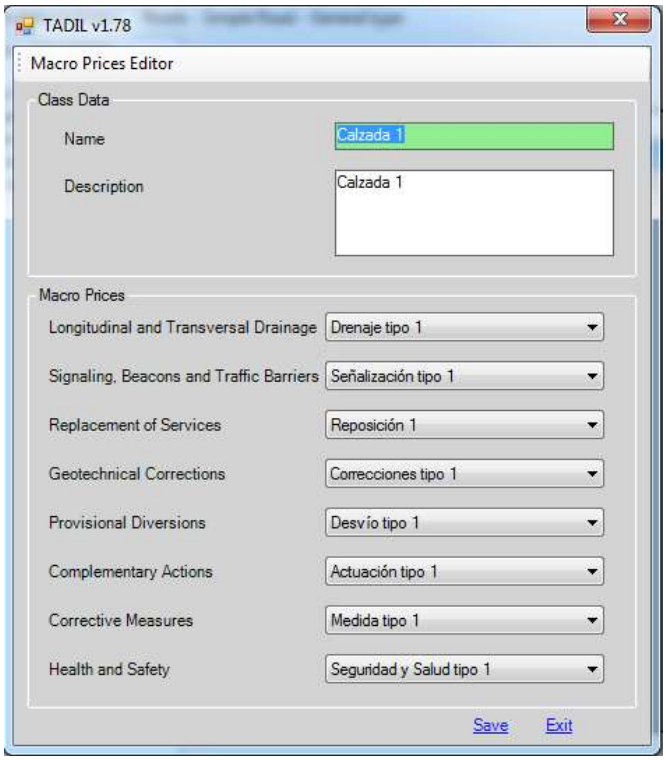


Image 78. Entering macro-prices for simple road data.

11.2.3.2. Macro-prices for double road

We follow just the same steps as we have done in the previous section; the costs must be in line with this type of infrastructures.

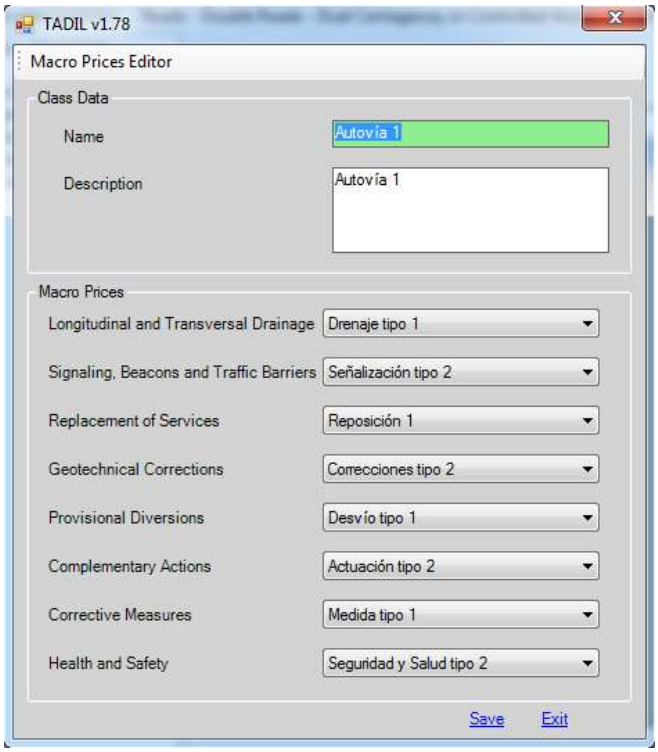


Image 79. Entering macro-prices for double road data.

11.2.4. Sections

This last section of TDB addresses to specify the geometry of the section of the ditches and the section of the road.

11.2.4.1. Ditches

- **Triangular ditches**

To create a new type of ditch we click on "New". In this menu, we name and describe the ditch and, afterwards, we define its geometrical conditions. Finally, we save it and exit.

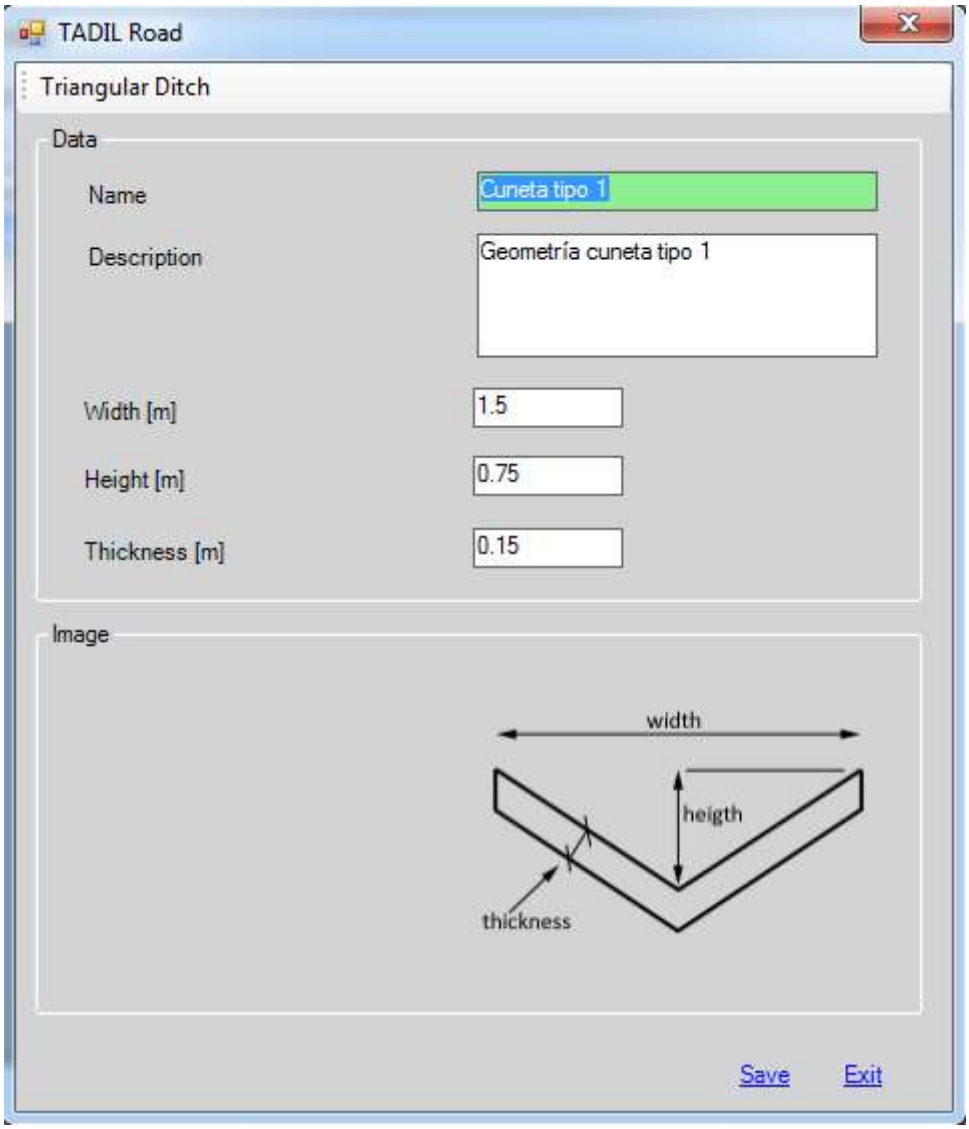


Image 80. Entering ditch data.

- **Trapezoidal ditches**

We follow the same steps as in the triangular ditches.

11.2.4.2. Roads

11.2.4.2.1. Type Section of Simple Road

- **General type**

We create a new record of simple road by clicking on "New". This new record can be edited or removed.

The first thing to do when creating a new type of section of simple road is to name and describe it.

The next step is to define its ditch. We can choose if the ditch is triangular or trapezoidal. Once we have chosen the type of ditch, we can move on to specify its geometry. We have previously created the different geometries of ditches in the section "11.2.4.1. Ditches".

Likewise, we have previously fixed the variety of prices for the ditches that TADIL offers now in "Construction units and prices". At this point, we should highlight that the price given must be consistent with the type of ditch selected.

Finally, to complete the ditch data of our section of simple road, we need to choose its location, at the level of the berm or at the starting level of the roadbase layers.

After that, we specify the road geometry. Generally, the geometry values correspond to the criteria specified by the administration or the regulations as well as to the traffic capacity study, which determines the number of requested lanes.

We can also display a section scheme.

After having introduced all the data, we click on "Save" and exit.

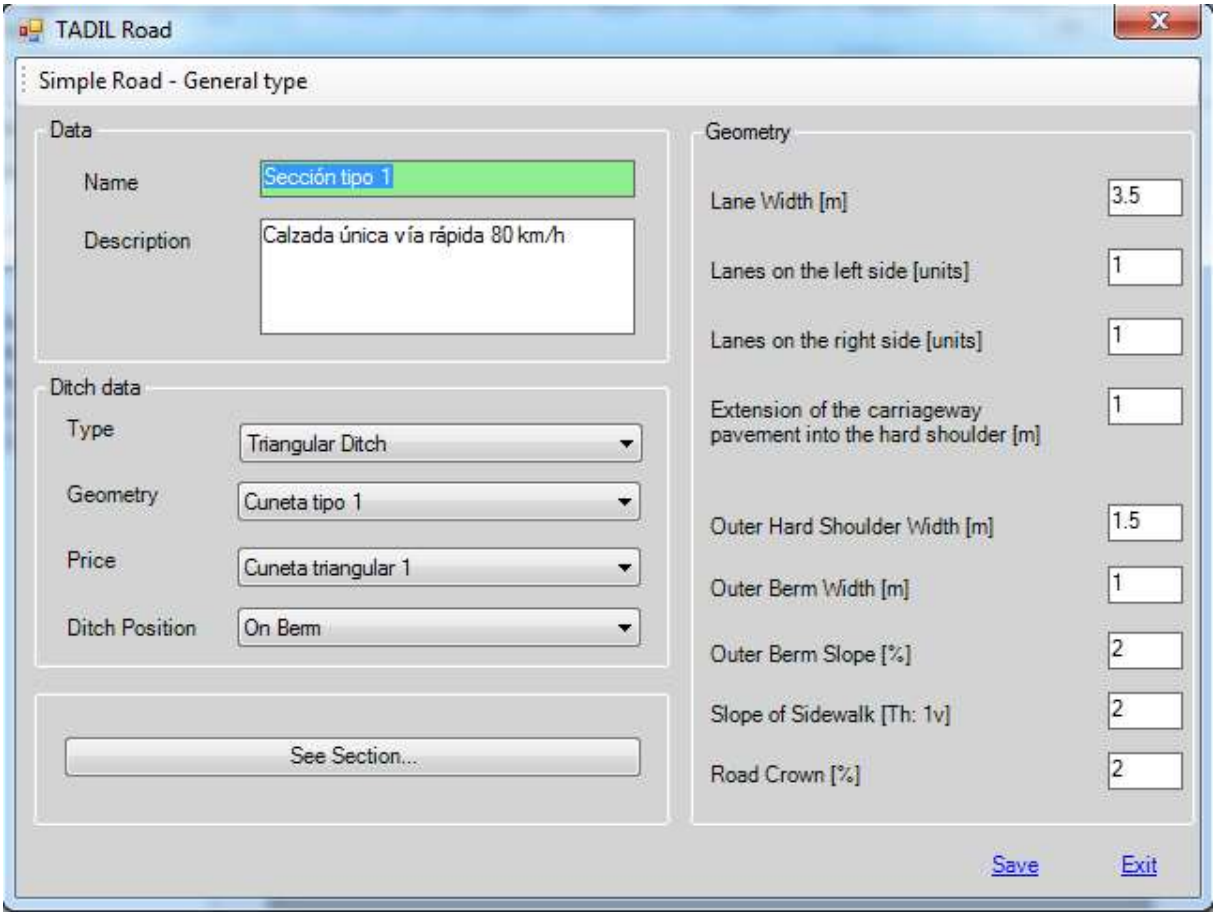


Image 81. Entering type section of simple road data.

11.2.4.2.2. Double road

- **Dual Carriageway or controlled-access motorway**

We enter the values following the same steps as in the simple road.

The main difference is that in this case there are two directions of traffic separated by a central reservation with internal ditch. We cannot choose the location of the internal ditch because it is placed in the central reservation.

Once we have determined all the data, we save them and exit.

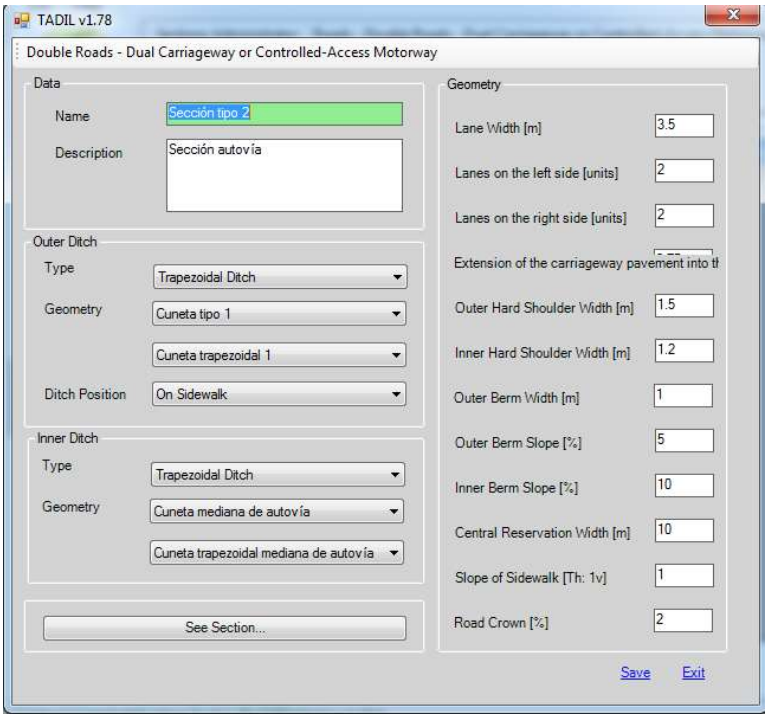


Image 82. Entering type section of double road data.

- **Dual Carriageway without central reservation**

We find ourselves before a particular case of the previous one. This type does not have central reservation, so we put a barrier between both lanes as traffic protection and division. This barrier is defined by default in the software. If we want to propose another type of barrier, we must save it in .dwg format and save the file into the software folder, inside the folder "cad", inside the folder "sec", inside the folder "bar".

After filling out all the gaps, we save and exit.

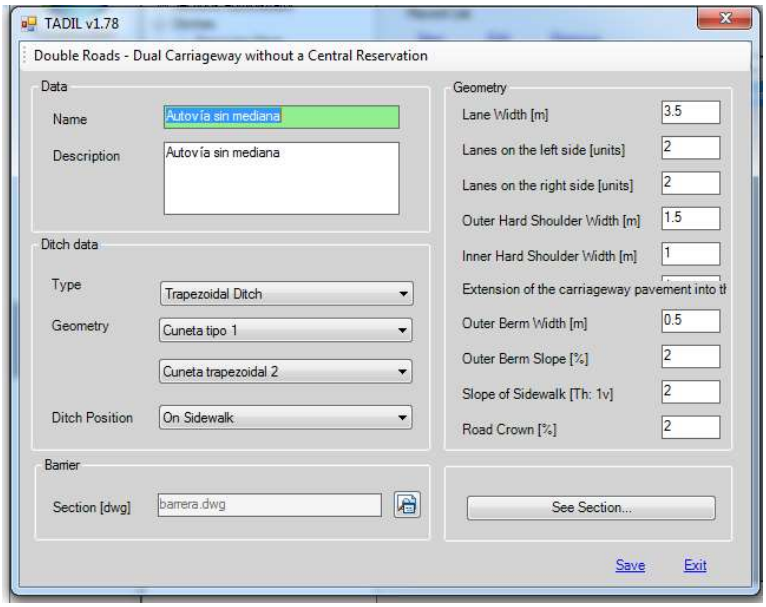


Image 83. Entering dual carriageway without central reservation data.

11.3. TDI implementation – Generating design in informative studies

When we have completely defined the database of our project, we can move on to develop a full informative study. In this section we are going to see how the design of different alternatives is generated.

11.3.1. Generating an informative study

The first step is to name the informative study. We select "New Informative Study" and in the emerging menu we write the name of our file; for our example, we choose the name "Valle Villa Ana.tadil".

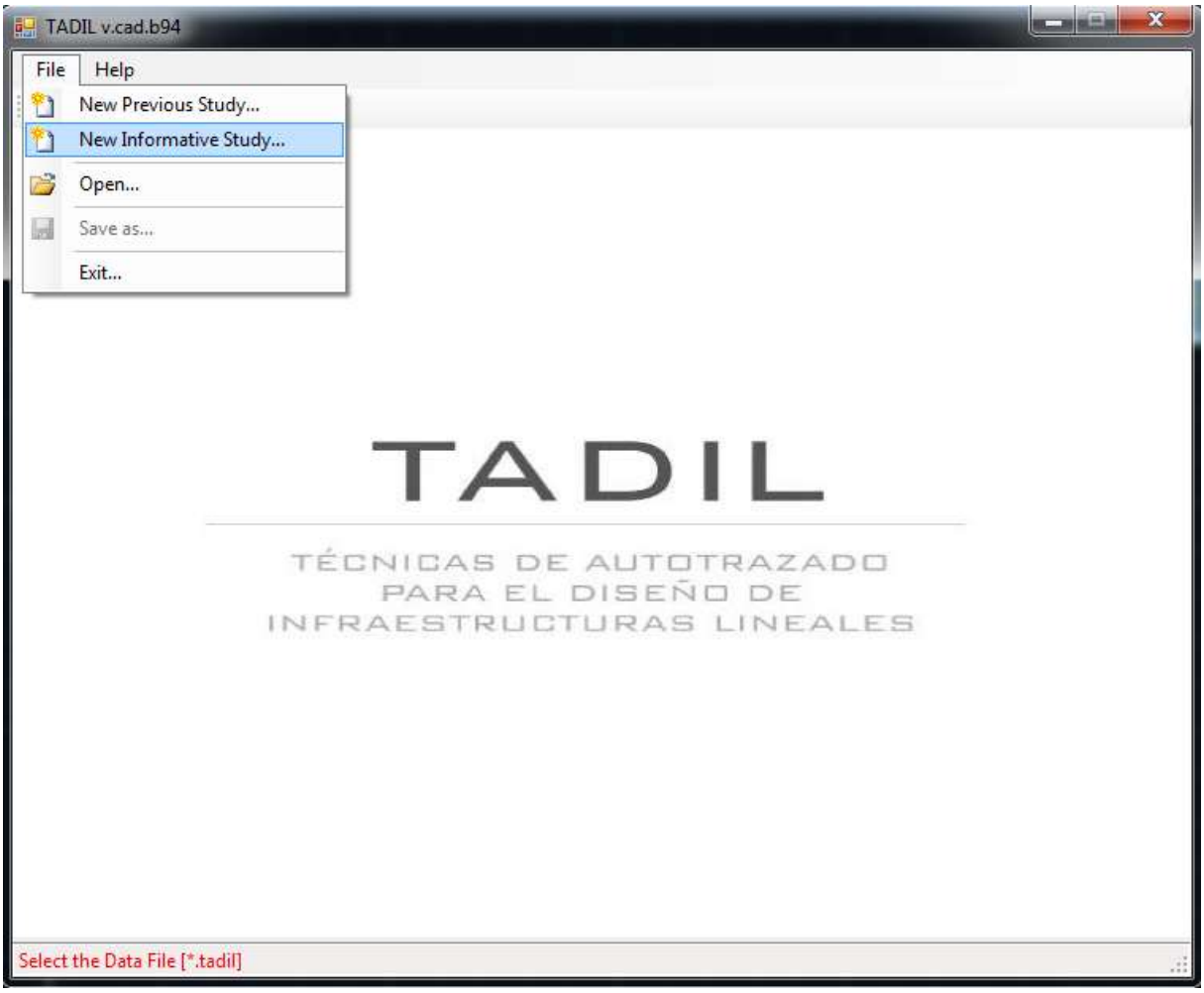


Image 84. Creating a new informative study.

11.3.2. Settings

- **File Paths**

First we must specify which regulation and database we are going to use for carrying out the informative study.

TADIL comes by default with the Spanish Regulations but the user will be able to enter the convenient regulations at any time, as explained in section "10.1.2.1. File Paths" of the previous study.

In our example, we will use the default one. Therefore, we push the "Select" button. Then, a window opens and, in the Software Folder we open the folder "dat". Finally, we open the folder "regulations", select the regulation and save.

Next we must load the database TDB that we want to use. In our case, we load the database we have just created. We click on "Select" and we look for the file we have just created.

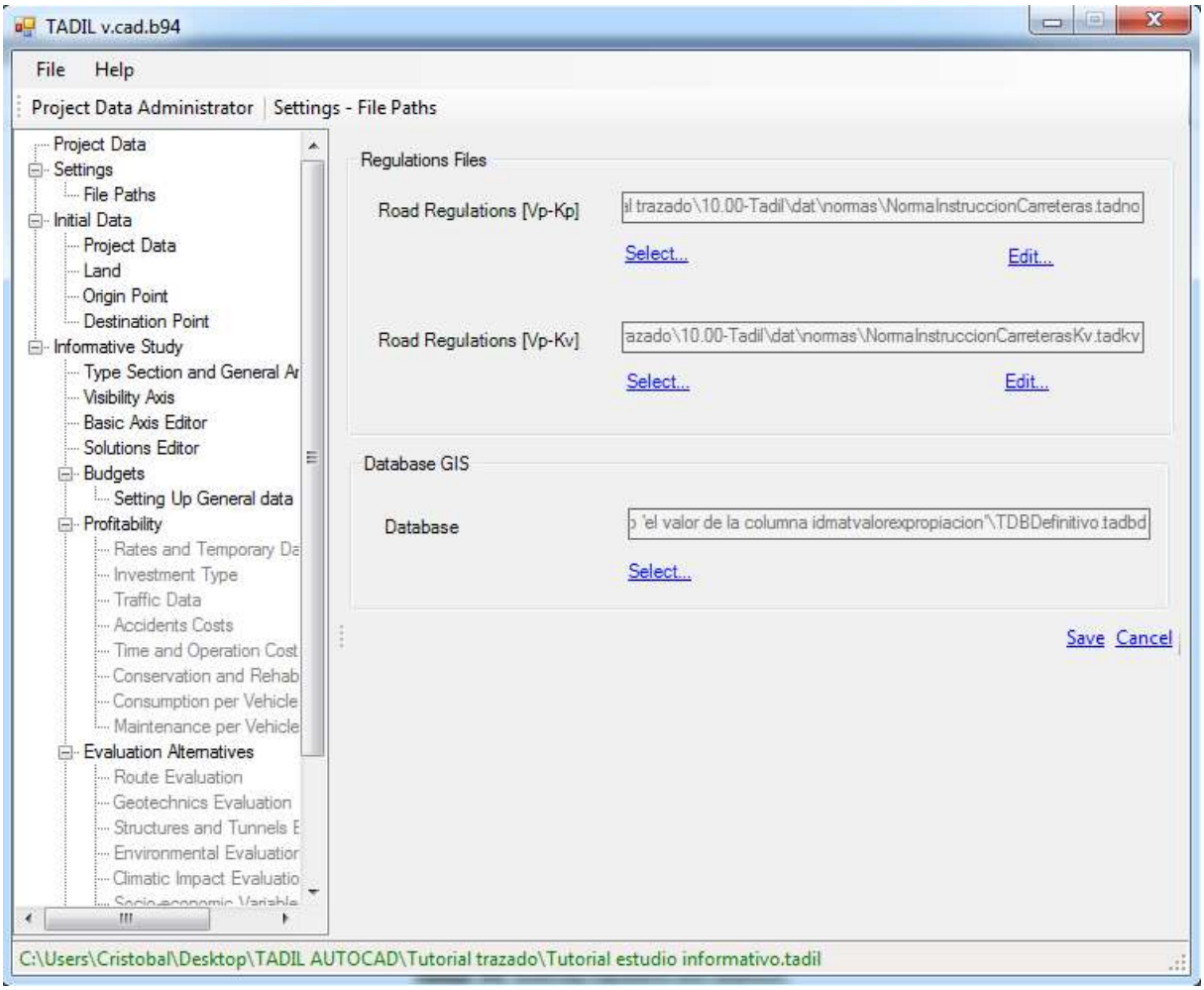


Image 85. Entering regulation and database.

11.3.3. Initial data

11.3.3.1. Project data

In the menu "Project Data" we enter the name of the study and its description. The interval of sections is greatly important in the study of the design to develop as it conditions the gap between the cross sections to obtain and, in consequence, the measure accuracy and the work budget. When we expect great accuracy, we must set the interval of 20 or 25 m. However, we must take into account that the nearer between sections, the slower the calculation time and obtaining of results. In general, we recommend elaborating calculations every 100 m for roads longer than 10 km (for all the alternatives), allowing the comparison between them and finally, carrying out the study with a lower distance (25 m for example) for those two or three solutions with better punctuation.

On the other side, the plan of earthwork will be also more accurate if they are nearer.

In our example, we have considered a gap of 100 m, which we apply to every alternative of the study. We click on "Save" and our conditions are defined.

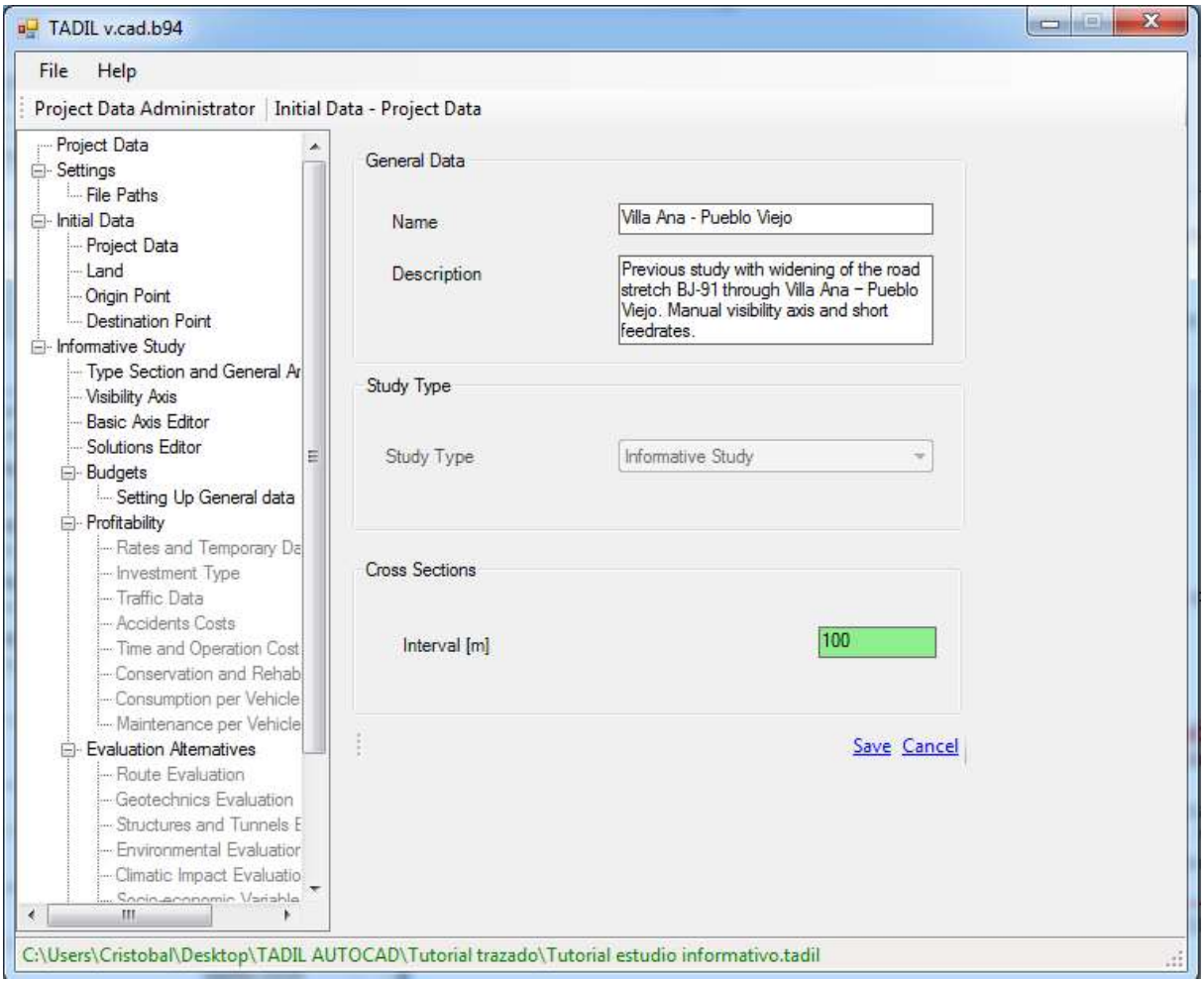


Image 86. Entering the name, the description and the interval between cross sections.

11.3.3.2. Land

We can enter additional banned areas to those created in the Geographic Information System. We can also remove areas with important natural slopes or areas according to our criteria, as explained in the previous study.

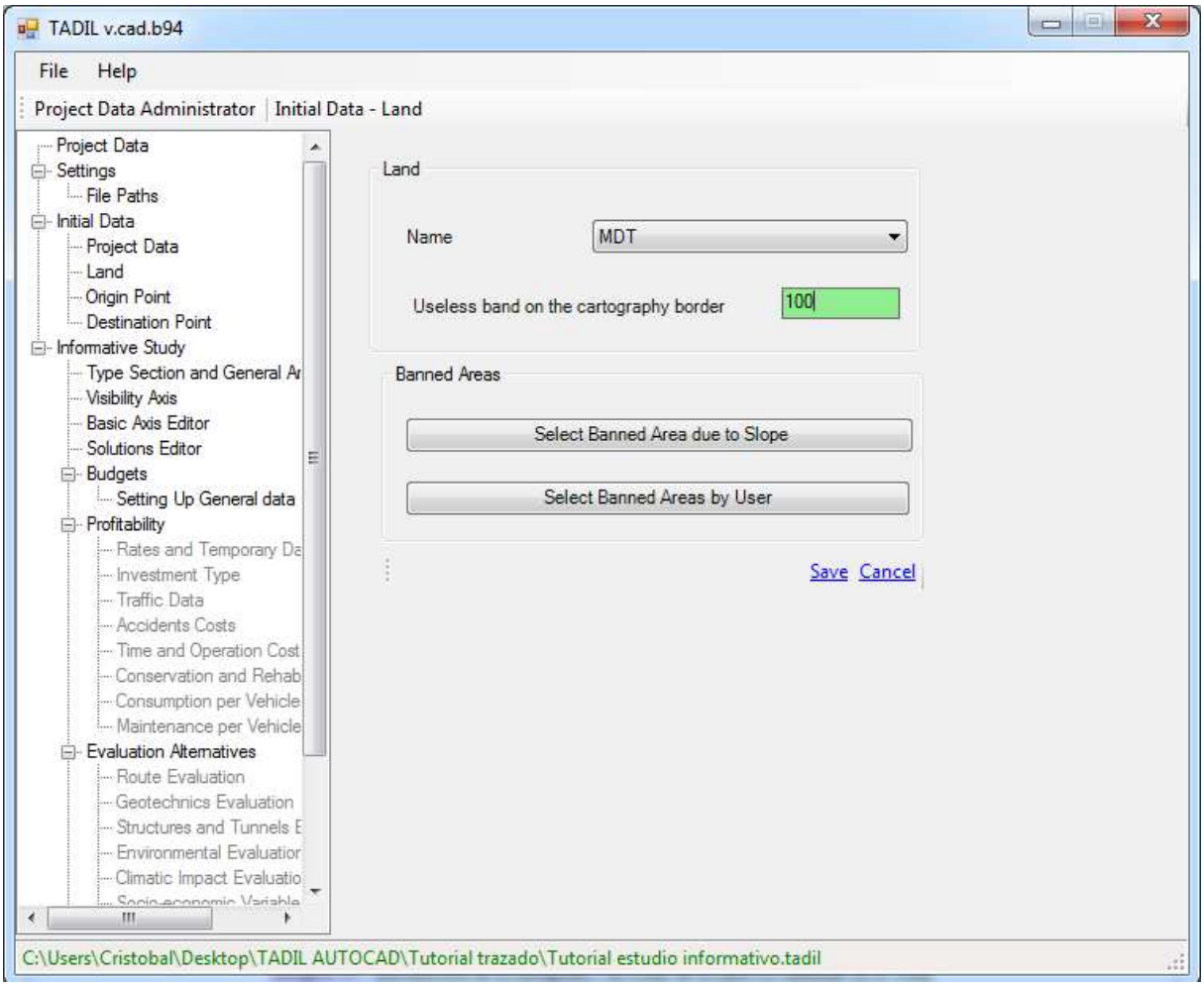


Image 87. Entering the cartography and the banned areas not defined in the TDB.

11.3.3.3. Origin and Destination Point

We consider the same data as in the previous study. See below.

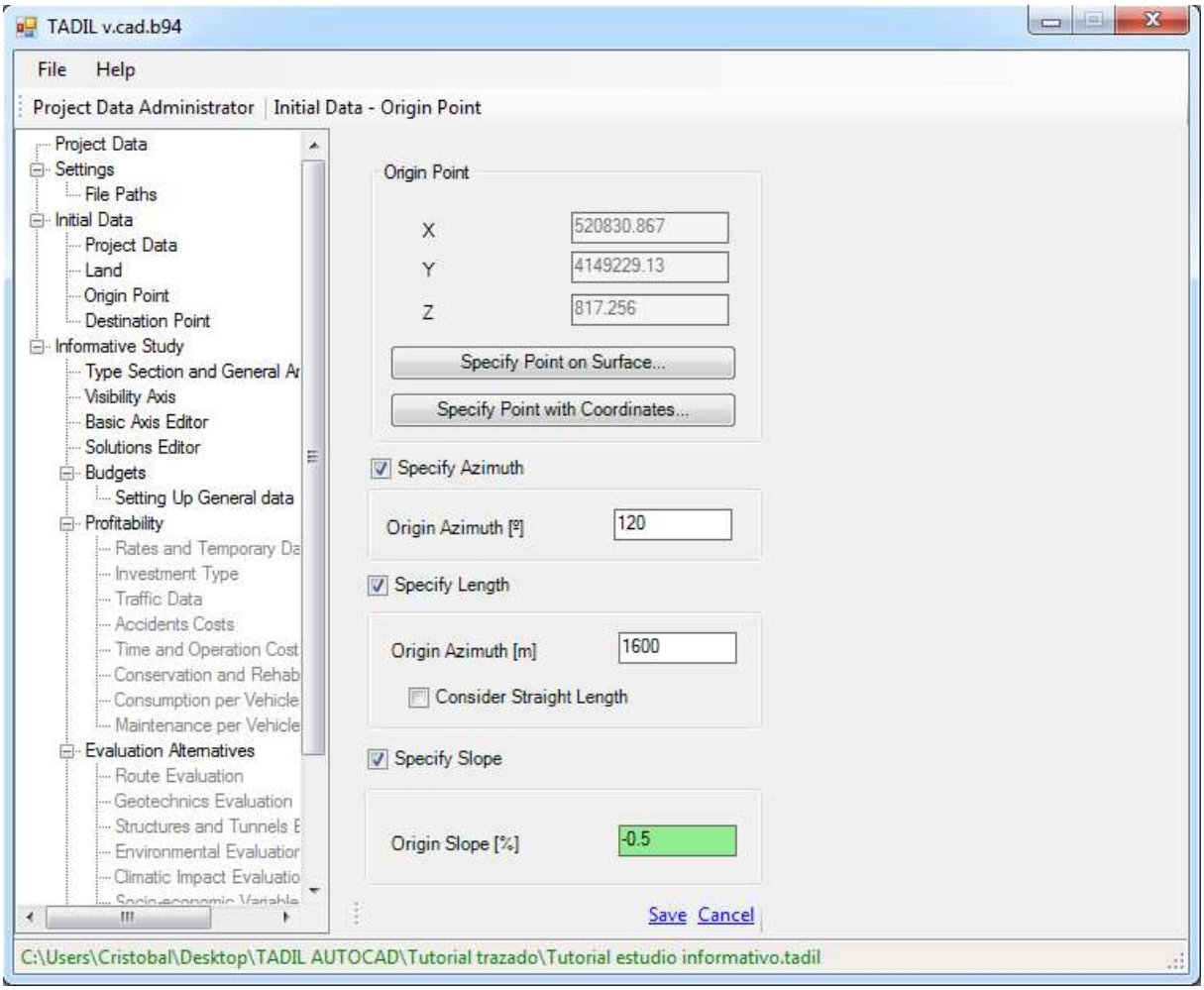


Image 88. Entering origin points data.

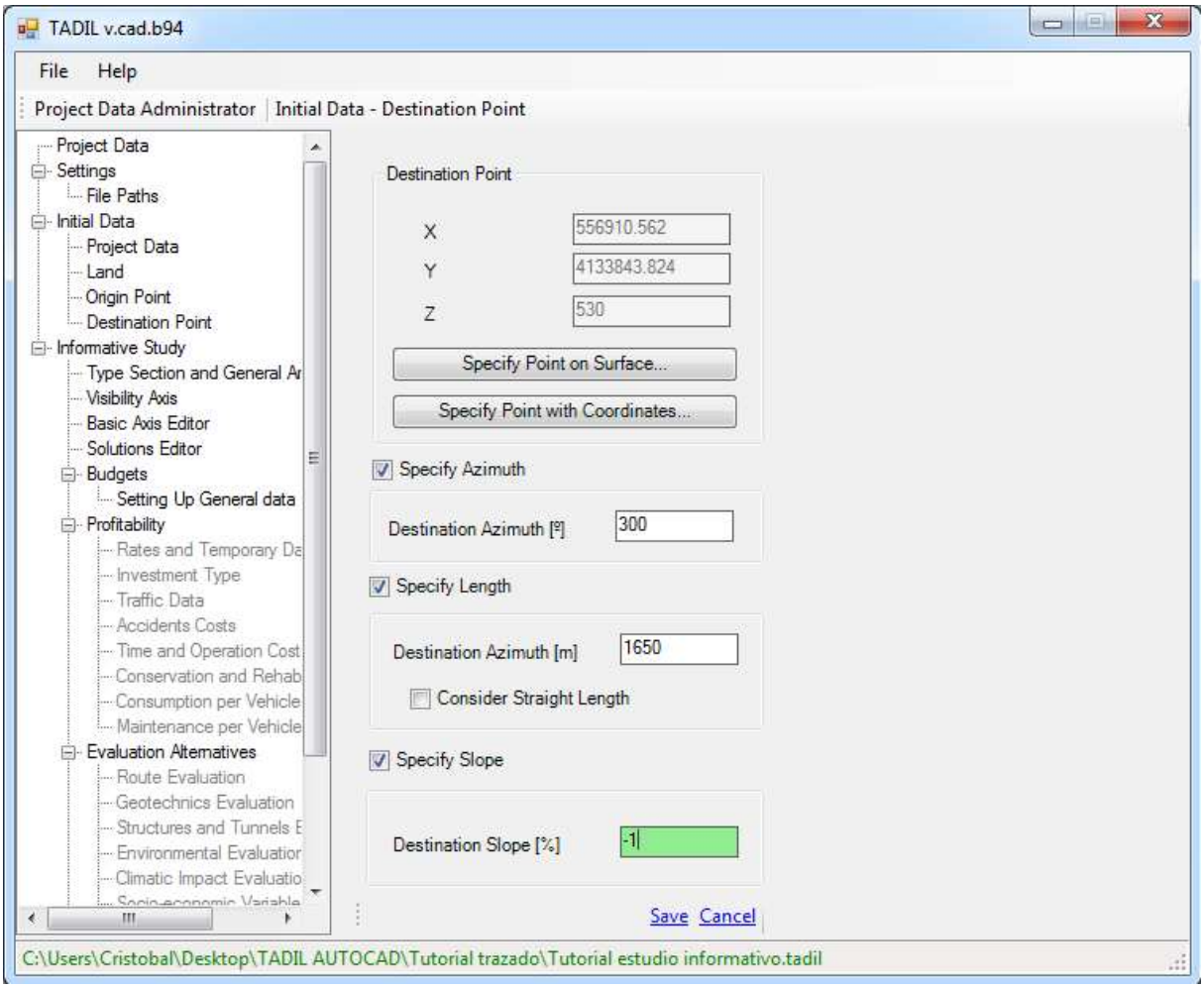


Image 89. Entering destination points data.

11.3.4. Informative study

11.3.4.1. Select section, macro-prices and general areas

In this menu we can select, from the basis of prices, the group of macro prices which best fits with the type of infrastructure we intend to develop. This will allow completing the construction budget.

Likewise, we can select the general area for earthwork, foundation, structures and tunnels. The general area represents the dominant area in the studied sector, so that when a point does not belong to a specific sector of earthwork, foundations, structures or tunnels, a general area is assigned. This process avoids problems from incorrect assignment of polylines and makes the calculation of homogeneous areas easier.

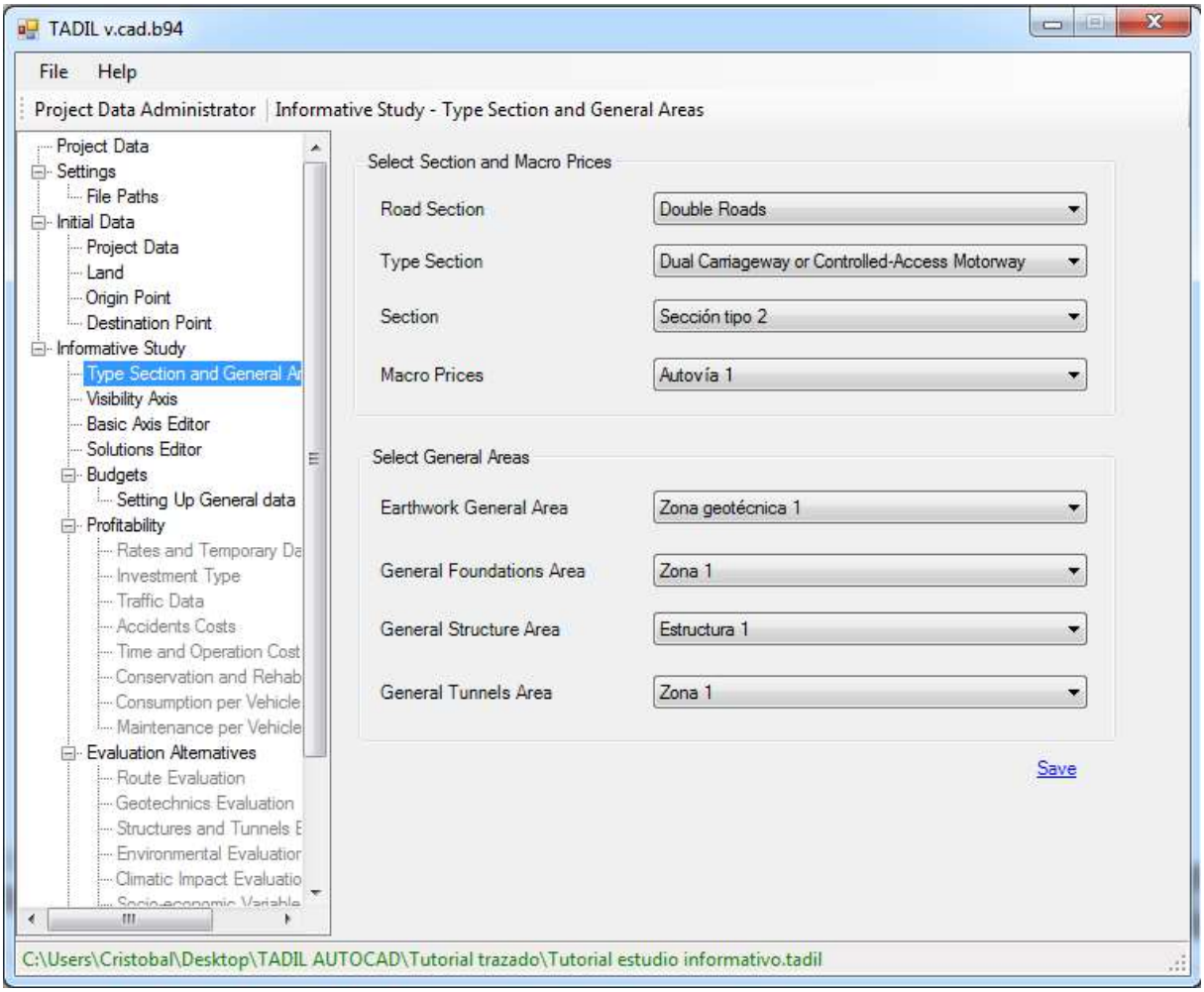


Image 90. Entering the section, macro-prices and the general areas.

11.3.4.2. Visibility axis

At this point, we can calculate the automatic visibility axis between the end of the origin alignment and the start of the destination alignment. In our example, we will use an automatic visibility axis.

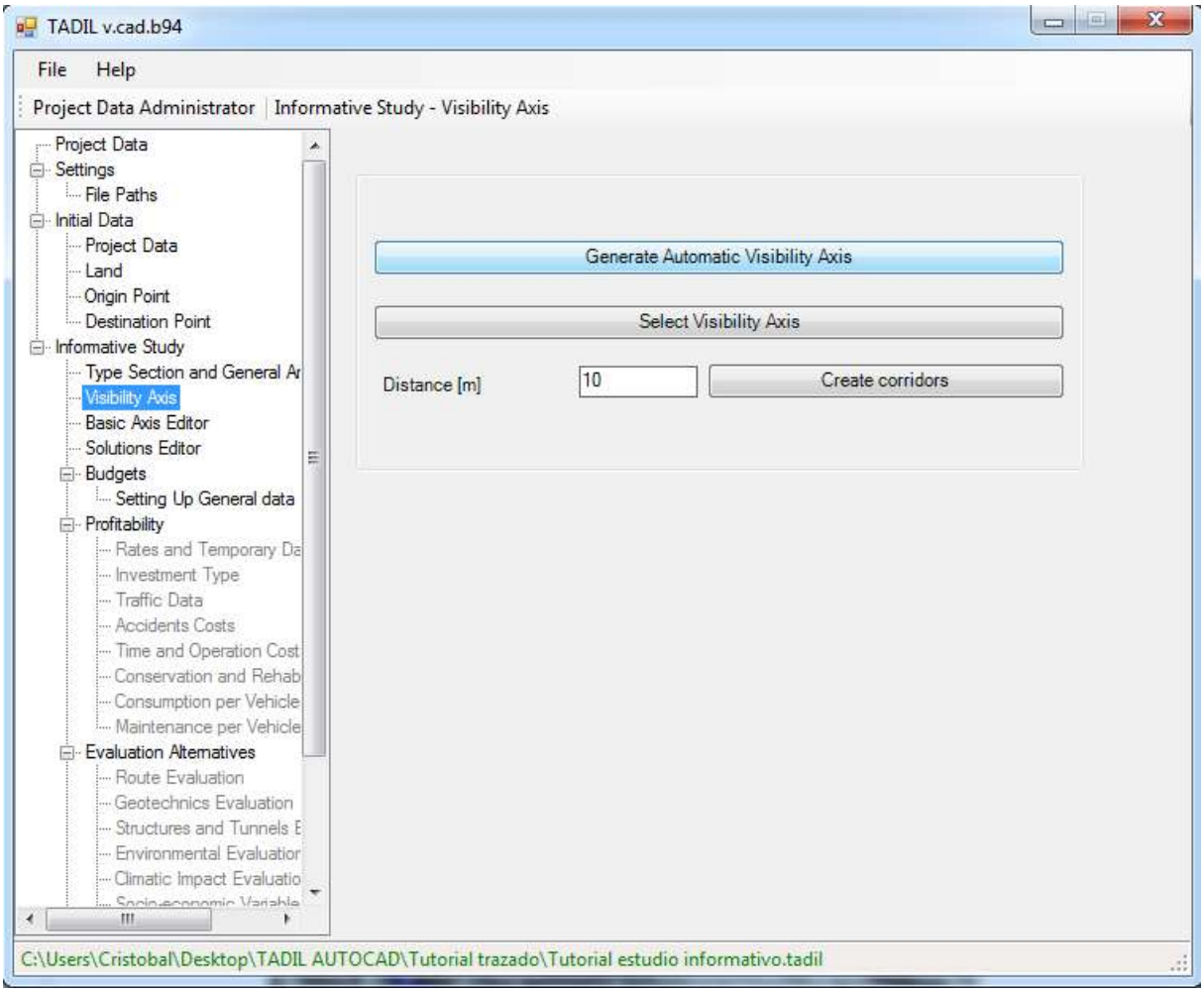


Image 91. Visibility axis.

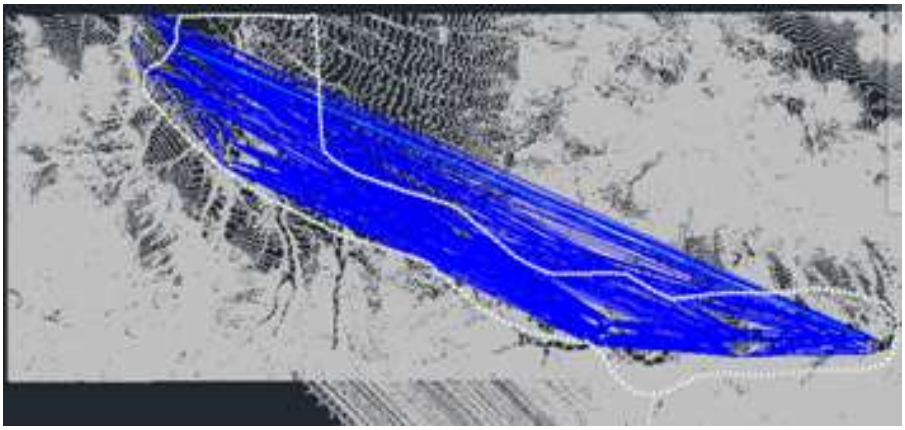


Image 92. Creating the automatic visibility axis.

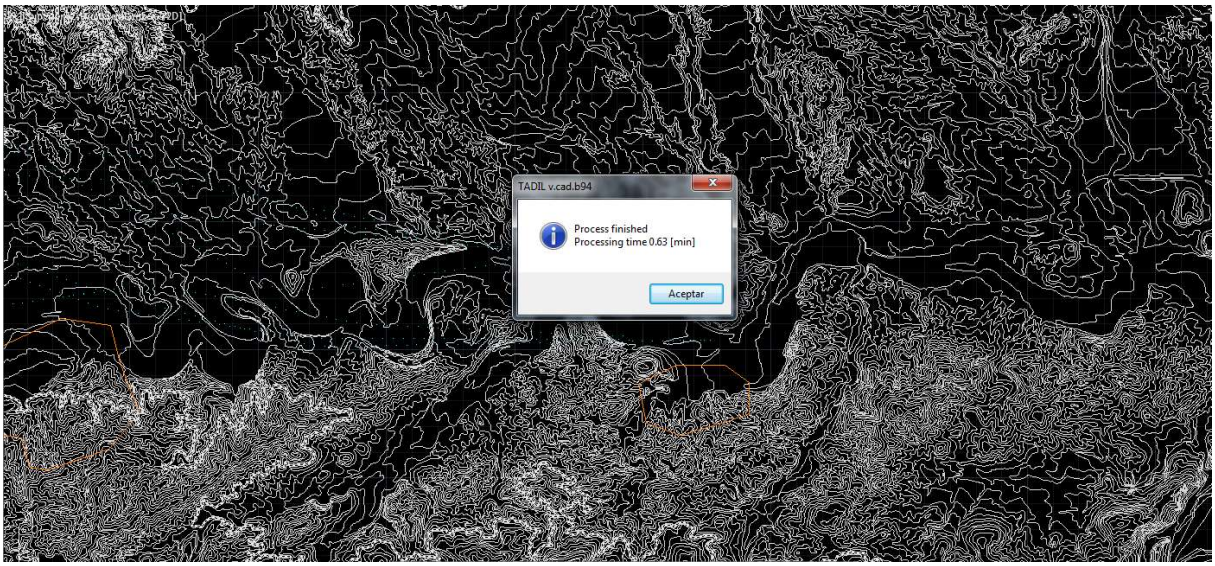


Image 93. Creating the automatic visibility axis and the invested time.

11.3.4.3. Basic Axis Editor

In this section we introduce the features of the infrastructure to plan. Unlike the previous study, we can see that in this case the tab "Geometry and Costs" does not appear. This is because in the informative study, data come from the Geographic Information System and from the construction units we have entered.

For our example, we have considered the same features than in the previous study, 120 km/h dual carriageway in the Class 1 and with minimum kv. In the remaining menus, we have considered maximum slopes of 7% in roads and 5% in structures. We apply a 0.85 reduction coefficient to these values entered in the last tab.

For the dynamic evaluation we have also considered the same percentages of evaluation for distance, cost and orography.

Finally, we consider default values for calculating in the section Advanced Options 1.

For more information about these menus, go to section "10.1.4.2. Basic axis editor".

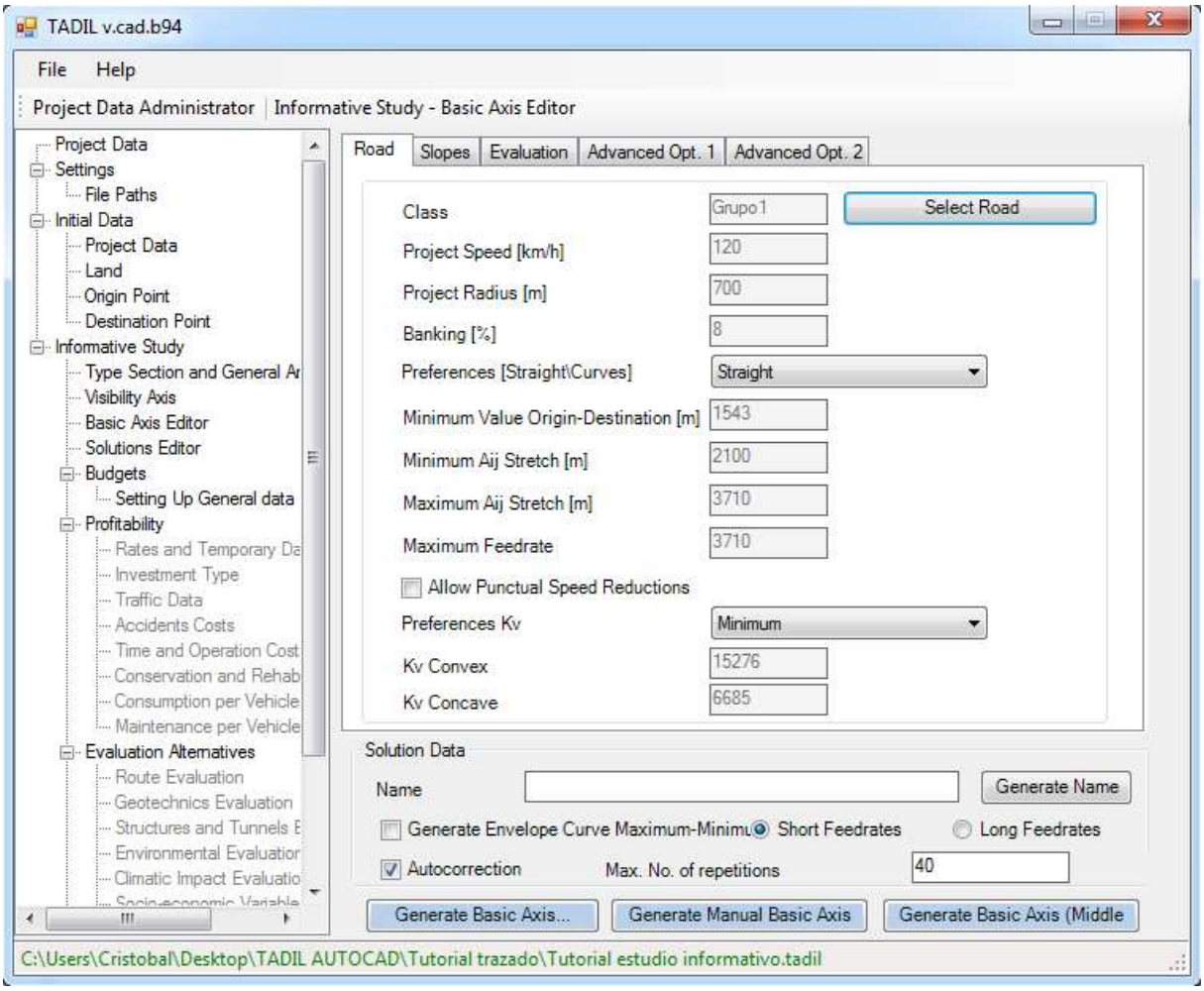


Image 94. Selecting the road.

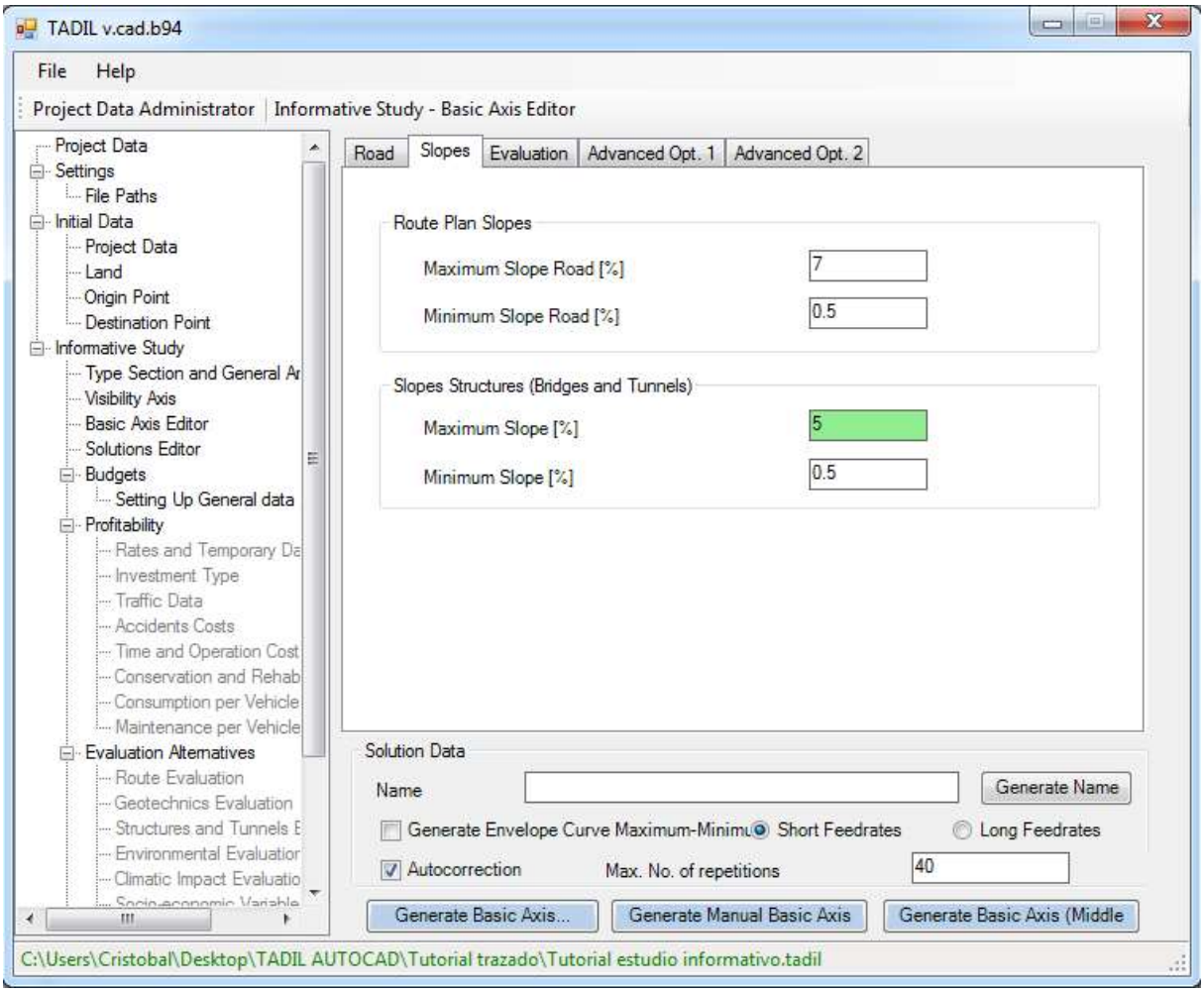


Image 95. Entering slopes.

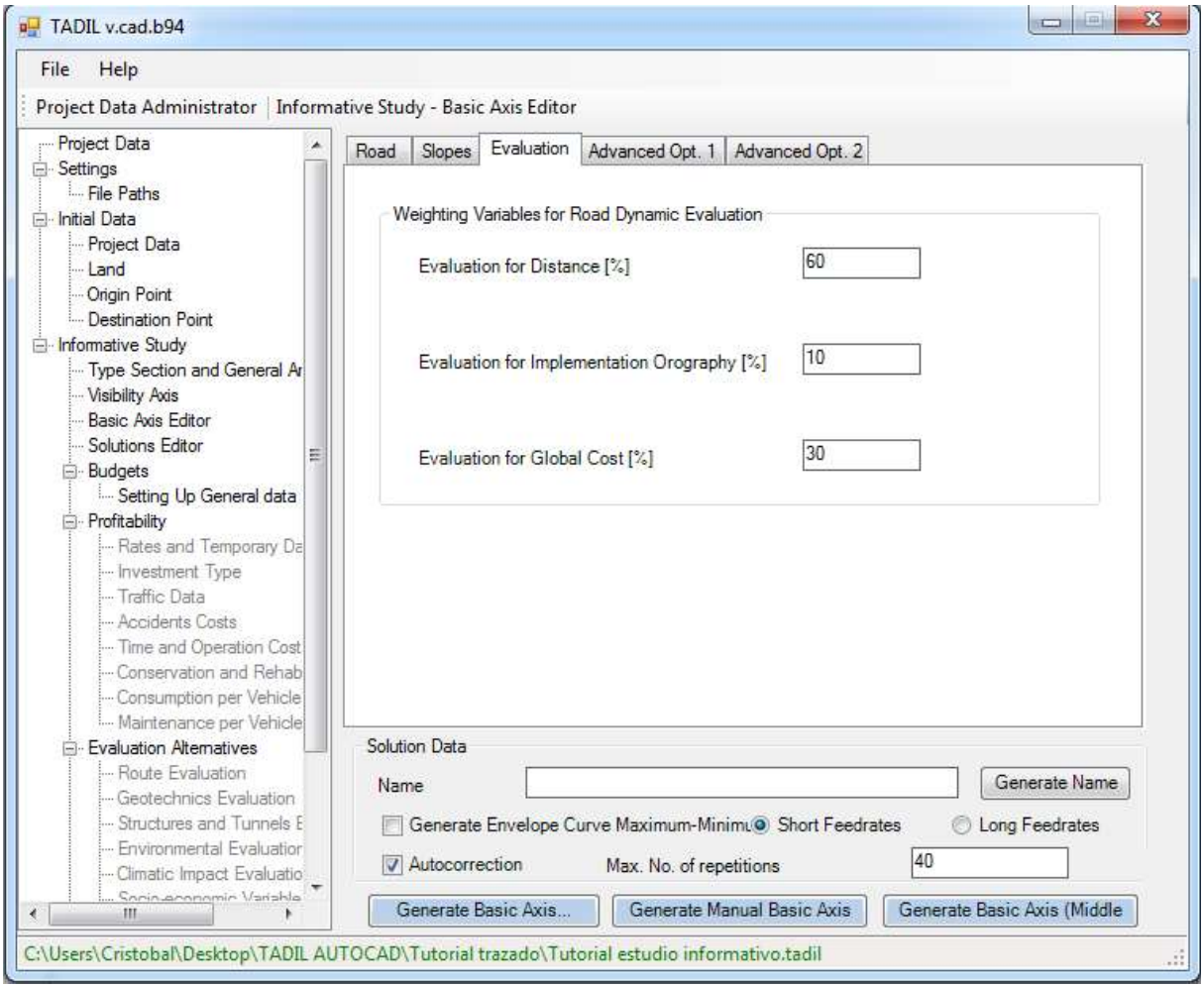


Image 96. Entering evaluations.

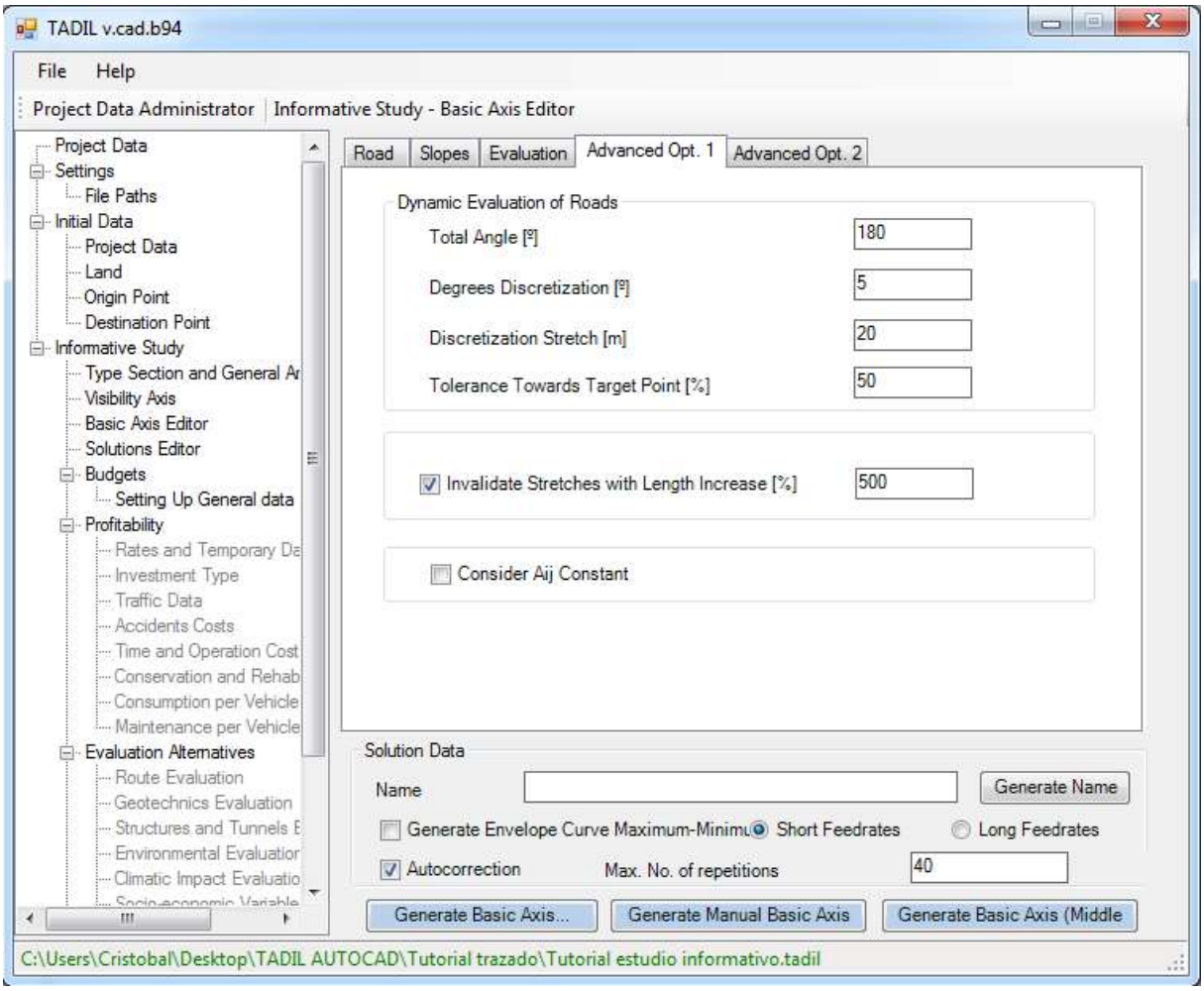


Image 97. Entering advanced options 1.

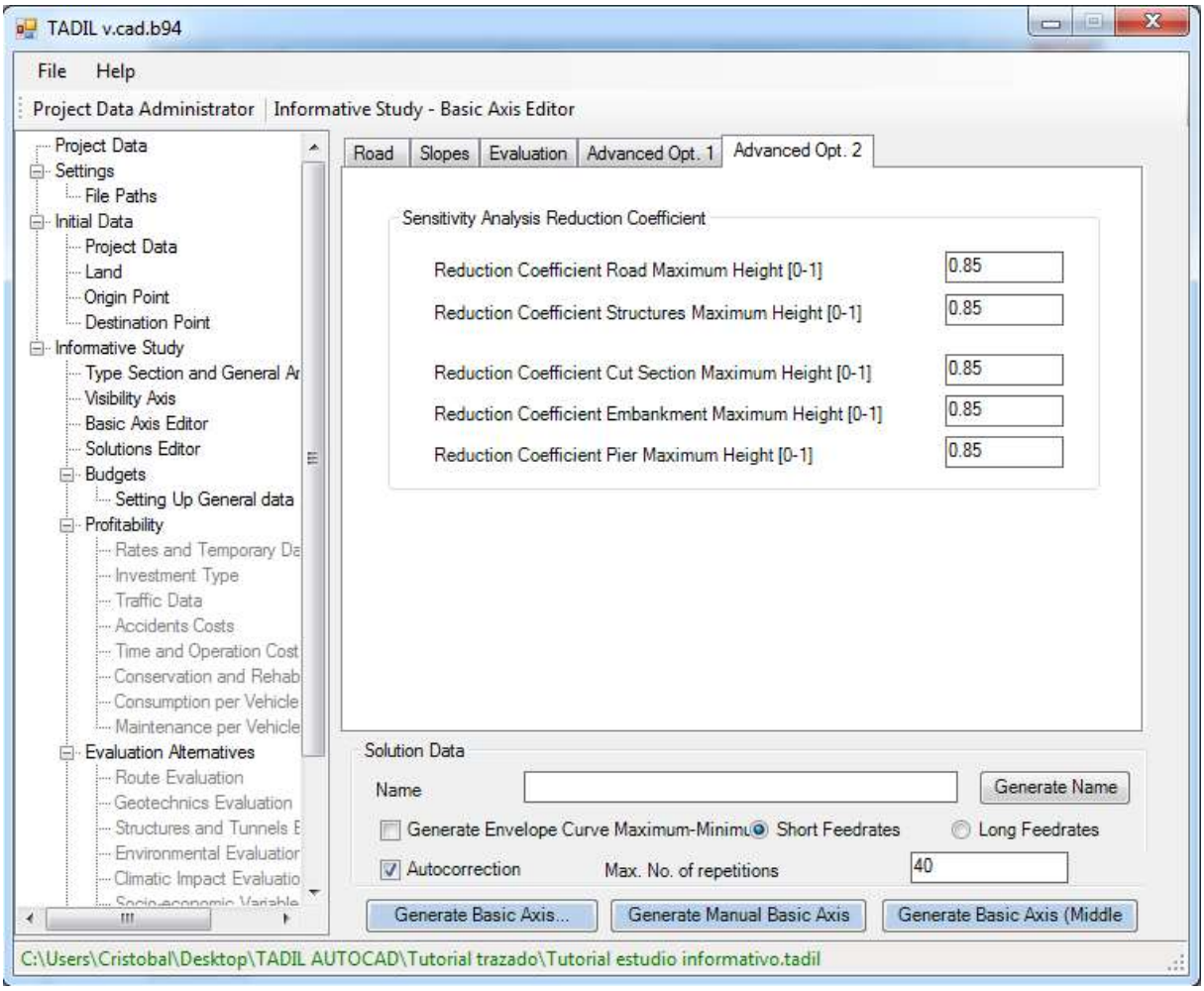


Image 98. Entering advanced options 2.

Then, we calculate the basic axis of the alternative itineraries.

First, from an automatic visibility axis, we calculate automatically the basic axis with two minimum and maximum envelope curves so generating three alternatives. Likewise, we will calculate a fourth alternative with an automatic visibility axis, calculating the basic axis to middle point.

To carry out a meticulous study, we can also create manually a visibility axis, which would allow us to create more basic axis and, therefore, more alternatives. In our informative study we use the same visibility axis created in the previous study, by drawing the same polyline, clicking on "Select visibility axis" and clicking on the polyline. So, we have another visibility axis.

We generate three more alternatives with this new visibility axis, with short feedrates and minimum and maximum envelope curves.

We will study a eighth alternative with manual basic axis in order to set the road as closer to the adjoining towns as possible.

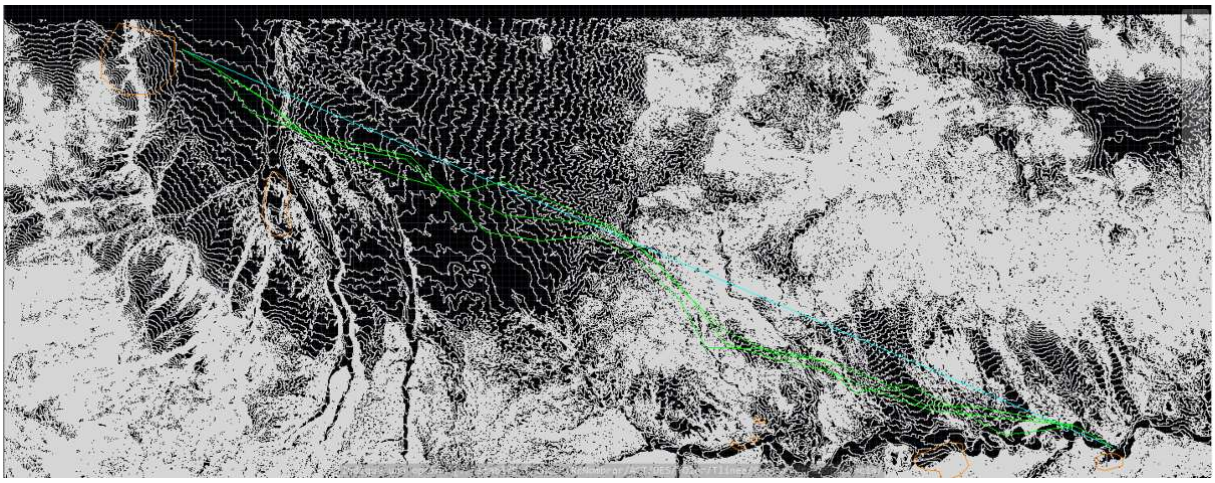


Image 99. Generating the three first basic axis.

11.3.4.4. Solutions editor

Firstly, we calculate the basic axis related to the primary solution of the automatic visibility axis and its minimum and maximum envelope curves. The basic axis of the three alternatives will appear ticked as calculated in the solution editor.

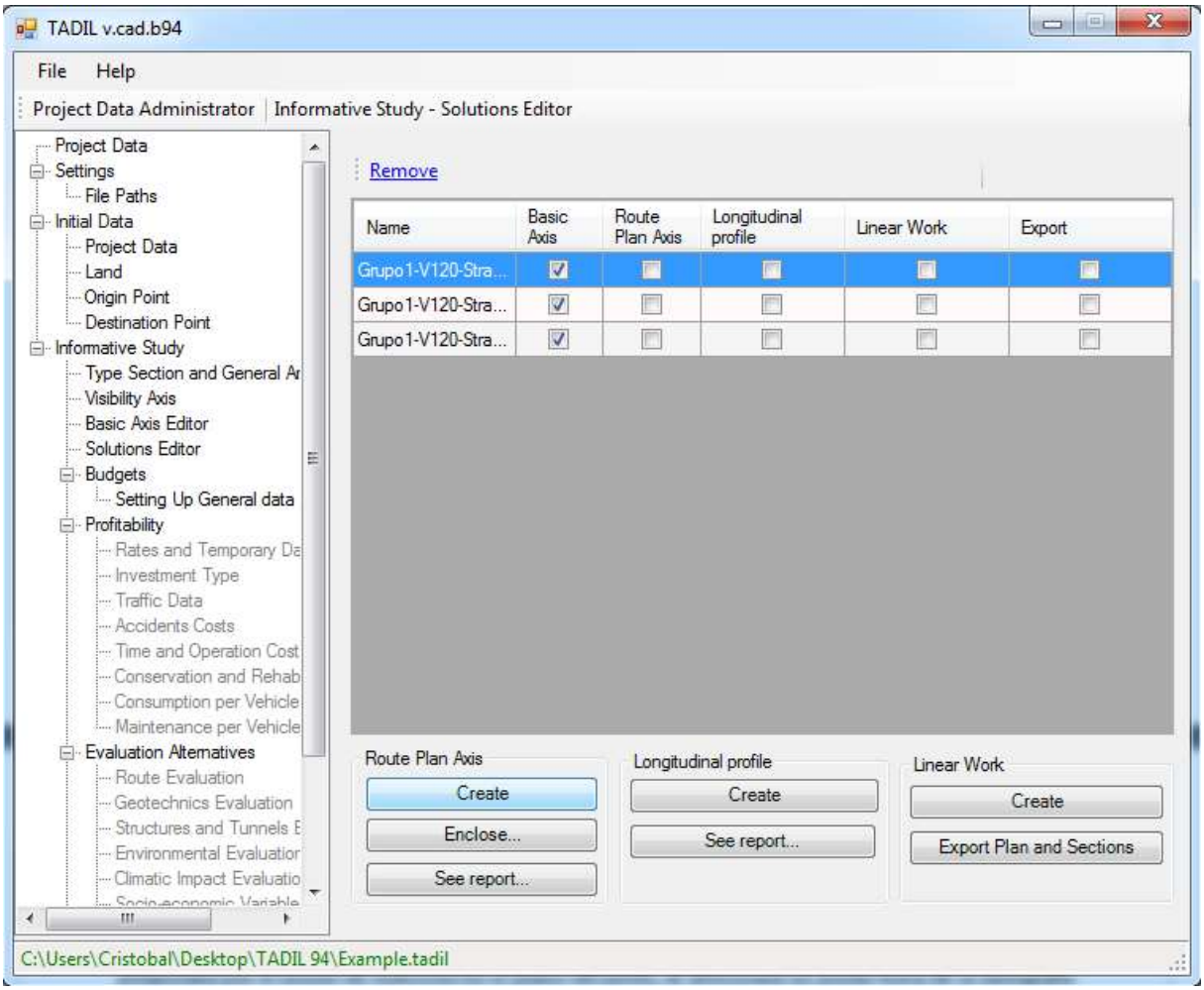


Image 100. Solutions editor.

- **Route plan**

Therefore, we can calculate the route plan axis solution by solution.

After doing so, they will appear ticked in the solution editor.

TADIL offers the possibility to create and see the report of the route plan, specifying the geometric characteristics of the alignments (straight lines, clothoids and circular curves). We can see the straight lines are coloured in red, the clothoids in green and the curves in yellow.

TADIL Road sin logo

Segment	Vertex	Element	Type	Final Azimuth	Start Point X	Start Point Y	End Point X	End Point Y	Centre Curve X	Centre Curve Y	Radius	Turn Direction	A clothoid	Length	Initial K.P.	Final K.P.
1		Straight Line	Stay firm	10.7852	372308.97	318218.74	372665.1184	320088.3581						1903.2377	0	1903.2377
		Clothoid			372665.1184	320088.3581	372684.2257	320177.978					253.2905	91.6515	1903.2377	1994.8892
	2	Curve	Off Tangent ...		372684.2257	320177.978	372764.0438	320366.5177	373361.8185	320002.2851	700	Clockwise		205.4762	1994.8892	2200.3654
		Clothoid			372764.0438	320366.5177	372815.0927	320442.6151					253.2905	91.6515	2200.3654	2292.0169
2		Straight Line	Stay firm	35.1054	372815.0927	320442.6151	373848.4915	321912.6963						1796.9563	2292.0169	4088.9731
		Clothoid			373848.4915	321912.6963	373907.8627	321994.3429					325.591	100.9614	4088.9731	4189.9346
	3	Curve	O.T.C. Reduc...		373907.8627	321994.3429	373914.3483	322002.6005	374736.8507	321349.9215	1050	Clockwise		10.5	4189.9346	4200.4346
		Clothoid			373914.3483	322002.6005	373979.6013	322079.6275					325.591	100.9614	4200.4346	4301.396
3		Straight Line	Stay firm	41.1876	373979.6013	322079.6275	376618.515	325095.3513						4007.3003	4301.396	8308.6963
		Clothoid			376618.515	325095.3513	376671.147	325157.0849					291.8669	81.1298	8308.6963	8389.8261
	4	Curve	O.T.C. Reduc...		376671.147	325157.0849	376677.7103	325165.2808	375854.8449	325817.5021	1050	Anti-Clockwise		10.5	8389.8261	8400.3261
		Clothoid			376677.7103	325165.2808	376726.4478	325230.1331					291.8669	81.1298	8400.3261	8481.4559
4		Straight Line	Stay firm	36.1876	376726.4478	325230.1331	377859.0561	326778.3492						1918.2738	8481.4559	10399.7297
		Clothoid			377859.0561	326778.3492	377914.7605	326851.1079					253.2905	91.6515	10399.7297	10491.3812
	5	Curve	Off Tangent ...		377914.7605	326851.1079	377919.3402	326856.5217	378451.4743	326401.7325	700	Clockwise		7.0911	10491.3812	10498.4724
		Clothoid			377919.3402	326856.5217	377981.8573	326923.5173					253.2905	91.6515	10498.4724	10590.1239
5		Straight Line	Stay firm	44.2698	377981.8573	326923.5173	380291.436	329292.728						3308.6724	10590.1239	13898.7963

Image 101. List of route plan.

When enclosing the axis, the straight lines are in red, the clothoids in green and the curves in yellow.

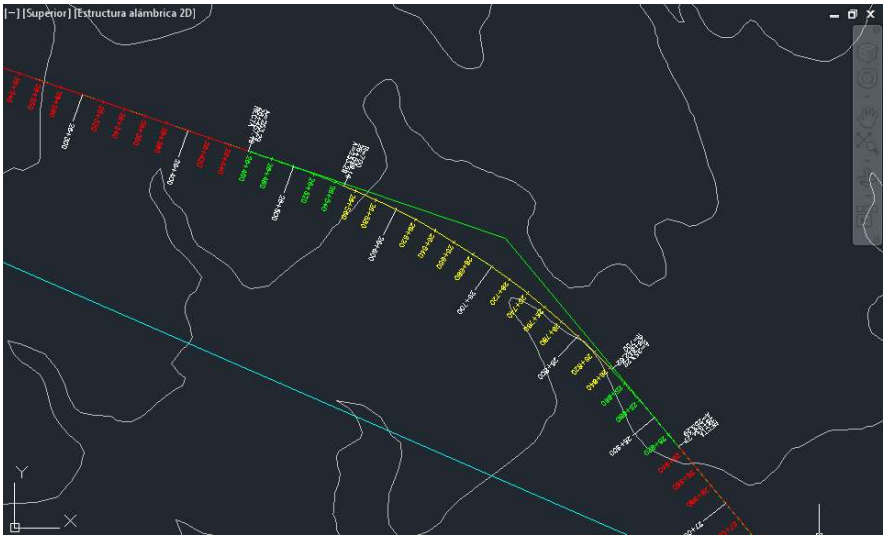


Image 102. "Route plan axis".

- **Longitudinal profile**

Next we calculate the longitudinal profile of the route, alternative by alternative. TADIL asks us to insert a point in the profile plan, we select a point out of the cartography and the longitudinal profile is placed in this location.

The basic axis of the longitudinal profile is drawn in red and the grade lines in yellow. The land profile corresponds to the white line.

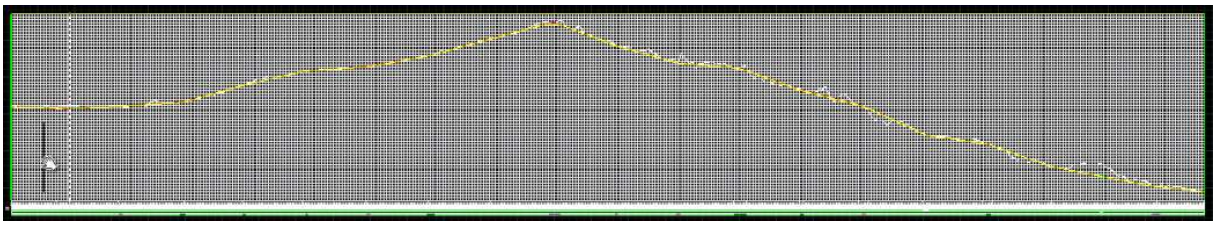


Image 103. Longitudinal profile of the primary axis.

The main difference between longitudinal profile in the previous study and in the informative one is that the structures are specified in the latter. Tunnels are in green and bridges are in red, both over the grade line itself.

Image 104. Detail of a tunnel.

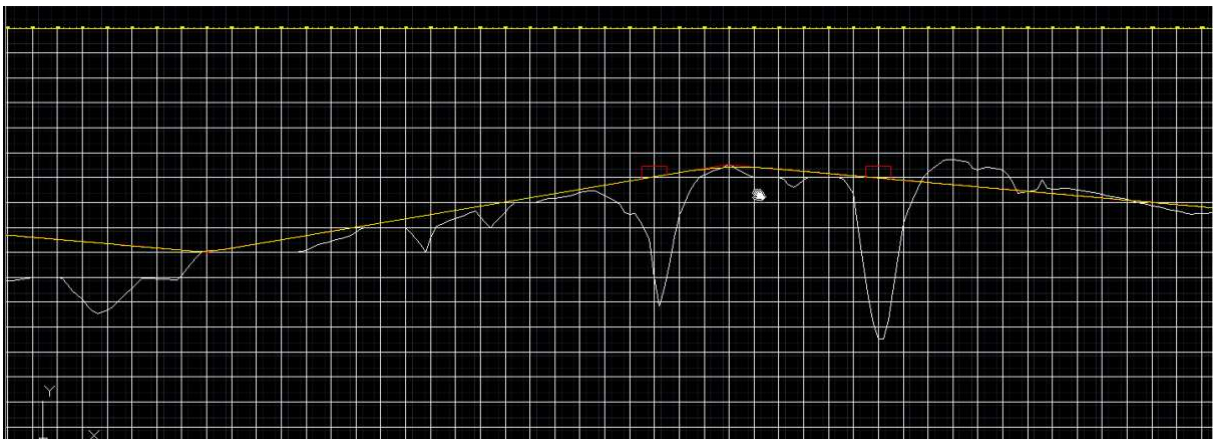


Image 105. Detail of two bridges.

In the graphic of the longitudinal profile TADIL gives the vertical curves, the land contour line, the gradient contour line, the cut section contour line and the embankment contour line along with the curvature diagram, the structures and the camber diagram.

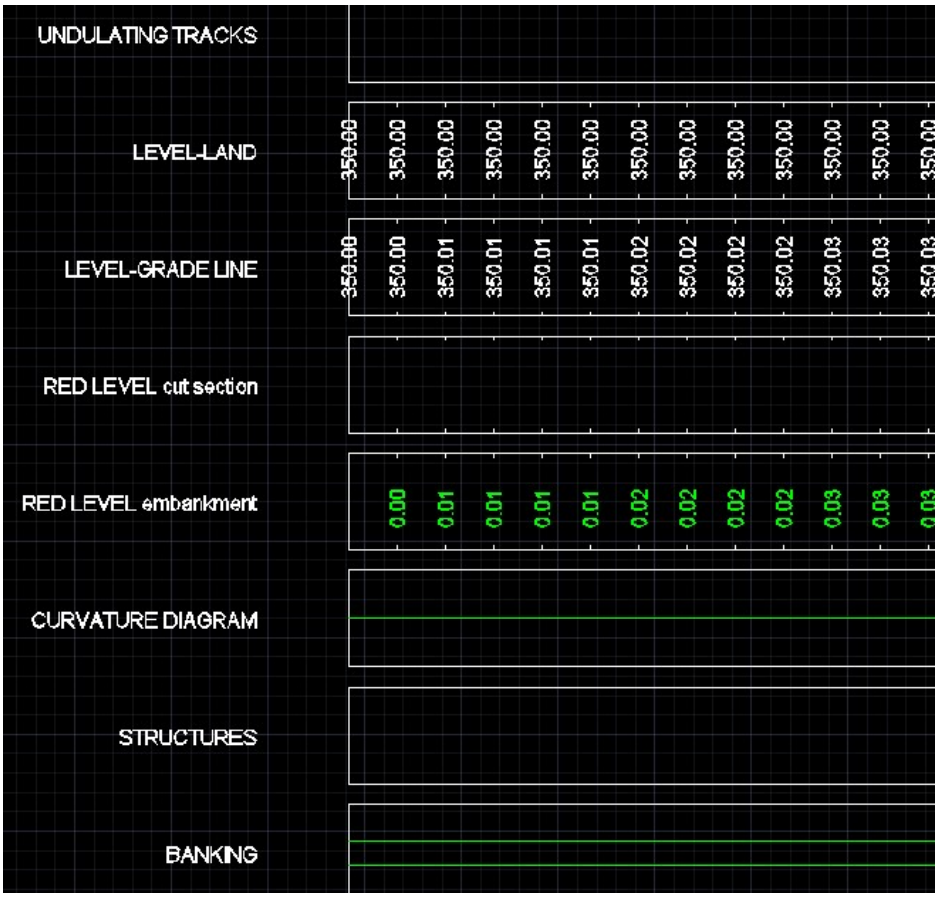


Image 106. Detail of the parameters of the graphic.

As for the route plan axis, TADIL offers the possibility to create and see the report of the longitudinal profile, specifying the geometric characteristics of the alignments.

TADIL Road sin logo

Entrance Slope	Length of Transition Curve on Track	Kv Parameter	Vertex KP	Vertex Level	Entrance KP	Entrance Level	Exit KP	Exit Level	Difference of Slopes
			0	247.317					
0.006	120	361642.84	2097.63	260.279	2037.63	259.913	2157.63	260.635	0
0.006	124.002	6685	4195.184	272.843	4133.183	272.192	4257.185	274.068	0.019
0.024	244.105	15276	6295.115	323.305	6173.062	320.814	6417.167	324.82	-0.016
0.008	120	66317.785	8395.076	341.5	8335.076	340.968	8455.076	342.087	0.002
0.01	165.87	15276	10494.928	362.728	10411.993	362.105	10577.863	362.901	-0.011
-0.001			13898.796	360.812					

Image 107. List of the longitudinal profile.

These reports can be exported in spreadsheet format.

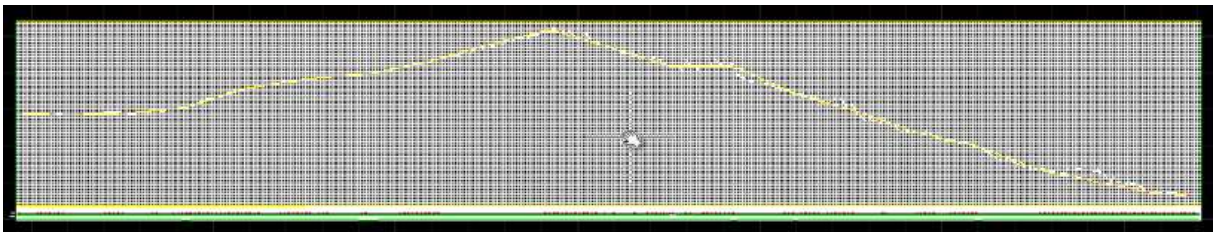


Image 108. Longitudinal profile of the maximum envelope.

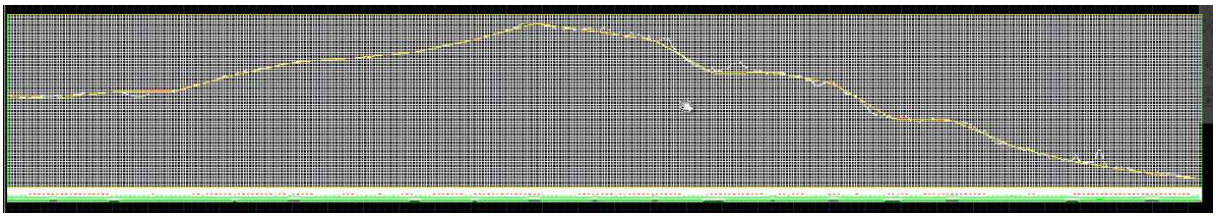


Image 109. Longitudinal profile of the minimum envelope.

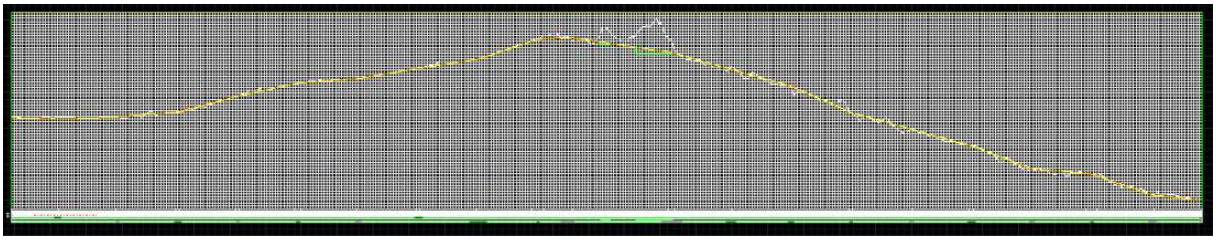


Image 110. Longitudinal profile of the solution of basic axis to middle point.

The longitudinal profiles of the different alternatives will be calculated and created this way.

- **Linear Work**

Finally, we calculate the linear work. Unlike in the previous study, in the informative study we can obtain the cross sections, the earthwork plan and the measures which we will use for making the earthwork balance and the budget. At the same time, we will use the budget for obtaining the profitability and, finally, with all the information and the GIS information we can evaluate the alternatives and select the solution.

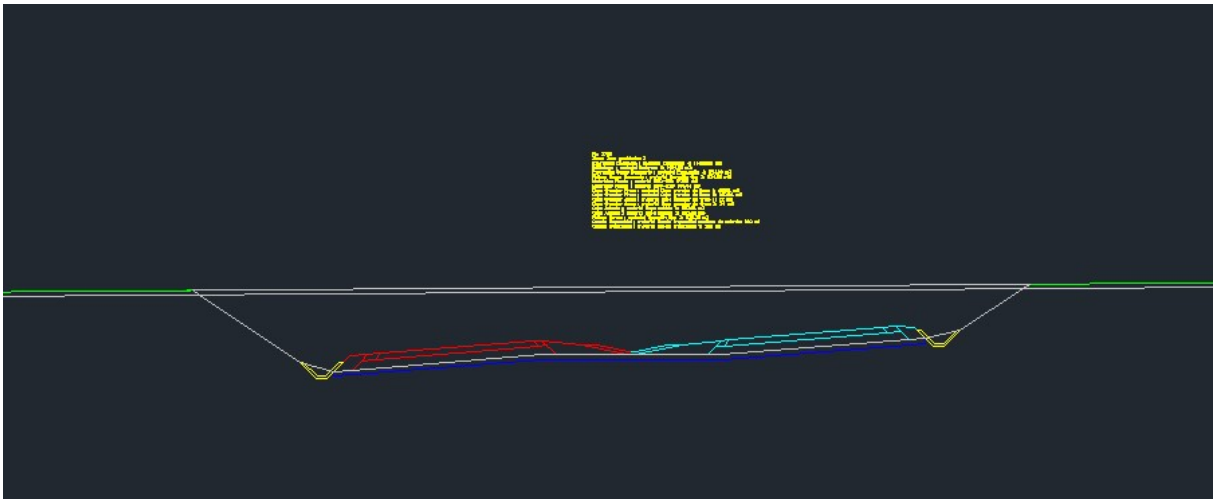


Image 111. Cross section with curve.

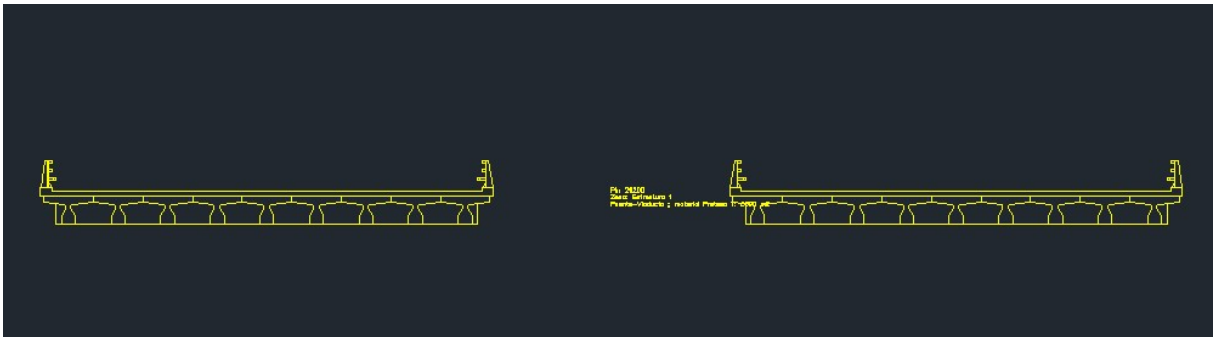


Image 112. Cross section with structure.

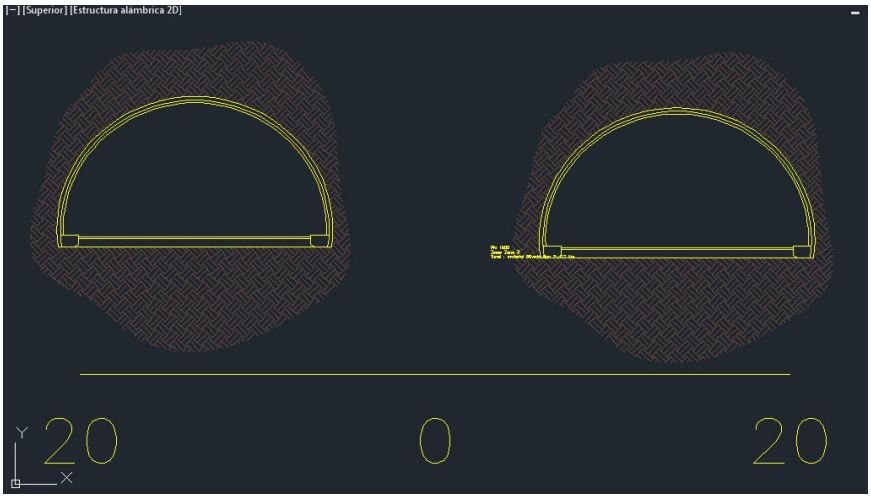


Image 113. Cross section with tunnel.

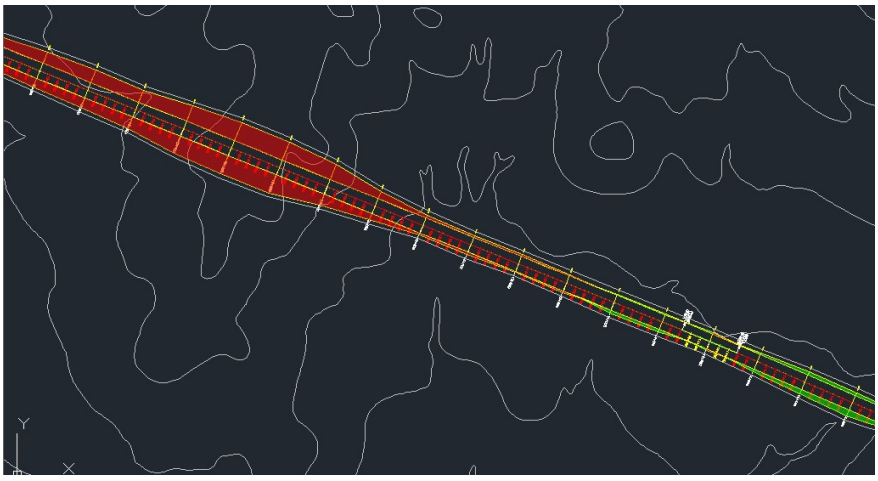


Image 114. Earthwork plan.

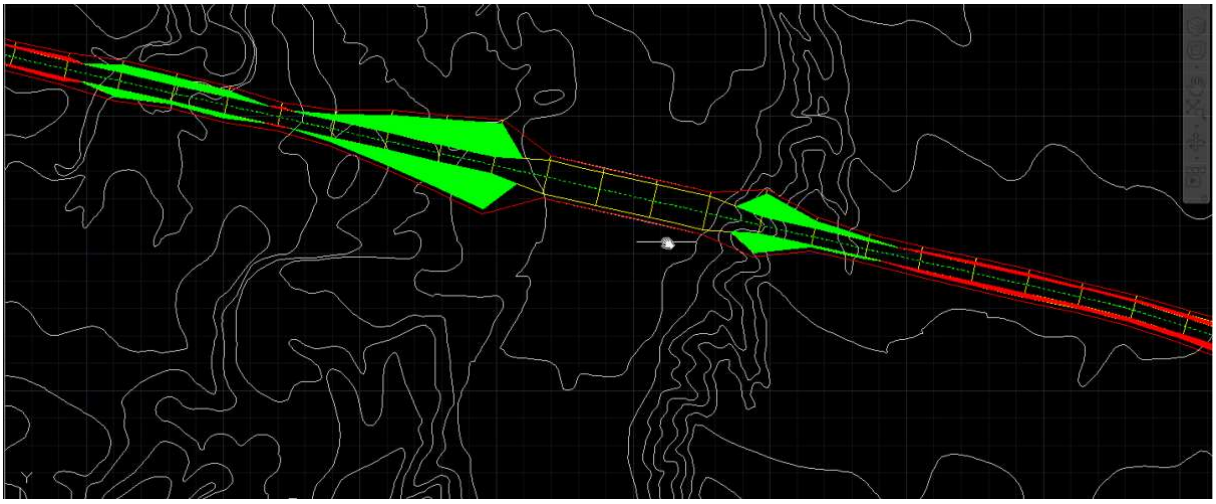


Image 115. Detail of a bridge over stream bed.

We will make the calculation alternative by alternative; upon completing, the box of calculated linear work will be ticked in the solution editor.

With each calculation, there will appear the drawing of the cross sections and the earthwork plan, as we can see in the previous images. In sections, in addition to the pk, we can see the measure section by section.

Just like we have done with these three alternatives, we follow with the three alternatives coming from the manual visibility axis, the alternative coming from the projection to middle point and the one coming from the manual basic axis.

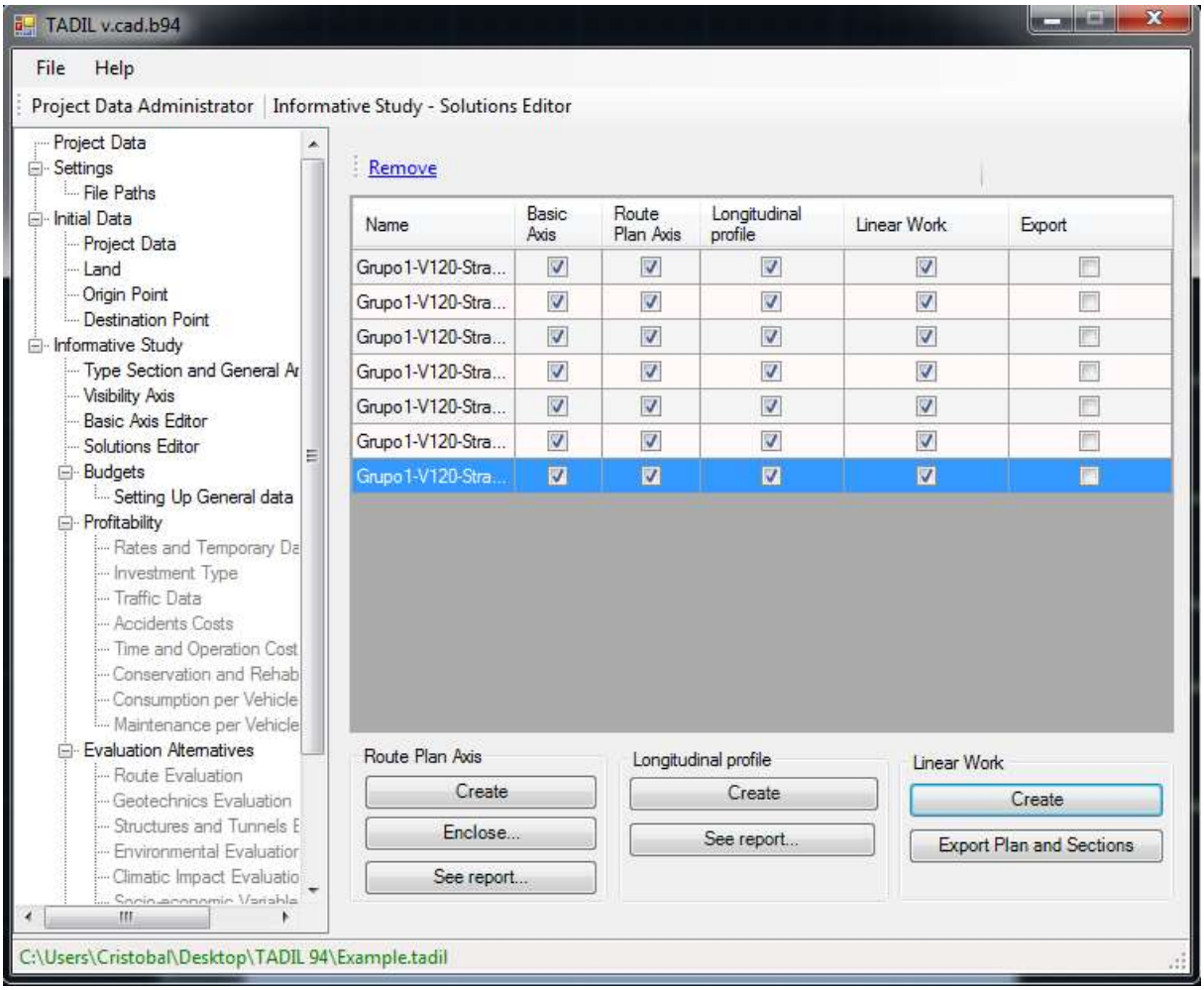


Image 116. Calculation of the seven alternatives.

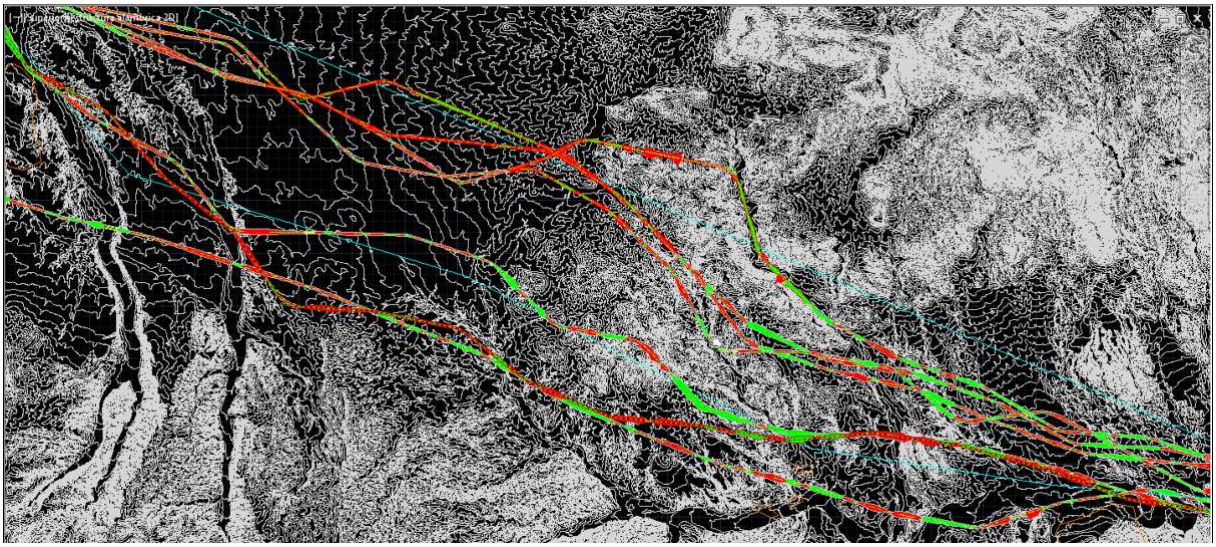


Image 117. Detail of the plan of the six alternatives which have a solution.

To download the memory to the work file, we can export both the plan drawing and the cross sections drawing to another file.

TADIL asks us to save the cross and plan sections. The box "Export" will be then ticked.

11.3.4.5. Budget data

- **Setting up general data**

Once we have calculated the linear work, we can obtain the budget of every alternative, after entering some data though.

These data allow specifying the budget of material execution and the bid budget. That is, the general costs, the industrial benefit, the quality control, the patrimonial conservation, landscape restoration and so forth. We enter the material execution as percentage (See the Methodological Guide). Finally, the VAT will allow us to determine the tax part in the budget.

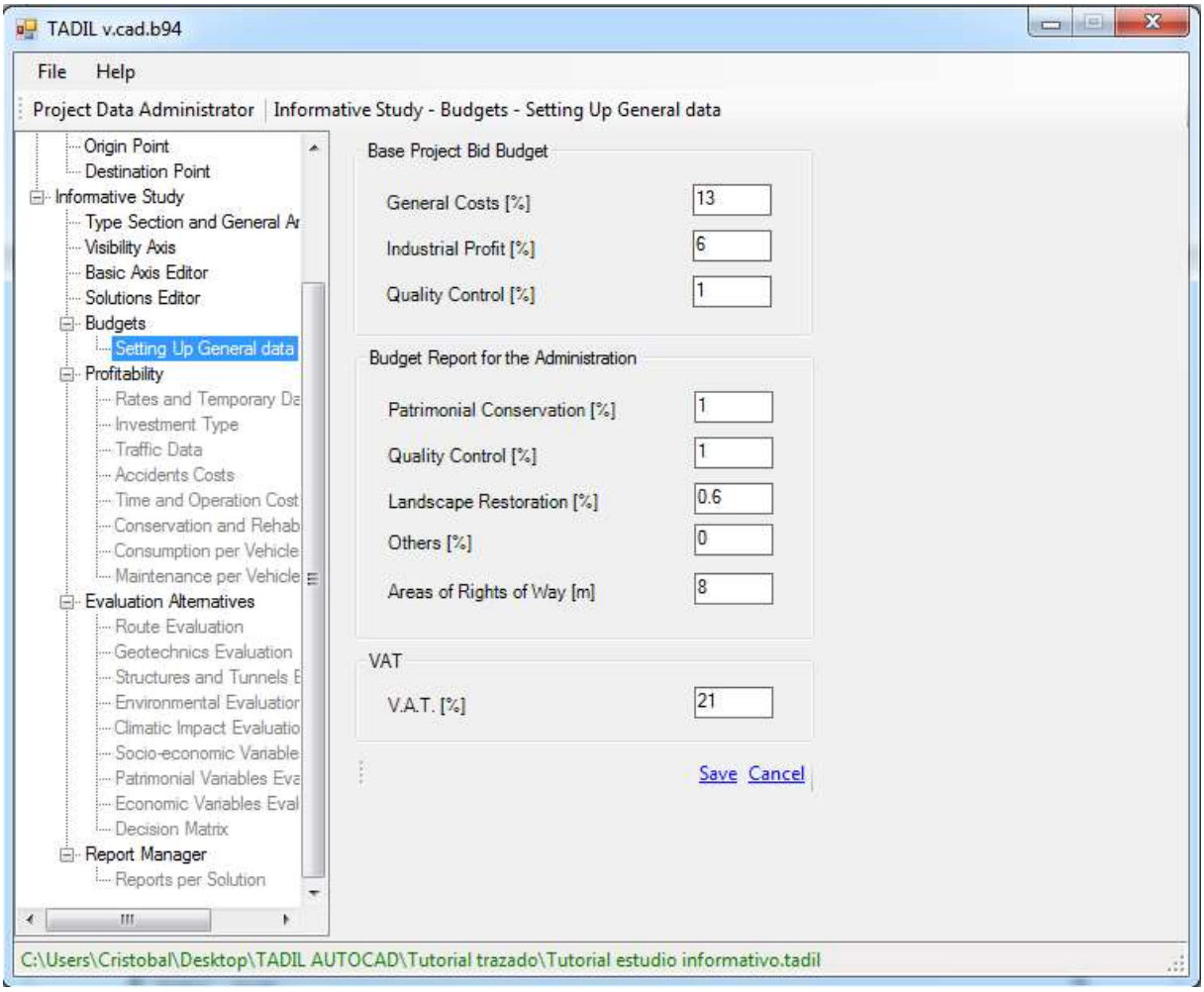


Image 118. Entering general data of budgets.

With the aforementioned values, we calculate the Budget Material Execution, the Base Project Bid Budget and, finally, the Budget Report for the Administration of every alternative.

Once we have calculated the budgets, we can move on to know the profitability of every alternative.

- **Remove a record**

If the user would like to eliminate one of the solutions or all of them to calculate again with other conditions but using the same MDT and TDB, the user must eliminate the previous records by selecting always the work and clicking on "Remove record".

11.3.4.6. Profitability data

Here we are going to analyse the profitability of the investment. We recommend reading the Methodological Application Guide to face more clearly the profitability study.

- **Rates and Temporary Data**

To carry out the profitability study year by year, we need to specify the exploitation period, the duration years of the infrastructure construction and the rates: update rate, CPI and the coefficient of review of construction prices (increase of construction prices during the construction period). (See Methodological Guide).

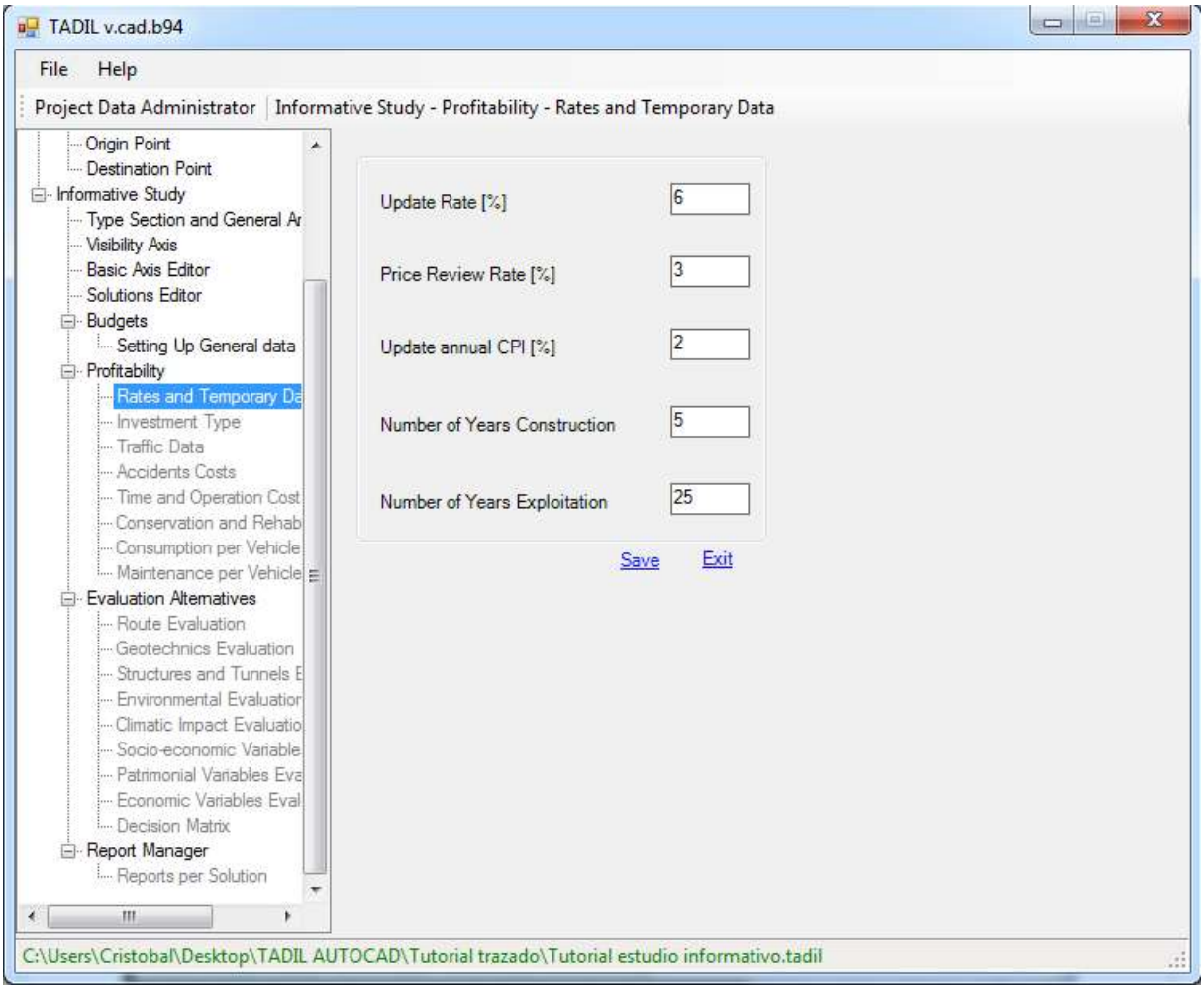


Image 119. Entering the rates and the temporary data.

- **Investment Type**

The second step is to specify the kind of investment; that is, if we are before a public or private investment or, if appropriate, a mixed one.

For the example, Valle Villa Ana we have firstly considered that the investment is a private development with public collaboration.

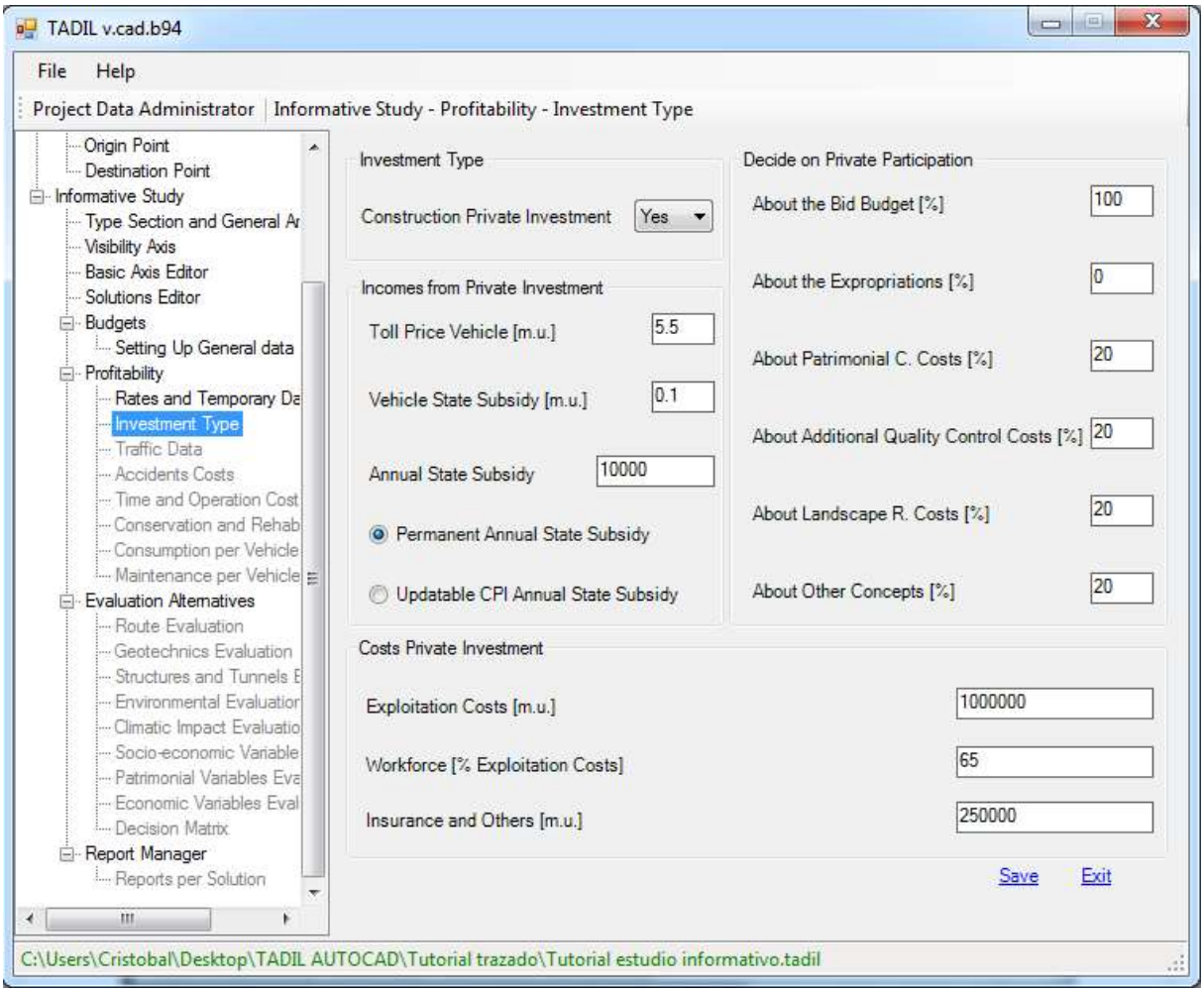


Image 120. Entering the investment type data.

If the investment were completely public, the data regarding the private investment would be disabled.

- **Traffic Data**

The next step is to specify the traffic data related to the inherent action. We consider we should start from a traffic study made during the phase of previous study.

In TADIL we enter data of the current connection and we specify if we maintain it or not.

As well, we indicate the ADT and the foreseen growth, the percentage of heavy vehicles and the foreseen traffic absorption for the new connection; we also enter the percentage of foreseen heavy vehicles.

It should be noted that if we do not maintain any former connection, the traffic absorption percentages of the new one will be 100% and the maintenance and rehabilitation costs from the former connection will not apply during the exploitation period.

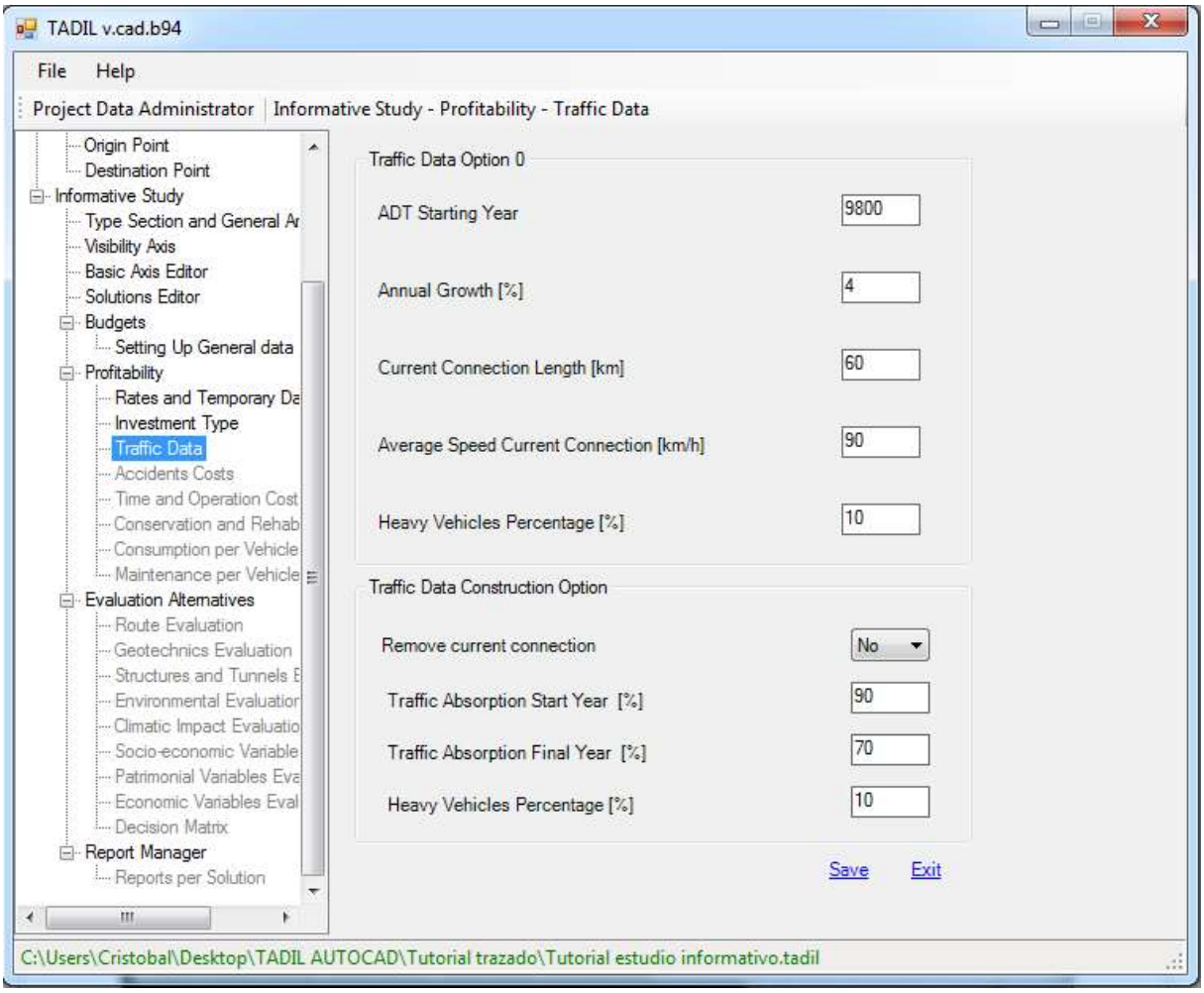


Image 121. Entering the traffic data.

Once we have entered the traffic data, we move on to specify all the remaining data regarding accident costs, time and operation, conservation and maintenance.

- **Accident Costs**

In the section Accident Costs, we enter the corresponding death and hazardousness data of the current connection and of the new one as well, the number of injured per accident, the cost per death and per injured (See Methodological Guide).

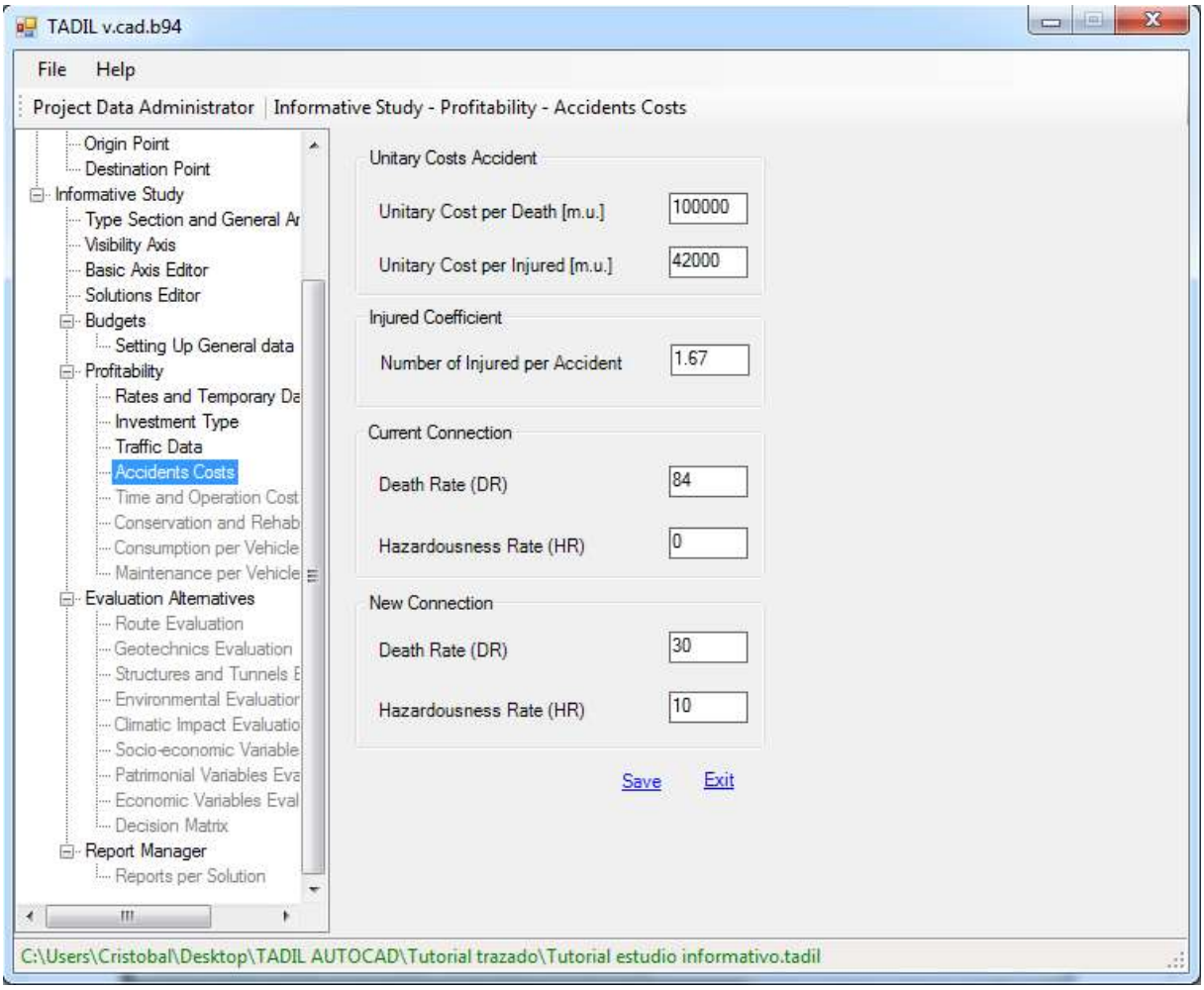


Image 122. Entering the accident costs data.

- **Time and Operation Costs**

In the section Operation Costs, we indicate the fuel and lubricant costs, the tyres costs and the vehicle pay-off cost, the time cost as well as a weighting coefficient which estimates the percentage of professional journeys , where time costs is attributable to the moving people costs (See Methodological Guide). These costs are specified for light and heavy vehicles.

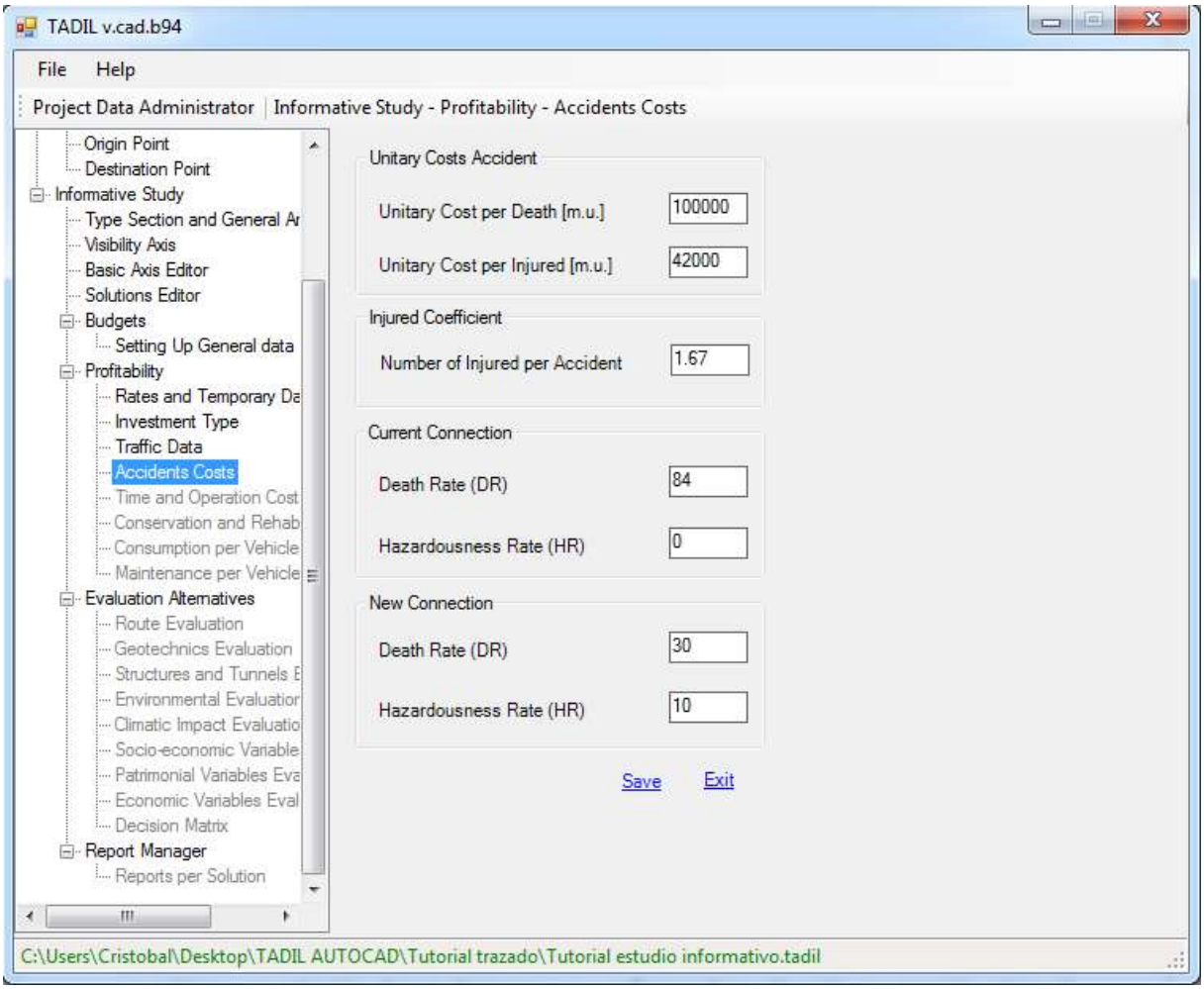


Image 123. Entering the time and operation costs data.

- **Conservation and Rehabilitation Costs**

TADIL allows entering conservation and maintenance costs of the new and the former connection.

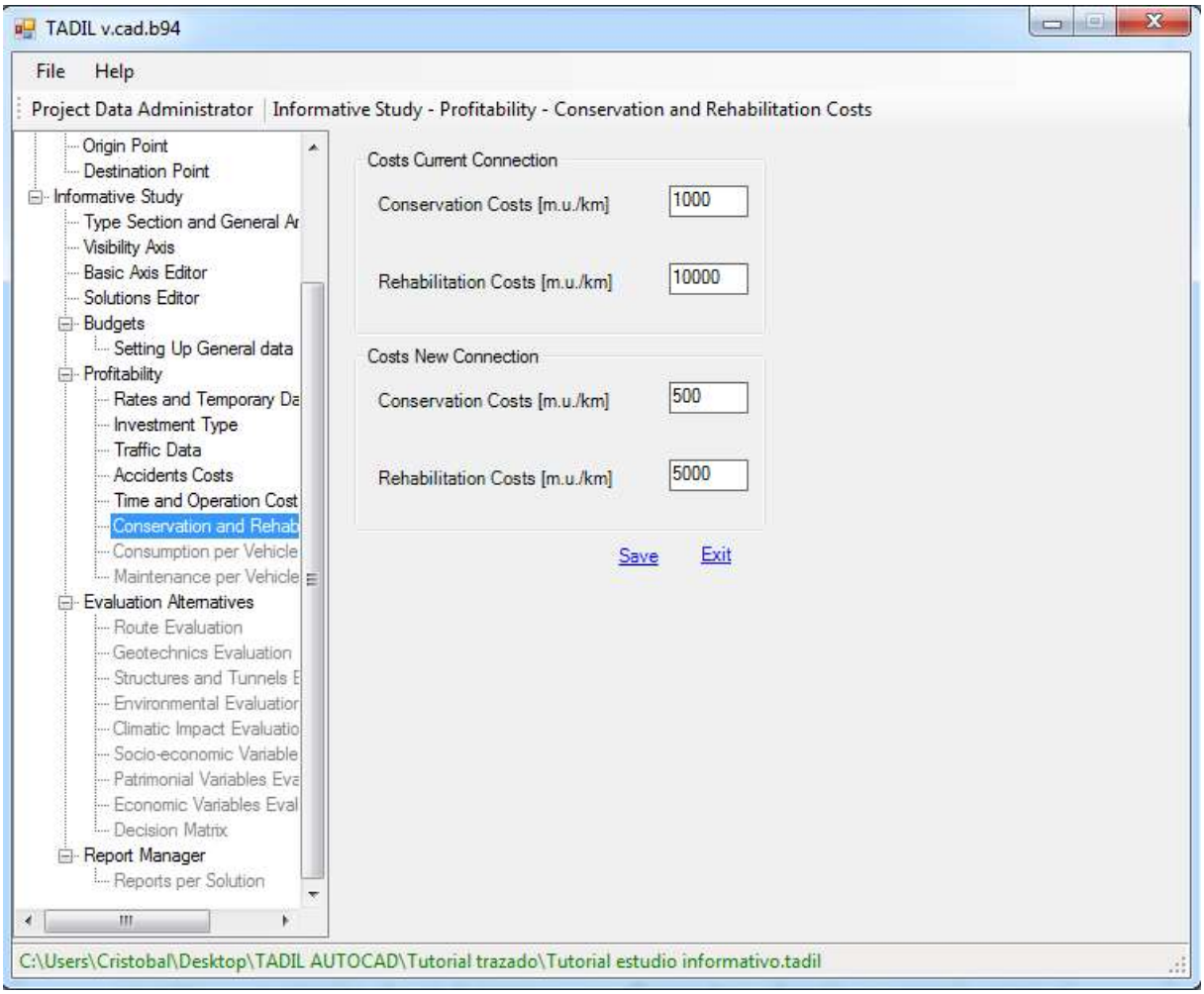


Image 124. Entering the general data about conservation and rehabilitation costs.

- **Maintenance and consumption costs per vehicle type**

The maintenance and consumption costs per vehicle, regardless it is light or heavy, can be edited in lists according to the average speed of vehicles, and saved.

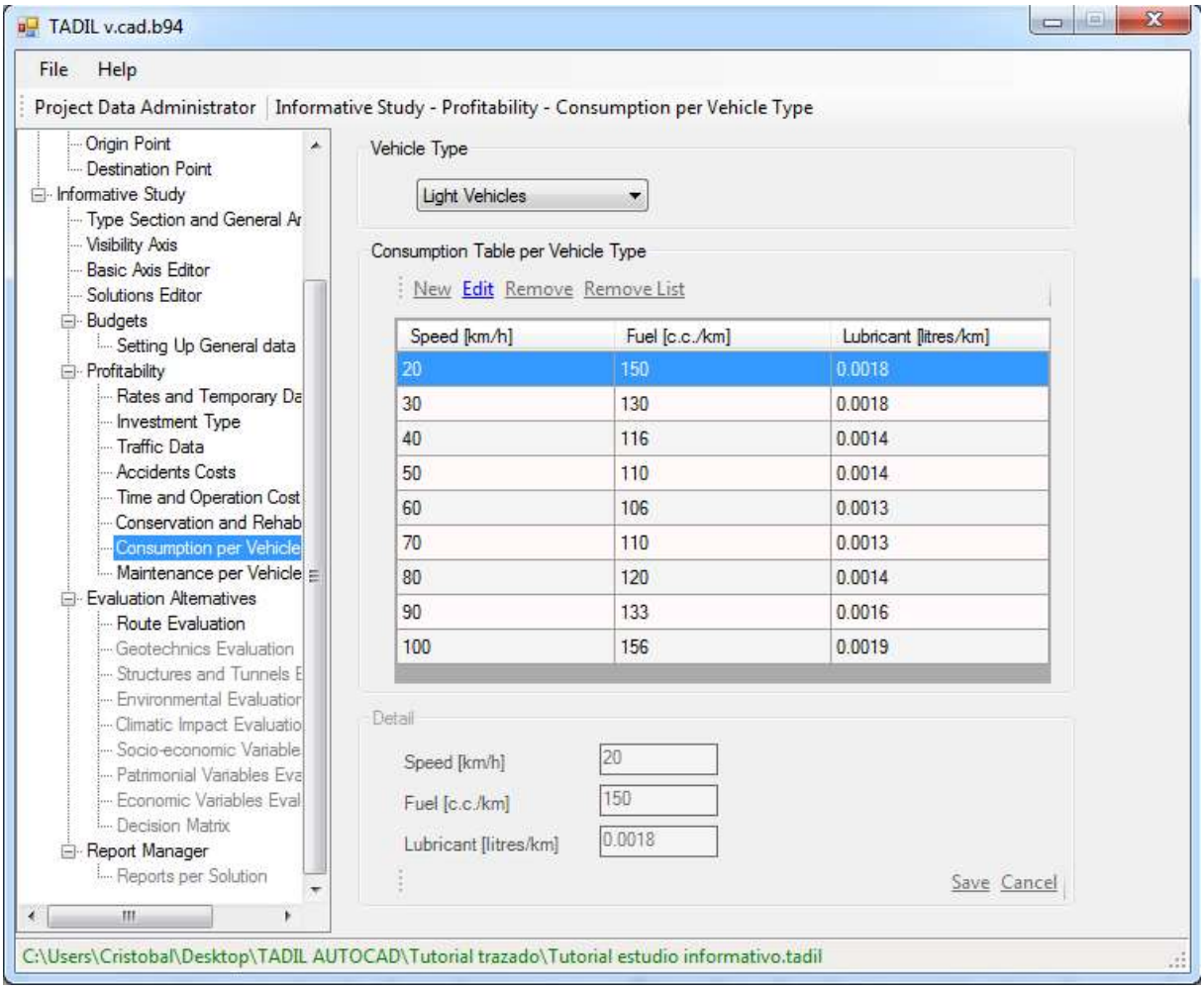


Image 125. Modifying the data related to consumption per vehicle according to speed.

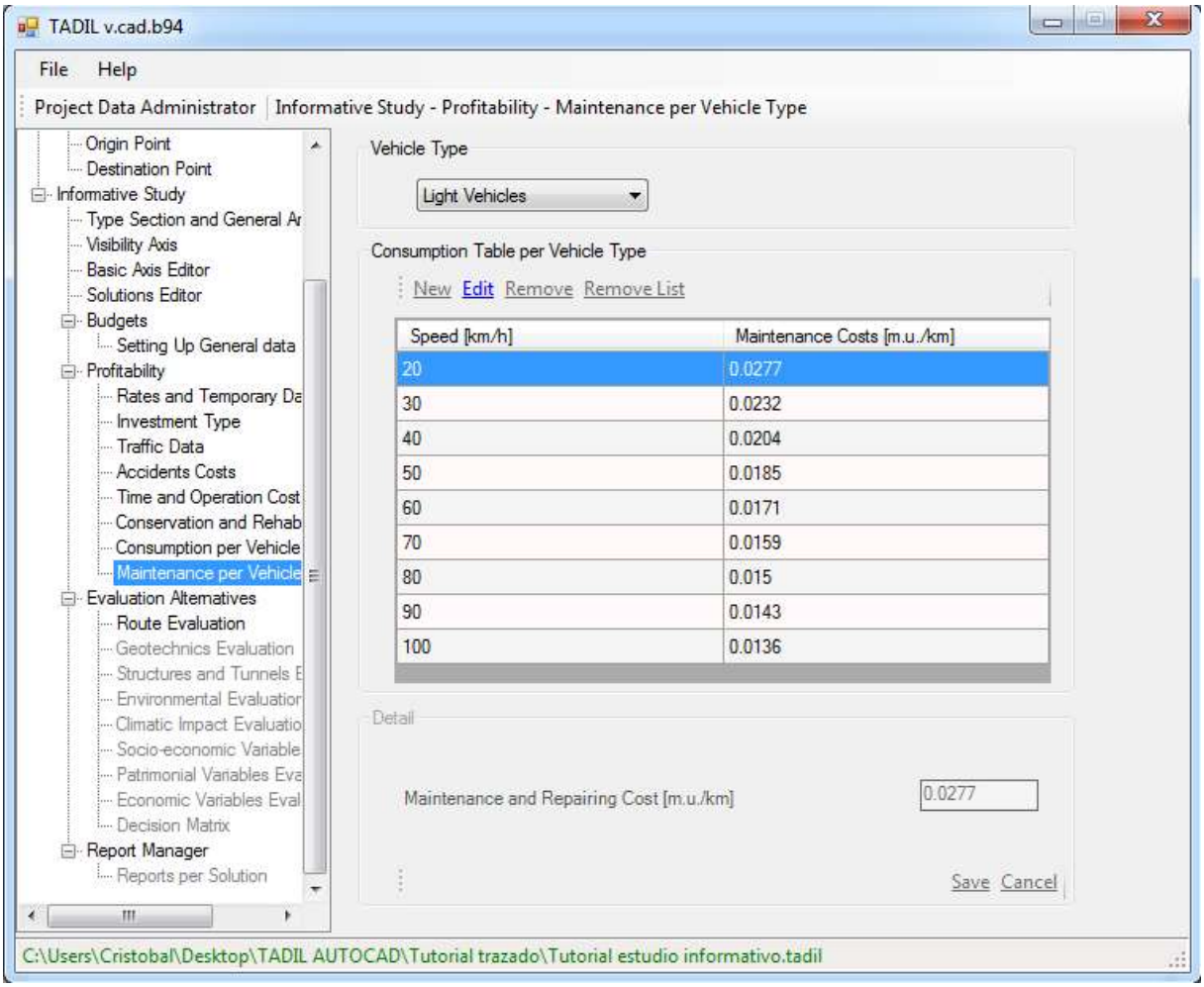


Image 126. Modifying the data related to maintenance per vehicle according to speed.

With all the aforementioned data, TADIL calculates the profitability of variables and obtains the IRR, the IRP, the relationship benefit/cost and the NPV (See Methodological Guide).

11.3.4.7. Alternatives evaluation

This is the last step in the informative study. In this section we have to evaluate the different alternatives and select the best solution.

So, we need to specify the percentage of every variable in each chapter.

We should enter the weighting percentages of next chapters:

- Draft
- Earthworks Geotechnics
- Structures, Tunnels and Walls Geotechnics
- Environmental Variables
- Climatic variables
- Socioeconomic Sectors
- Patrimonial variables
- Economic Variables

In the Methodological Guide we detail the formula we use for every variable in each chapter.

TADIL offers local and global marks. As for global marks, a final evaluation on a 10 point scale is given. For the best solution we have 0.

For each group of variables, the alternative with a 0 will be the best.

We must once again insist on clicking on "Save" after entering the data in each menu (even with default data).

The scores we have given to our informative study are the following:

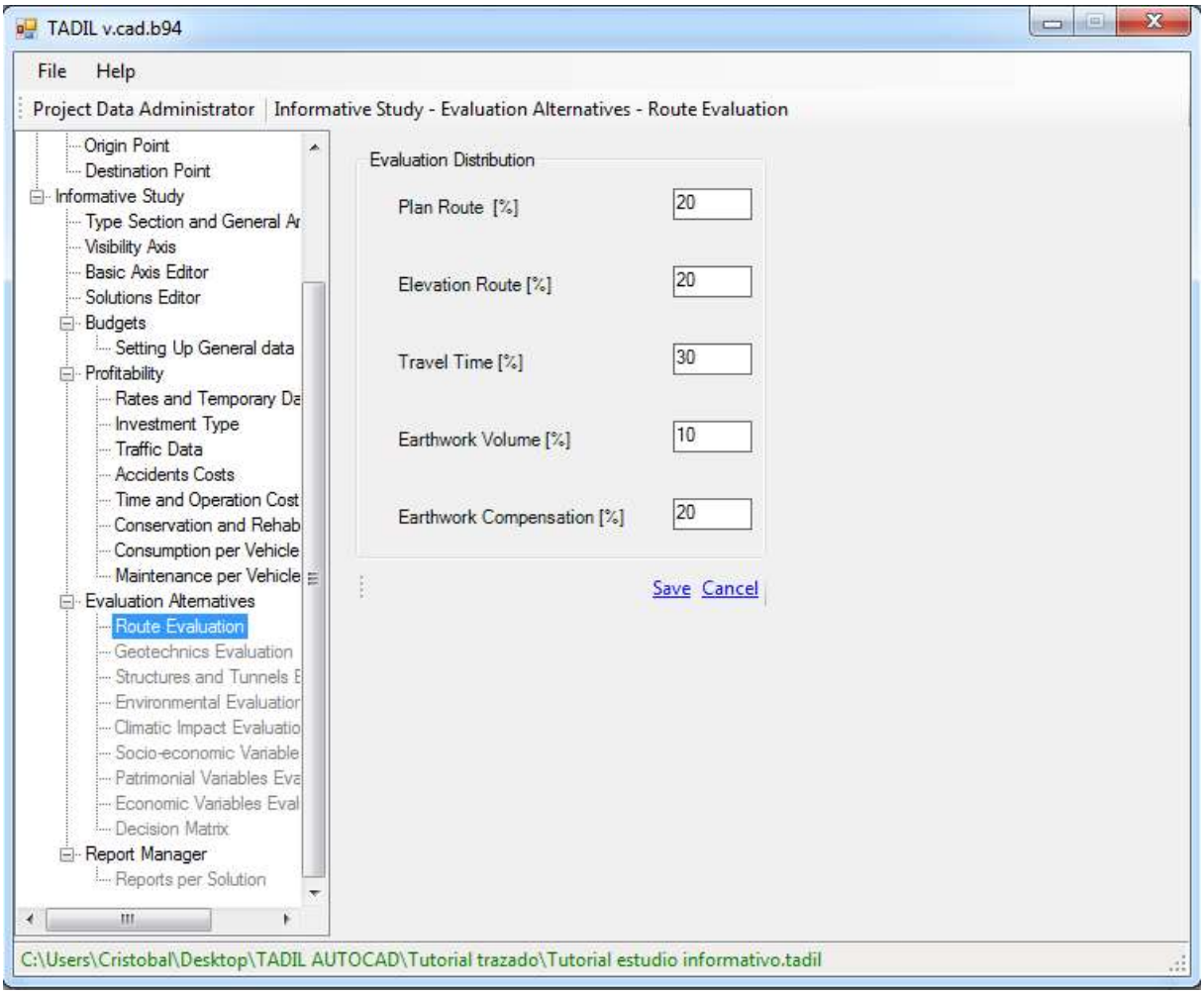


Image 127. Entering the weighting percentages of the route plan variables.

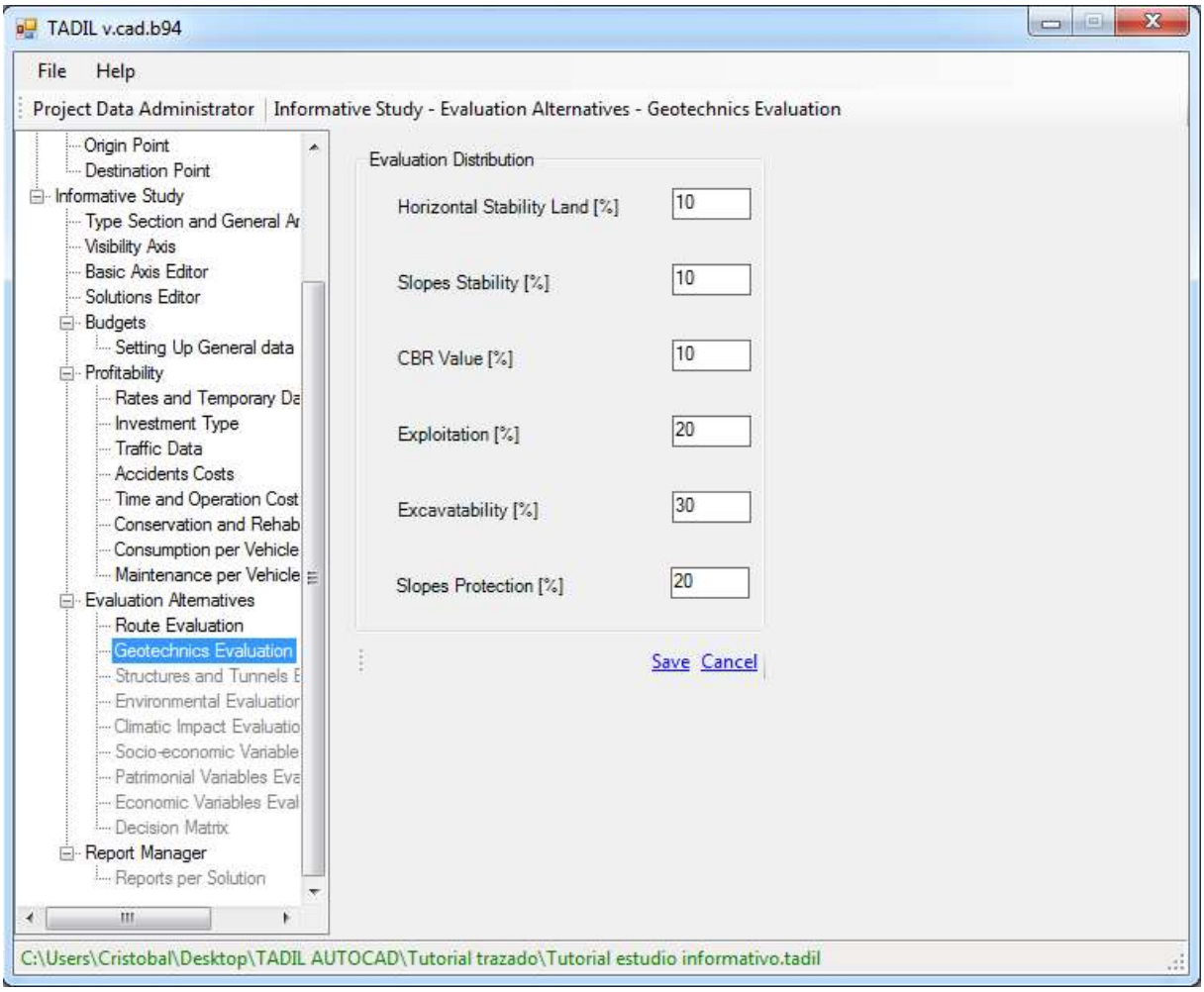


Image 128. Entering the weighting percentages of the geotechnical variables.

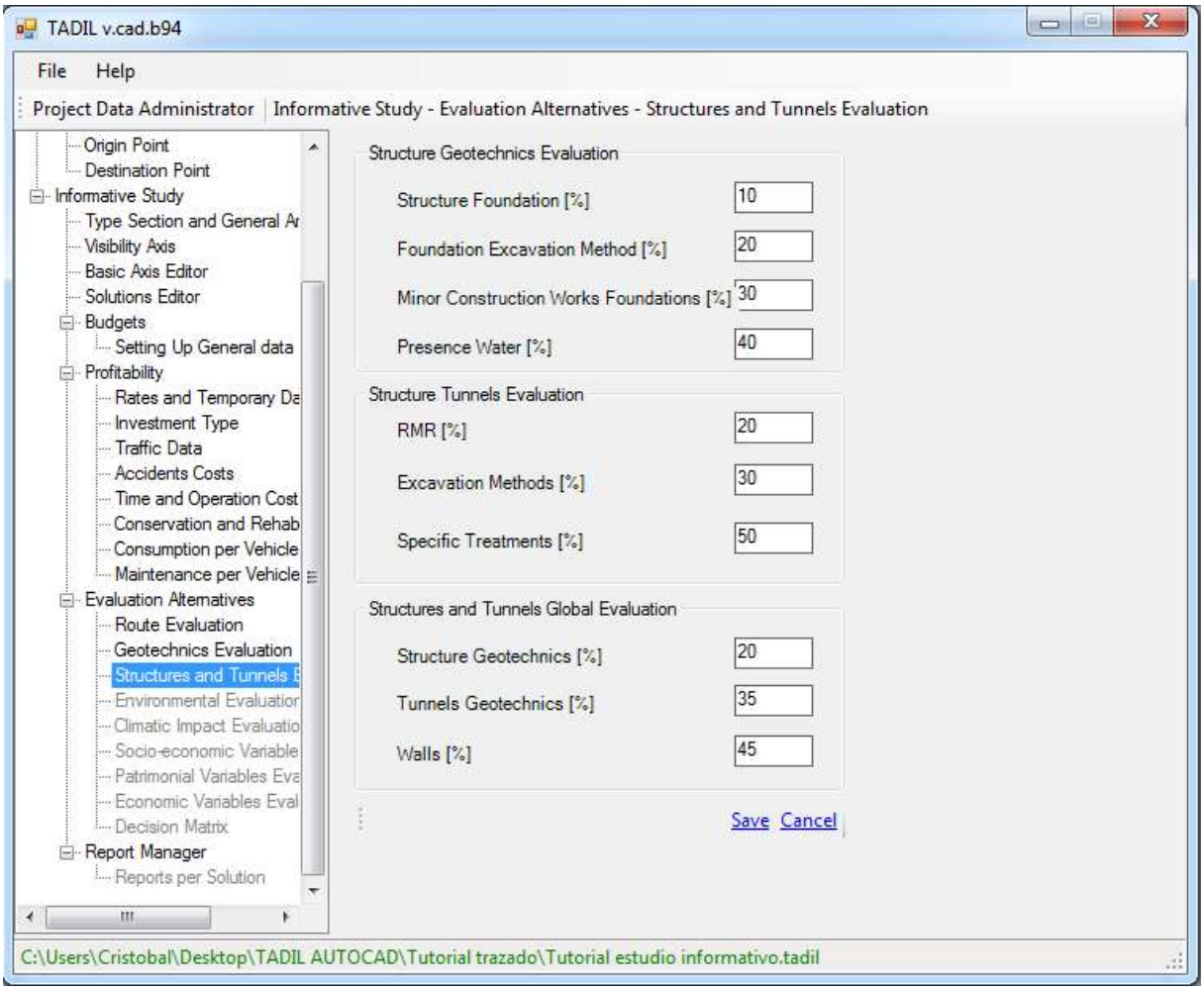


Image 129. Entering the weighting percentages of the geotechnical variables of tunnels, structures and walls.

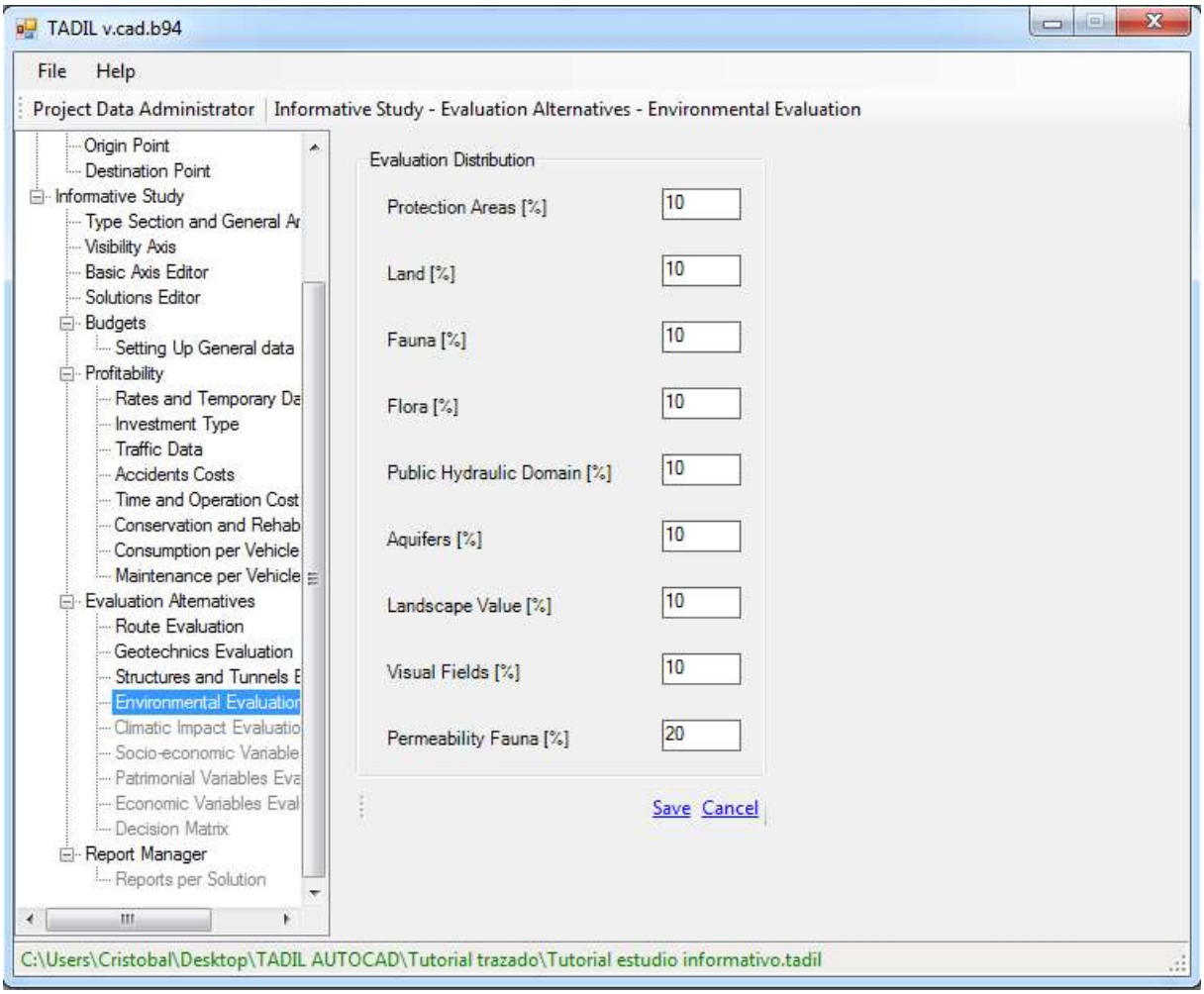


Image 130. Entering the weighting percentages of the environmental variables.

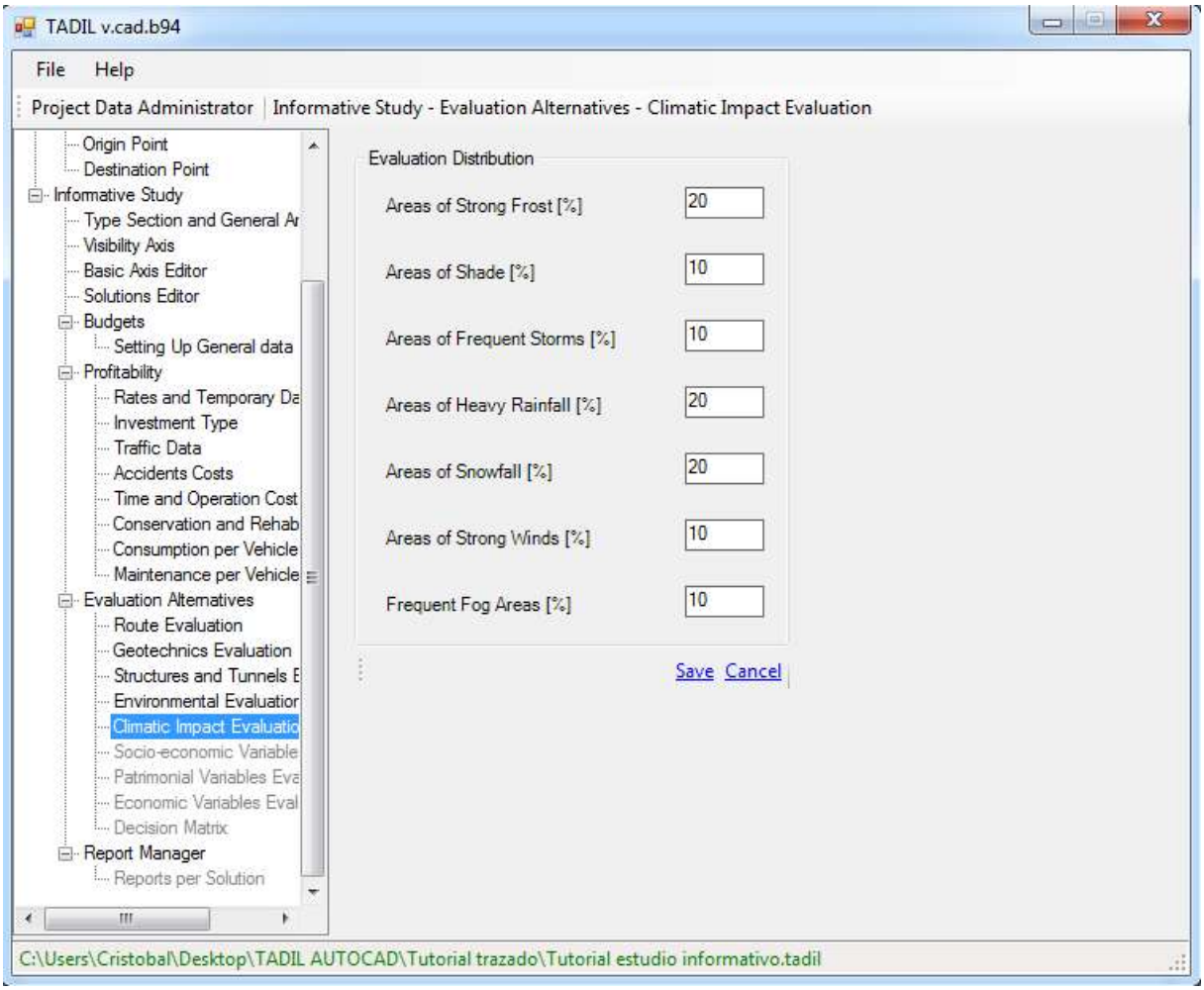


Image 131. Entering the weighting percentages of the climatic variables.

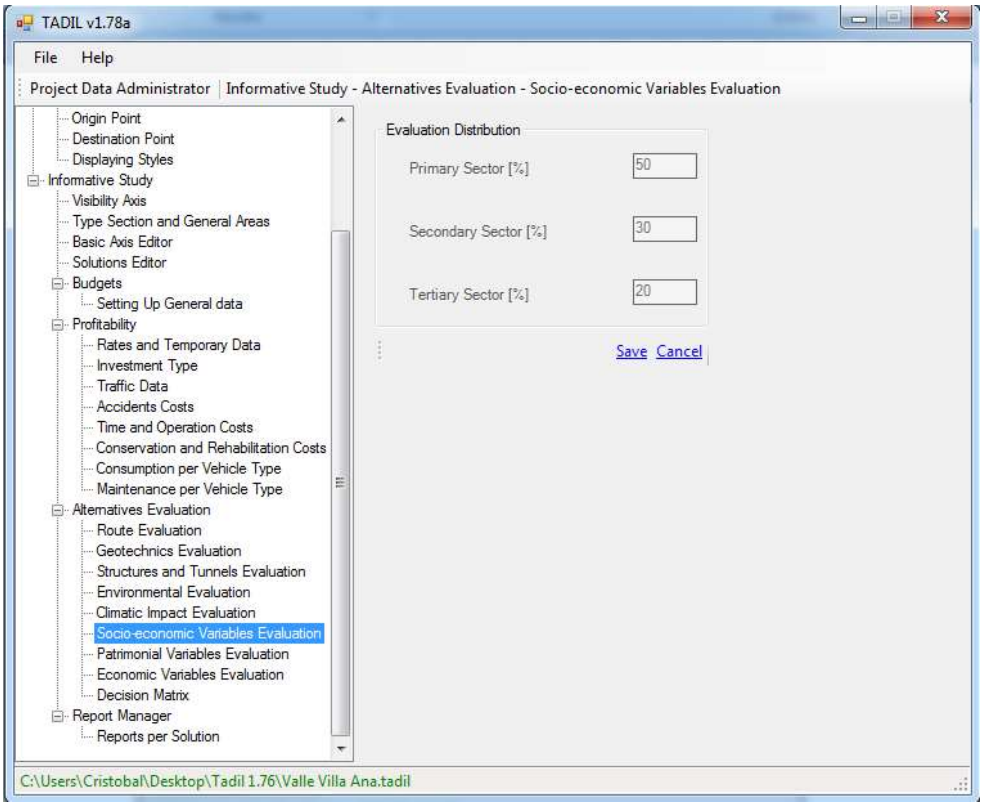


Image 132. Entering the weighting percentages of the socioeconomic variables.

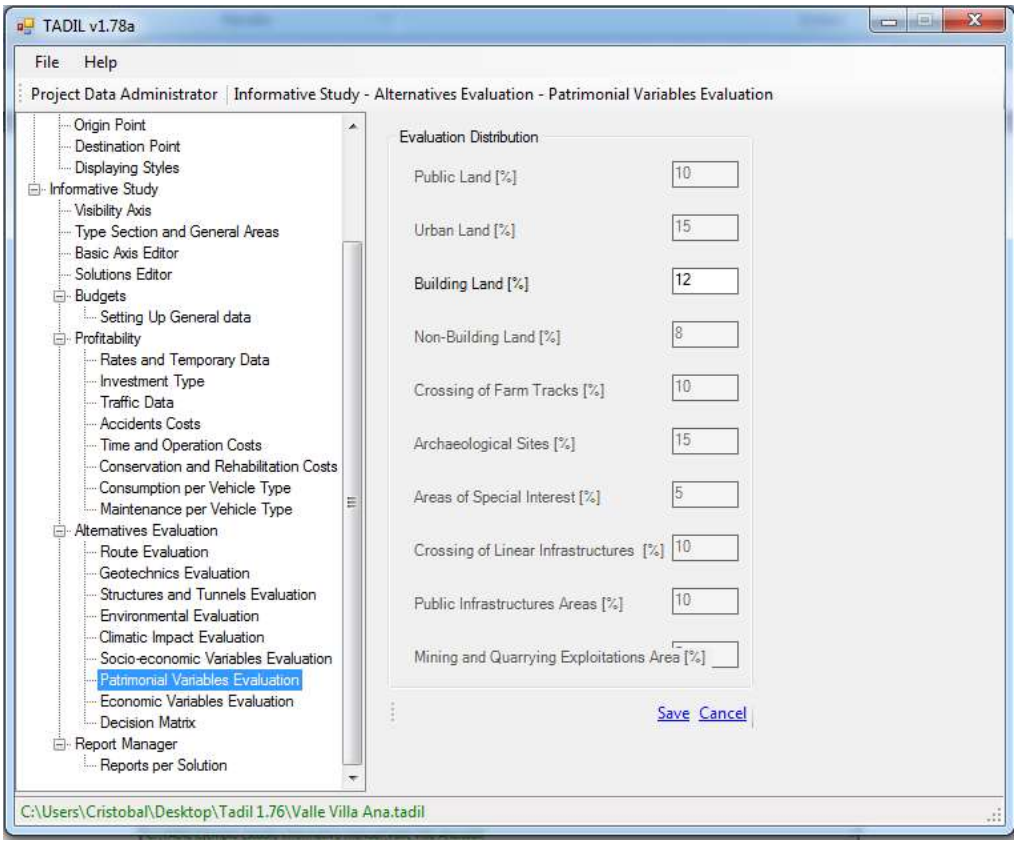


Image 133. Entering the weighting percentages of the patrimonial variables.

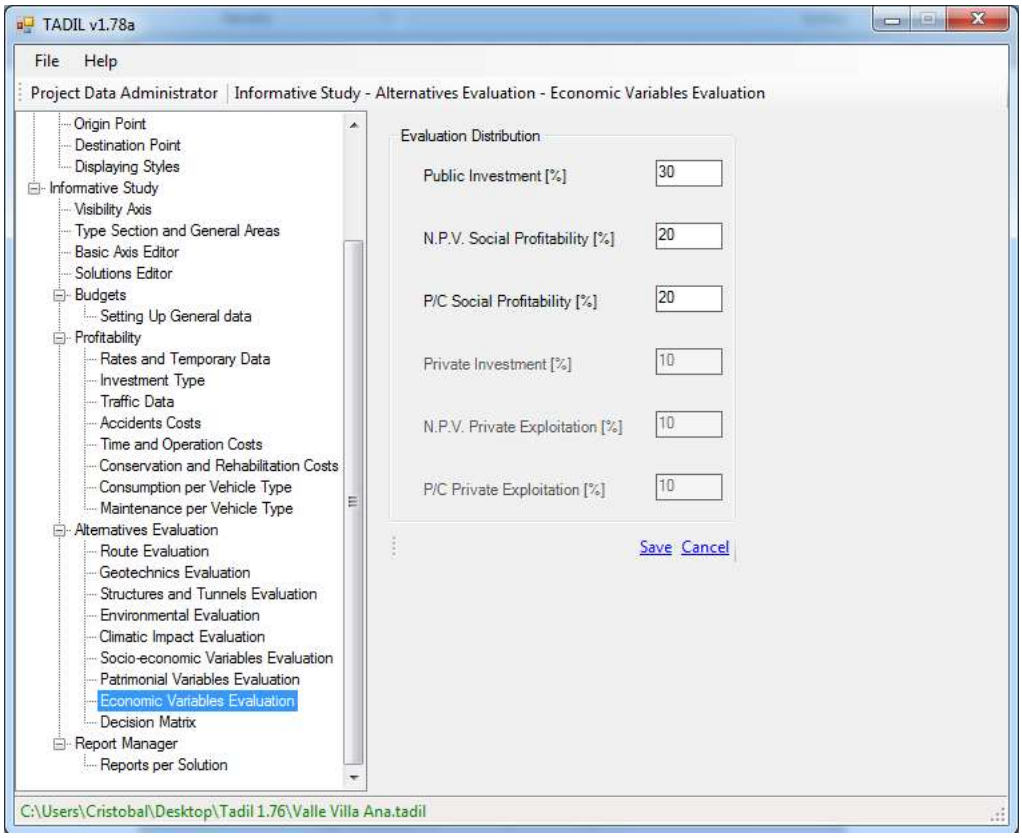


Image 134. Entering the weighting percentages of the economic variables.

- **Decision Matrix**

With the aforementioned data, TADIL move on to calculate the evaluation of all the alternatives by suggesting as solution that of less score (0, as global mark).

In the section "Decision Matrix", TADIL shows the marks of each alternative; in addition, we can consult the marks of each chapter of every alternative and, finally, every variable of each chapter.

Previously, we should have specified which alternatives we want to evaluate and the weighting hypothesis of chapters [see Methodological Guide).

Afterwards, we click on "Evaluate Solutions for Hypothesis".

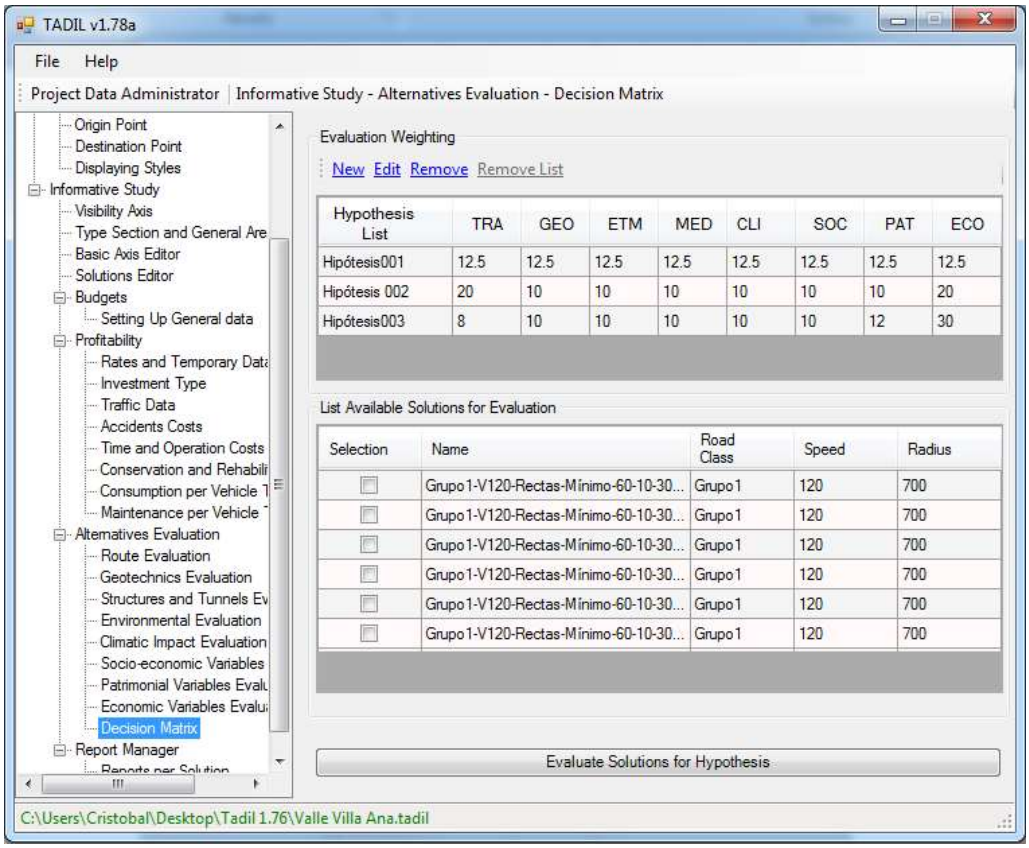


Image 135. Entering the weighting percentages in the decision matrix and selecting the alternatives to be evaluated.

Once TADIL shows the hypothesis-evaluated solutions list, we can obtain a succinct report (first button) or a detailed report (second button).

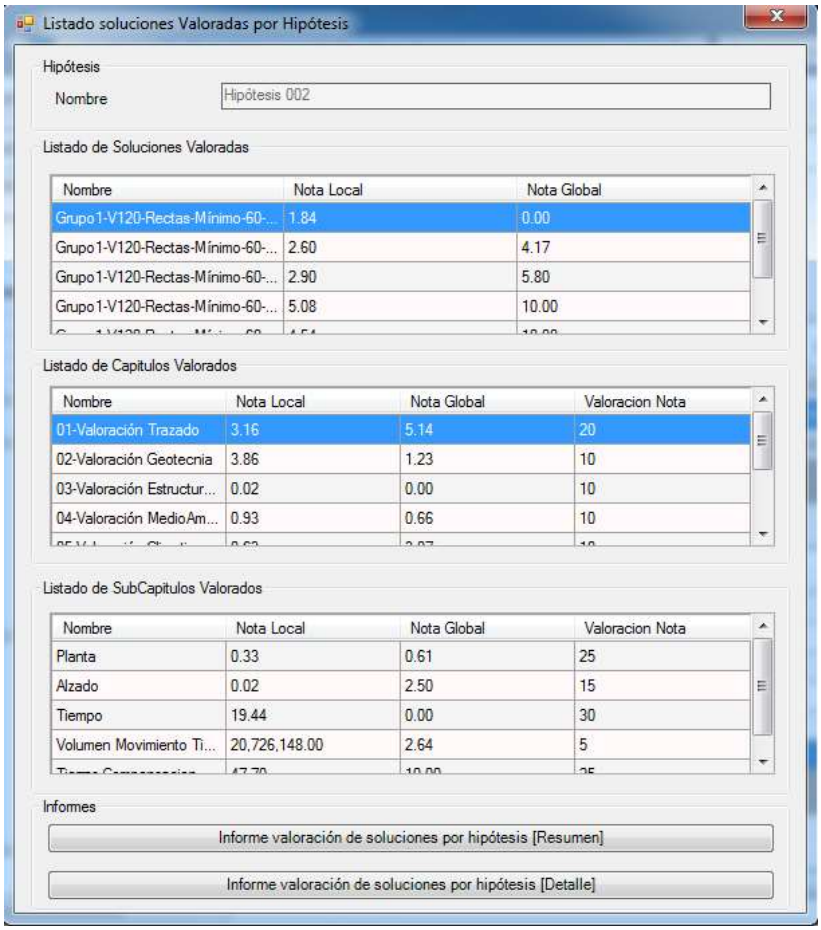


Image 136. Obtaining evaluations per alternative.

The process described previously has been made for the six feasible alternatives, which it is a quite complete study.

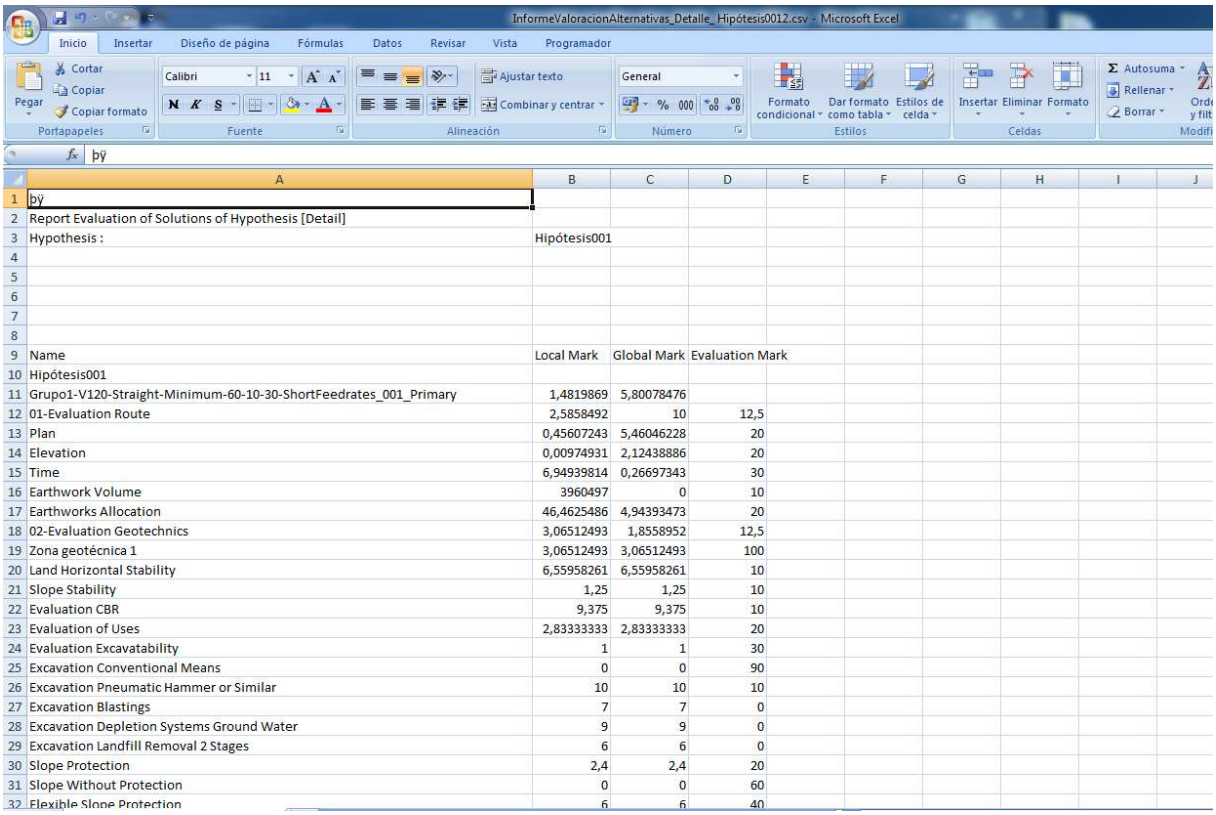
Finally, to these six alternatives, we can add some others by doing the following:

- Modify the type of investment.
- Include long feedrates in the basic axis calculation (for a speed higher than 80 km/h will not affect).
- Modify the coefficients of reduction.
- Visibility axis with corridors

For a study of this kind, we consider the following points to be a good analysis:

- obtaining more or less 20 to 30 route basic axis.
- between 10 and 20 route axis calculated with their longitudinal profiles.
- a minimum of 6 alternatives with linear works completely calculated and ready to enter in the decision matrix.

Next we show the evaluation report for the six alternatives we have studied:



InformeValoracionAlternativas_Detalle_Hipótesis0012.csv - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J
1	þÿ									
2	Report Evaluation of Solutions of Hypothesis [Detail]									
3	Hypothesis :	Hipótesis001								
4										
5										
6										
7										
8										
9	Name	Local Mark	Global Mark	Evaluation Mark						
10	Hipótesis001									
11	Grupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary	1,4819869	5,80078476							
12	01-Evaluation Route	2,5858492	10	12,5						
13	Plan	0,45607243	5,46046228	20						
14	Elevation	0,00974931	2,12438886	20						
15	Time	6,94939814	0,26697343	30						
16	Earthwork Volume	3960497	0	10						
17	Earthworks Allocation	46,4625486	4,94393473	20						
18	02-Evaluation Geotechnics	3,06512493	1,8558952	12,5						
19	Zona geotécnica 1	3,06512493	3,06512493	100						
20	Land Horizontal Stability	6,55958261	6,55958261	10						
21	Slope Stability	1,25	1,25	10						
22	Evaluation CBR	9,375	9,375	10						
23	Evaluation of Uses	2,83333333	2,83333333	20						
24	Evaluation Excavatability	1	1	30						
25	Excavation Conventional Means	0	0	90						
26	Excavation Pneumatic Hammer or Similar	10	10	10						
27	Excavation Blastings	7	7	0						
28	Excavation Depletion Systems Ground Water	9	9	0						
29	Excavation Landfill Removal 2 Stages	6	6	0						
30	Slope Protection	2,4	2,4	20						
31	Slope Without Protection	0	0	60						
32	Flexible Slope Protection	6	6	40						

Image 137. Example list of evaluation per alternatives.

11.3.4.8. Report obtaining

Once we have evaluated the alternatives, we can obtain the editable files of budget and profitability as well as the evaluation reports. We go to the last tab "Reports per Solution", where we can find three more tabs, the first one is for budgets, the second one for profitability and the third one, for geometric aspects of the work.

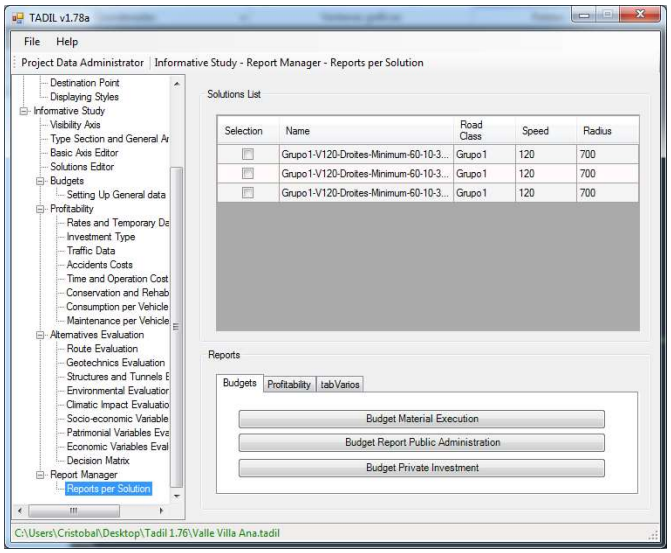


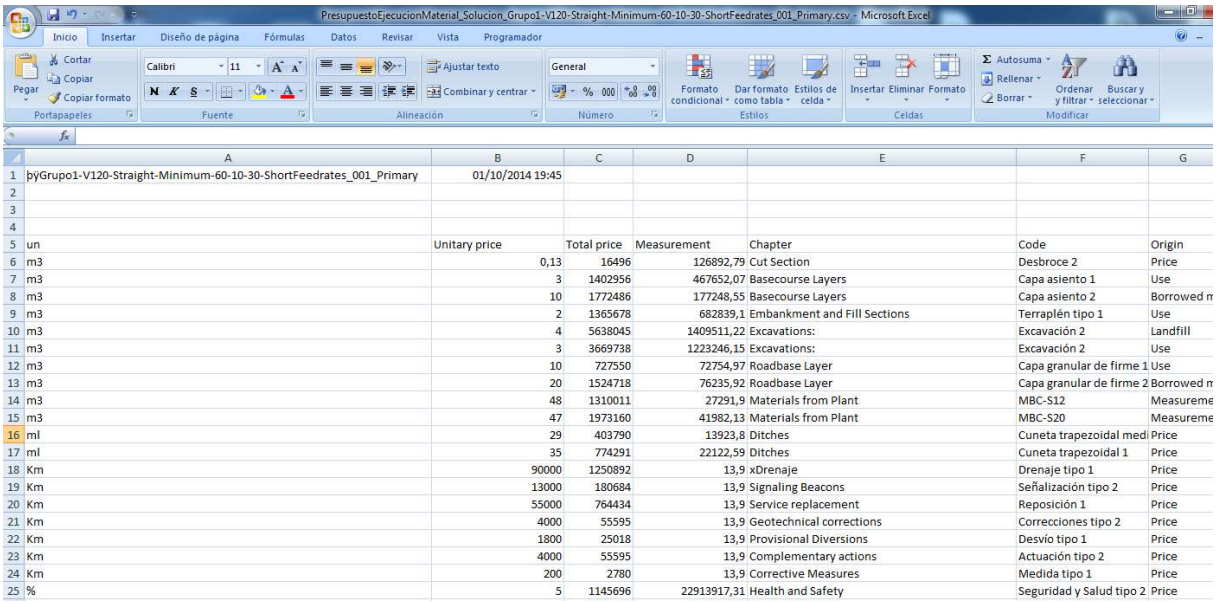
Image 138. Menu for exporting the budgets lists.

We must prove that we obtain said reports in .csv format (comma separated value). We should convert the file to .xlsx format for editing them.

Next we show some reports examples:

11.3.4.8.1. Budgets

- **Budget Material Execution**

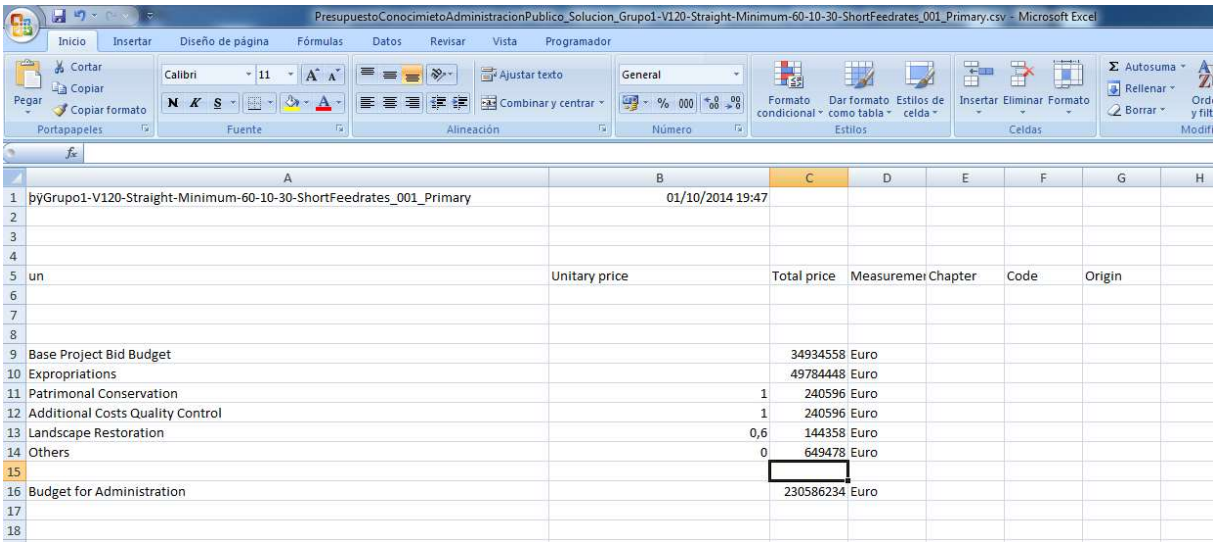


	A	B	C	D	E	F	G
1	þÿGrupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary	01/10/2014 19:45					
2							
3							
4							
5	un	Unitary price	Total price	Measurement	Chapter	Code	Origin
6	m3	0,13	16496	126892,79	Cut Section	Desbroce 2	Price
7	m3	3	1402956	467652,07	Basecourse Layers	Capa asiento 1	Use
8	m3	10	1772486	177248,55	Basecourse Layers	Capa asiento 2	Borrowed m
9	m3	2	1365678	682839,1	Embankment and Fill Sections	Terraplén tipo 1	Use
10	m3	4	5638045	1409511,22	Excavations:	Excavación 2	Landfill
11	m3	3	3669738	1223246,15	Excavations:	Excavación 2	Use
12	m3	10	727550	72754,97	Roadbase Layer	Capa granular de firme 1	Use
13	m3	20	1524718	76235,92	Roadbase Layer	Capa granular de firme 2	Borrowed m
14	m3	48	1310011	27291,9	Materials from Plant	MBC-S12	Measureme
15	m3	47	1973160	41982,13	Materials from Plant	MBC-S20	Measureme
16	ml	29	403790	13923,8	Ditches	Cuneta trapezoidal medi	Price
17	ml	35	774291	22122,59	Ditches	Cuneta trapezoidal 1	Price
18	Km	90000	1250892	13,9	xDrenaje	Drenaje tipo 1	Price
19	Km	13000	180684	13,9	Signaling Beacons	Señalización tipo 2	Price
20	Km	55000	764434	13,9	Service replacement	Reposición 1	Price
21	Km	4000	55595	13,9	Geotechnical corrections	Correcciones tipo 2	Price
22	Km	1800	25018	13,9	Provisional Diversions	Desvío tipo 1	Price
23	Km	4000	55595	13,9	Complementary actions	Actuación tipo 2	Price
24	Km	200	2780	13,9	Corrective Measures	Medida tipo 1	Price
25	%	5	1145696	22913917,31	Health and Safety	Seguridad y Salud tipo 2	Price

Image 139. Example of base bid budget list.

The whole construction with more than 40 km of highway over mountainous terrain costs less than 210 million euros as Base Bid Budget.

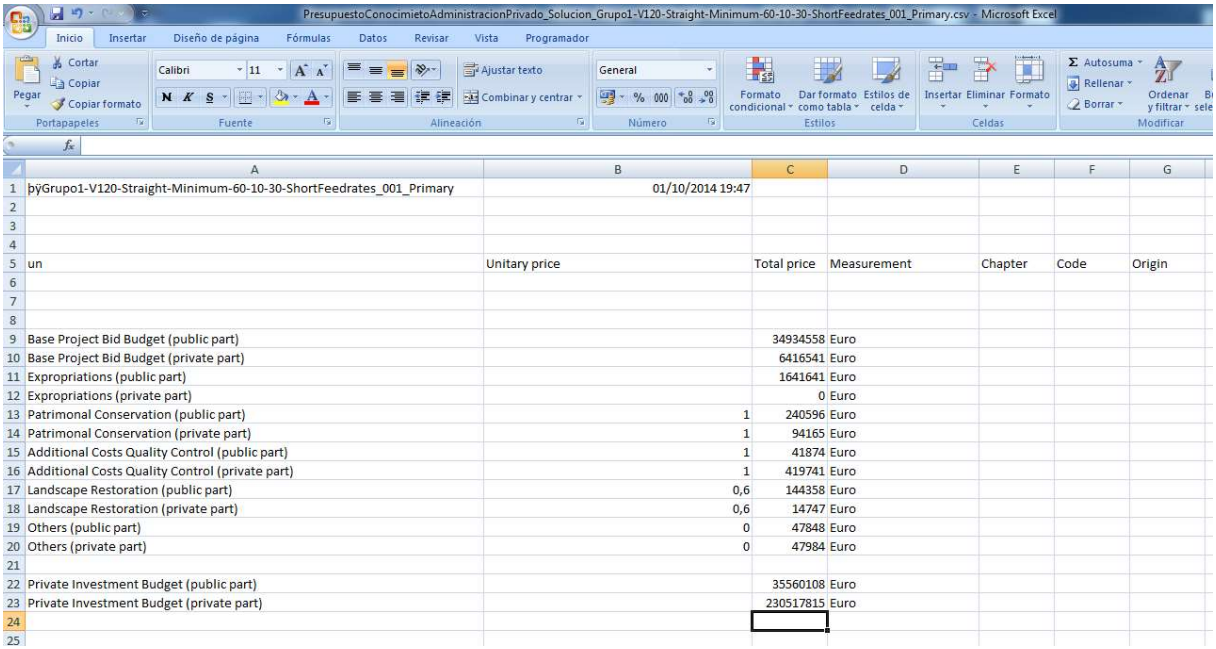
- **Budget Report for the Administration with public investment**



	A	B	C	D	E	F	G	H
1	þÿGrupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary	01/10/2014 19:47						
2								
3								
4								
5	un	Unitary price	Total price	Measuremer	Chapter	Code	Origin	
6								
7								
8								
9	Base Project Bid Budget		34934558	Euro				
10	Expropriations		49784448	Euro				
11	Patrimonal Conservation	1	240596	Euro				
12	Additional Costs Quality Control	1	240596	Euro				
13	Landscape Restoration	0,6	144358	Euro				
14	Others	0	649478	Euro				
15								
16	Budget for Administration		230586234	Euro				
17								
18								

Image 140. Example of budget report for the administration list.

- **Budget for the Administration with private investment**

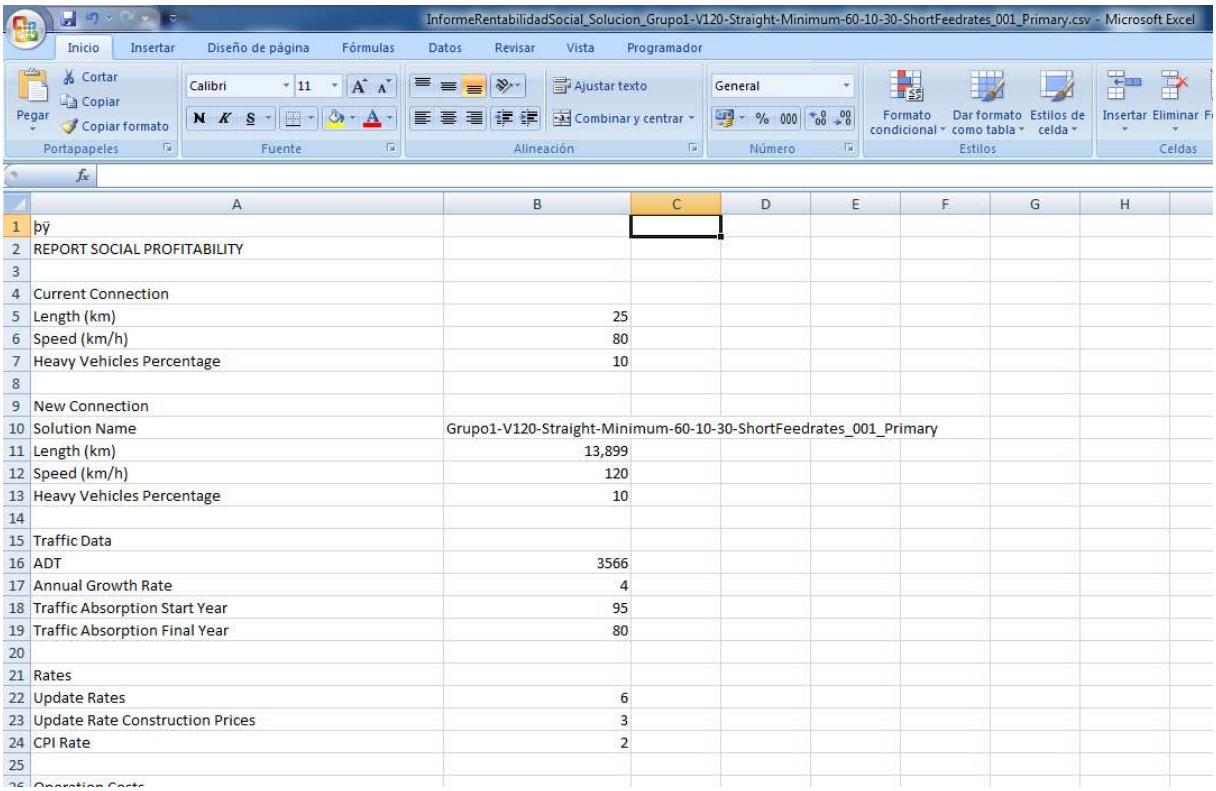


	A	B	C	D	E	F	G
1	þÿGrupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary	01/10/2014 19:47					
2							
3							
4							
5	un	Unitary price	Total price	Measurement	Chapter	Code	Origin
6							
7							
8							
9	Base Project Bid Budget (public part)		34934558	Euro			
10	Base Project Bid Budget (private part)		6416541	Euro			
11	Expropriations (public part)		1641641	Euro			
12	Expropriations (private part)		0	Euro			
13	Patrimonal Conservation (public part)	1	240596	Euro			
14	Patrimonal Conservation (private part)	1	94165	Euro			
15	Additional Costs Quality Control (public part)	1	41874	Euro			
16	Additional Costs Quality Control (private part)	1	419741	Euro			
17	Landscape Restoration (public part)	0,6	144358	Euro			
18	Landscape Restoration (private part)	0,6	14747	Euro			
19	Others (public part)	0	47848	Euro			
20	Others (private part)	0	47984	Euro			
21							
22	Private Investment Budget (public part)		35560108	Euro			
23	Private Investment Budget (private part)		230517815	Euro			
24							
25							

Image 141. Example of list of budget for Administration with private investment.

11.3.4.8.2. Profitability

- **Report on Social Profitability**



	A	B	C	D	E	F	G	H
1	þÿ							
2	REPORT SOCIAL PROFITABILITY							
3								
4	Current Connection							
5	Length (km)	25						
6	Speed (km/h)	80						
7	Heavy Vehicles Percentage	10						
8								
9	New Connection							
10	Solution Name	Grupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary						
11	Length (km)	13,899						
12	Speed (km/h)	120						
13	Heavy Vehicles Percentage	10						
14								
15	Traffic Data							
16	ADT	3566						
17	Annual Growth Rate	4						
18	Traffic Absorption Start Year	95						
19	Traffic Absorption Final Year	80						
20								
21	Rates							
22	Update Rates	6						
23	Update Rate Construction Prices	3						
24	CPI Rate	2						
25								

Image 142. Example of social profitability list per year.

We need to take into consideration that the Internal Rate of Return is given in parts per unit.

For our solution we have obtained quite good social profitability data with a NPV higher than 254 million €, B/C relation higher than 1.9, IRR touching 50% and a Period of Investment Return of 7 years.

- **Report on Private Profitability**

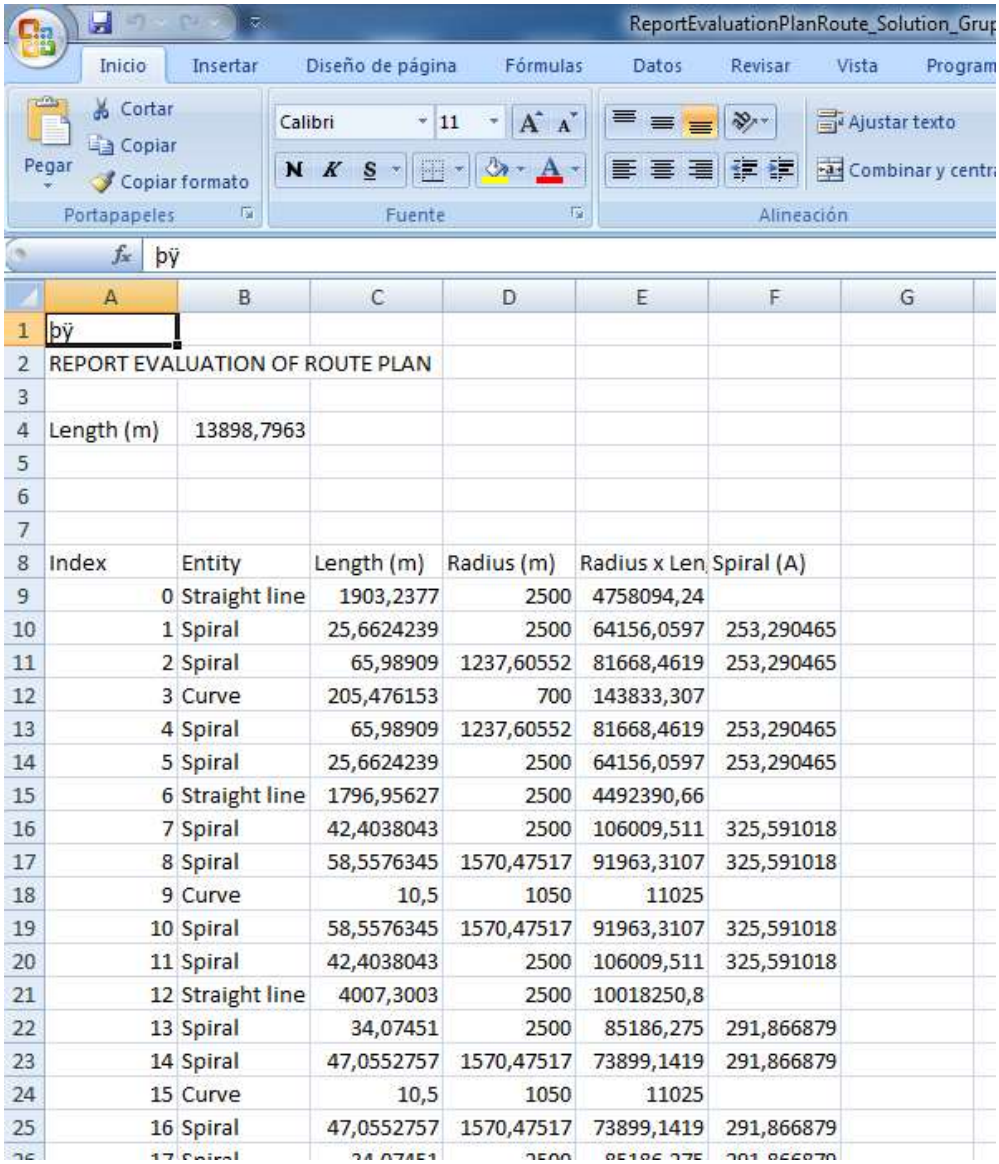
78	14	Exploitation	9	0	1,17165938	1	2,26090396	1718420	171842	1546578
79	15	Exploitation	10	0	1,19509257	1	2,39655819	1770250	188089	1582161
80	16	Exploitation	11	0	1,21899442	1	2,54035168	1822445	205025	1617420
81	17	Exploitation	12	0	1,24337431	1	2,69277279	1874640	222614	1652026
82	18	Exploitation	13	0	1,26824179	1	2,85433915	1926470	240809	1685661
83	19	Exploitation	14	0	1,29360663	1	3,0255995	1978665	259700	1718965
84	20	Exploitation	15	0	1,31947876	1	3,20713547	2030495	279193	1751302
85	21	Exploitation	16	0	1,34586834	1	3,3995636	2082690	299387	1783303
86	22	Exploitation	17	0	1,37278571	1	3,60353742	2134885	320233	1814652
87	23	Exploitation	18	0	1,40024142	1	3,81974966	2186715	341674	1845041
88	24	Exploitation	19	0	1,42824625	1	4,04893464	2238910	363823	1875087
89	25	Exploitation	20	0	1,45681117	1	4,29187072	2291105	386624	1904481
90	26	Exploitation	21	0	1,4859474	1	4,54938296	2342935	410014	1932921
91	27	Exploitation	22	0	1,51566634	1	4,82234594	2395130	434117	1961013
92	28	Exploitation	23	0	1,54597967	1	5,1116867	2447325	458873	1988452
93	29	Exploitation	24	0	1,57689926	1	5,4183879	2499155	484211	2014944
94	30	Exploitation	25	0	1,60843725	1	5,74349117	2551350	510270	2041080
95										
96										
97										
98										
99										
100										
101										
102	VAN:	89658963								
103	B/C:	1,528								
104										
105	IRR:	0,973								
106	PRI:	20								
107										

Image 143. Example of private profitability list in a public-private investment.

In this case, the report of private profitability is also quite good with a NPV higher than 90 million €, B/C relation higher than 1.5, IRR almost 10% and a Period of Investment Return of 20 years,

11.3.4.8.3. Reports of route: plan, profile and time

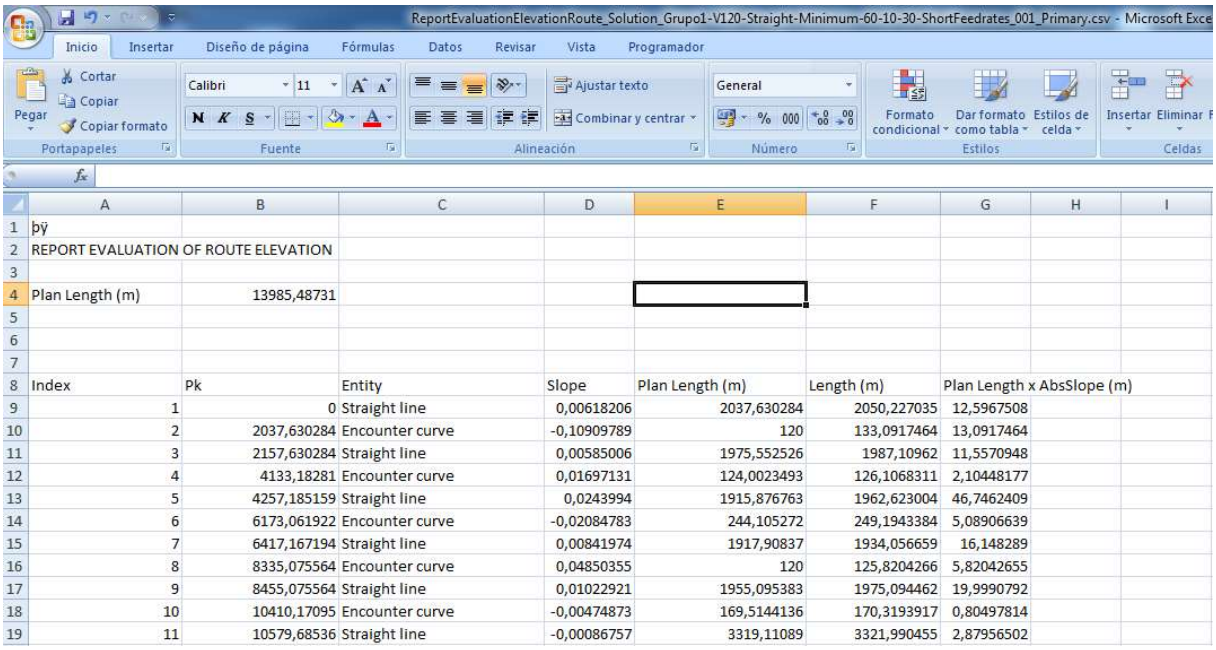
- **Report of route (plan)**



	A	B	C	D	E	F	G
1	þÿ						
2	REPORT EVALUATION OF ROUTE PLAN						
3							
4	Length (m)	13898,7963					
5							
6							
7							
8	Index	Entity	Length (m)	Radius (m)	Radius x Len	Spiral (A)	
9	0	Straight line	1903,2377	2500	4758094,24		
10	1	Spiral	25,6624239	2500	64156,0597	253,290465	
11	2	Spiral	65,98909	1237,60552	81668,4619	253,290465	
12	3	Curve	205,476153	700	143833,307		
13	4	Spiral	65,98909	1237,60552	81668,4619	253,290465	
14	5	Spiral	25,6624239	2500	64156,0597	253,290465	
15	6	Straight line	1796,95627	2500	4492390,66		
16	7	Spiral	42,4038043	2500	106009,511	325,591018	
17	8	Spiral	58,5576345	1570,47517	91963,3107	325,591018	
18	9	Curve	10,5	1050	11025		
19	10	Spiral	58,5576345	1570,47517	91963,3107	325,591018	
20	11	Spiral	42,4038043	2500	106009,511	325,591018	
21	12	Straight line	4007,3003	2500	10018250,8		
22	13	Spiral	34,07451	2500	85186,275	291,866879	
23	14	Spiral	47,0552757	1570,47517	73899,1419	291,866879	
24	15	Curve	10,5	1050	11025		
25	16	Spiral	47,0552757	1570,47517	73899,1419	291,866879	

Image 144. Example of evaluation list of route (plan).

- **Report of route (profile)**

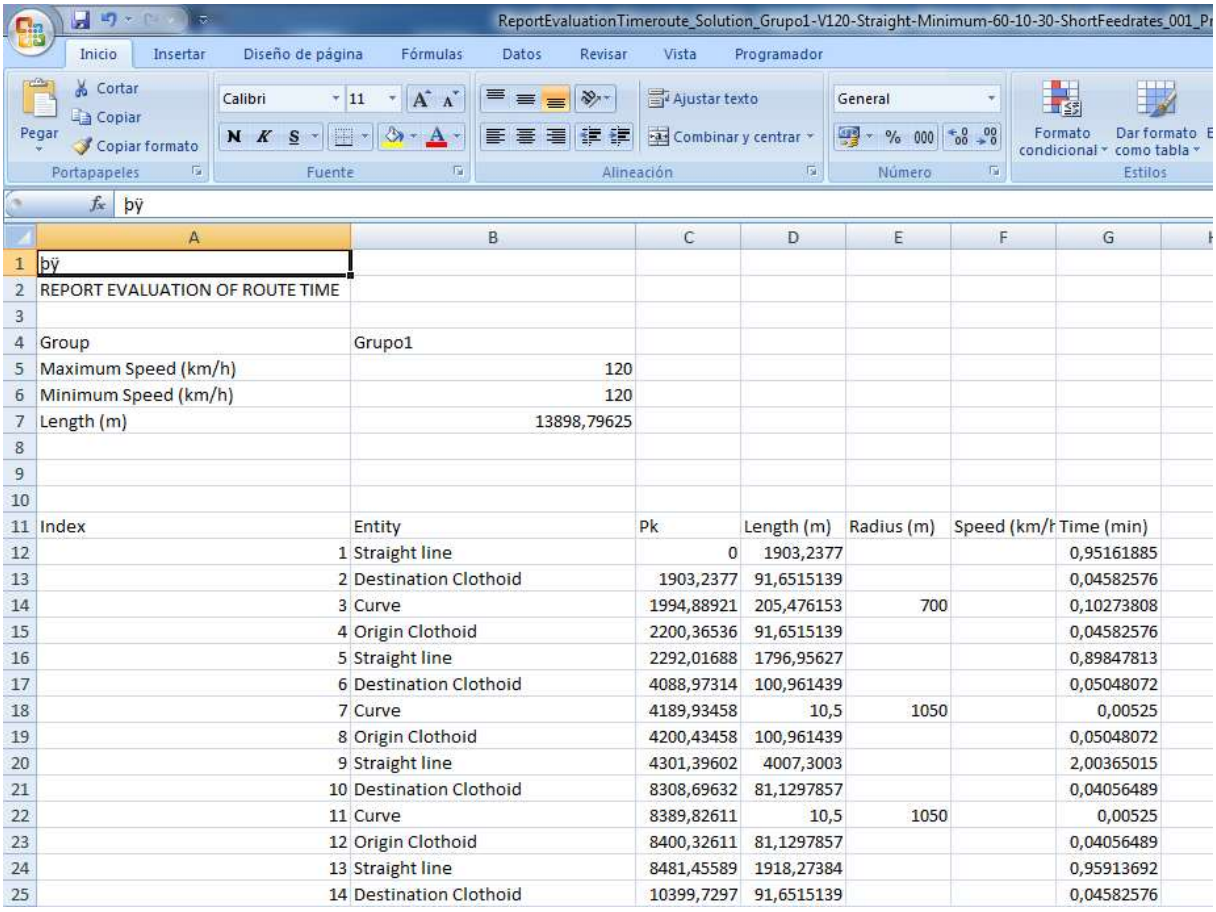


ReportEvaluationElevationRoute_Solution_Grupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_Primary.csv - Microsoft Excel

	A	B	C	D	E	F	G	H	I
1	þÿ								
2	REPORT EVALUATION OF ROUTE ELEVATION								
3									
4	Plan Length (m)	13985,48731							
5									
6									
7									
8	Index	Pk	Entity	Slope	Plan Length (m)	Length (m)	Plan Length x AbsSlope (m)		
9	1	0	Straight line	0,00618206	2037,630284	2050,227035	12,5967508		
10	2	2037,630284	Encounter curve	-0,10909789	120	133,0917464	13,0917464		
11	3	2157,630284	Straight line	0,00585006	1975,552526	1987,10962	11,5570948		
12	4	4133,18281	Encounter curve	0,01697131	124,0023493	126,1068311	2,10448177		
13	5	4257,185159	Straight line	0,0243994	1915,876763	1962,623004	46,7462409		
14	6	6173,061922	Encounter curve	-0,02084783	244,105272	249,1943384	5,08906639		
15	7	6417,167194	Straight line	0,00841974	1917,90837	1934,056659	16,148289		
16	8	8335,075564	Encounter curve	0,04850355	120	125,8204266	5,82042655		
17	9	8455,075564	Straight line	0,01022921	1955,095383	1975,094462	19,9990792		
18	10	10410,17095	Encounter curve	-0,00474873	169,5144136	170,3193917	0,80497814		
19	11	10579,68536	Straight line	-0,00086757	3319,11089	3321,990455	2,87956502		

Image 145. Example of evaluation list of route (profile).

- **Report of time**



ReportEvaluationTimeroute_Solution_Grupo1-V120-Straight-Minimum-60-10-30-ShortFeedrates_001_P

	A	B	C	D	E	F	G
1	þÿ						
2	REPORT EVALUATION OF ROUTE TIME						
3							
4	Group	Grupo1					
5	Maximum Speed (km/h)	120					
6	Minimum Speed (km/h)	120					
7	Length (m)	13898,79625					
8							
9							
10							
11	Index	Entity	Pk	Length (m)	Radius (m)	Speed (km/h	Time (min)
12	1	Straight line	0	1903,2377			0,95161885
13	2	Destination Clothoid	1903,2377	91,6515139			0,04582576
14	3	Curve	1994,88921	205,476153	700		0,10273808
15	4	Origin Clothoid	2200,36536	91,6515139			0,04582576
16	5	Straight line	2292,01688	1796,95627			0,89847813
17	6	Destination Clothoid	4088,97314	100,961439			0,05048072
18	7	Curve	4189,93458	10,5	1050		0,00525
19	8	Origin Clothoid	4200,43458	100,961439			0,05048072
20	9	Straight line	4301,39602	4007,3003			2,00365015
21	10	Destination Clothoid	8308,69632	81,1297857			0,04056489
22	11	Curve	8389,82611	10,5	1050		0,00525
23	12	Origin Clothoid	8400,32611	81,1297857			0,04056489
24	13	Straight line	8481,45589	1918,27384			0,95913692
25	14	Destination Clothoid	10399,7297	91,6515139			0,04582576

Image 146. Example of evaluation list of route (time).

12. MEASURE UNITS

TADIL uses the metric decimal system to measure the axis, to establish their labelling per kilometre points, the design of grade line and the section measures that we have set up in the budget.

We can use the monetary unit (m.u.) that we wish.

In the construction units and prices, the monetary unit are:

- Cut materials: m^3.
- Excavations: m^3.
- Fill sections: m^3.
- Materials from treatment plants: m^3.
- Ditches: linear metre.
- Walls: m^3.
- Structures: m^3.
- Tunnels: km.
- Macro-prices: km.
- Expropriations: m^2.

13. ERROR MESSAGES

Next we list the most frequent error messages from TADIL:

- *Error while Assigning Maximum{0} and Minimum {1} Marks*

We have entered a mark out of the range between 0 and 10.

- *Error while Saving File*

We have clicked on "Save as" and, after that, we have aborted the process. The file is not saved.

- *Error while Validating Form Data*

We have entered data out of range or we have not entered any mandatory data.

- *Value out of Range ; Maximum Value {0}*

We have entered a value which is higher than the maximum one.

- *Value out of Range ; Minimum Value {0}*

We have entered a value which is smaller than the minimum one.

- *The Text Length is out of range ; Maximum Value {0}*

The text has more characters than allowed.

- *You must select one record*

We have clicked on a calculation button but we have not selected the project to be calculated.

- *The route plan axis already exists*

We have clicked on "Route plan axis" in a solution where the route plan axis was previously calculated.

- *Entity with IDs {0} \not found in the current file*

We have calculated the linear work and the name of the solution have remained in the TADIL memory. We have modified some data in the TDB or we have opened a cartography which does not correspond to the place where the work was first calculated. After that, we have open the file again and, when we have tried to use it, TADIL does not identify it. We recommend using and saving the cartography and the TDB for each single project.

- *To remove the record linked to the entity is recommended*

When a solution is not found in the file, we recommend removing the solution.

- *The lineal work already exists*

We have clicked on "Linear Work" in a solution where the linear work was previously calculated.

- *The longitudinal profile already exists*

We have clicked on "Longitudinal Profile" in a solution where the longitudinal profile was previously calculated.

- *There is no solution maximum envelope curve*

From the primary solution, there is no solution of maximum envelope curve

- *There is no solution minimum envelope curve*

From the primary solution, there is no solution of minimum envelope curve

- *There is no solution with the parameters of initial design*

There is no solution with the data entered by the user. We recommend changing the origin and destination point and, if this is not possible, trying with the distance, the orography and the global cost. The route plan slopes and the structures can be also modified. If we make different combination of these factors, we might not find any solution.

- *There are no entities to export*

If we have not calculated the linear work, neither have we created the plan or the cross sections, we cannot export them.

- *The lineal work has been already exported*

We have clicked on "Export Plan and Sections" in a solution where we had previously exported the plan and the sections.

- *The selected entity is not a polyline*

We have selected an entity in AutoCAD which is not a polyline. We must stress that, when we link polylines to GIS, these must be polylines and not just lines.

- *The connecting stretch fails to comply with the design criteria*

Given the data entered in TADIL, there is no solution to connect the last stretch with the destination point. Modifying the slopes is recommended.

- *The point is out of the cartography*

Or the origin or destination point selected is out of the DTM network or no DTM has been loaded in the tab "Land".

- *Error while Validating Form Data*

When loading the database for an informative study, the name of the path file where TDB was saved is too long.

- *The record corresponding to value 140 in the TablaTablaKv is not found*

In the basic axis editor, a road with inadmissible project speed has been selected. A road with another project speed needs to be selected, or edit the regulation.

- *You must complete the table "Type section and general areas"*

The basic axis has been tried to design without previous completion of the menu "Type Section and General Areas".

- *File Lince.jpg not found*

A GIS area has been entered in the TDB and the image linked to it cannot be found in the folder "TADIL\10.00-Tadil\img\gis"

- *An open polyline cannot be linked to a GIS area.*

You have tried to link an open polyline to a GIS area. Remember that all the polylines to be linked to GIS areas must be closed polylines.

- *Unable to cast object of type polyline 3D, when creating the DTM.*

You are trying to create a DMT out of a layer of contour lines which includes 3D polylines. In section "8. CREATING THE DIGITAL TERRAIN MODEL (DTM)" is explained in greater detail how to avoid this error.

- *The width of the section is over the maximum value [2000], when creating the linear work.*

There is a cross section whose slope is practically parallel to the land slope and said cross section would make more than 1000 meters, so it has not been measured. We recommend modifying the slopes in this area or choosing a different way to carry out the cut section or embankment (with wall).

- *The route axis to the middle point can be made only with short feedrates.*

You have tried to create a basic axis with the method "middle point" with long feedrates but this kind of basic axis can be used only for short feederated.

- *Error: Evaluations must have a maximum value of 10 and a minimum value of 0*

When entering the subjective variables, one of the values must be the best (number 0) and another value must be the worst (number 10).

- *Names cannot include special characters*

You have tried to created a basic axis whose name includes a special character (" @ ^, etc).

14. FREQUENT ASKED QUESTIONS

In this section we gathering together some of the FAQ by the users:

a. What type of digital terrain model can I load?

The digital terrain model must have been generated with TADIL.

b. Can I modify the regulation and save it?

You can generate your own regulation with the specified format in the Regulation Editor, where you must indicate the radius and the camber for each speed of the axis and, for elevation, the minimum and optimum Kv for convex or concave transition curve on undulating track.

c. Can I work in the project administrator without completing the database file?

At least, you must complete the geotechnical area of earthwork, structures and tunnels as well as the geotechnical area of foundation, indicating the general areas. At the same time, by completing those areas you will be requested to complete the corresponding construction units.

The remaining GIS areas have just a qualitative nature, so you do not need to complete them. If you want to calculate expropriations, you will have to specify the socioeconomic areas with their evaluation and the patrimonial areas with the land value.

d. Is it necessary to enter the banned areas again if we have specified them in the GIS?

No, it is not. You can enter areas you have not implemented in the Database Administrator.

e. By clicking on "Select Banned Area due to Slope", is a banned polygon automatically created?

No, it is not. The polygons which had been calculated when the MDT was created will be marked.

f. Can I specify the destination and origin alignment just with its length?

No, you cannot. You must specify its azimuth too.

g. What happens when the origin or destination permanent alignment does not comply with the project criteria?

The software warns that the project parameters related to the origin alignment are not respected, but it keep on calculating.

h. How can I enter Target points?

The target points are entered just like the manual visibility axis.

i. Can I calculate alternatives without indicating general areas?

For the informative study, you must indicate the general areas. For the previous study, you do not have to.

j. How does the option "Allow Isolated Speed Reductions" affect?

It may affect to the isolated failure of some vertical transition curve on undulating track.

k. How does the modification of dynamic evaluation condition the obtaining of drafts?

The higher the evaluation percentages per distance are, the shorter and more direct will be the drafts, but more expensive instead. The higher the evaluation percentages per cost are, the cheaper will be the infrastructure per length unit, but longer instead.

l. What is Aij constant for?

This option aims to be used in very complicated orography, with high slopes and very marked stream beds. Entering values of Aij constant allows you to have more success in searching for itineraries, although this algorithm will impose isolated radios reductions (and, therefore, speed reductions) when it is not possible to find solutions with your criteria.

m. What are coefficients of reduction for?

They allow to carry out sensitivity studies and to obtain new solutions for reducing some or all the parameters regarding maximum cut sections/embankments or slopes.

n. For obtaining budgets, which data are the percentages of the Setting Menu Project Data given about?

About the Budget Material Execution.

o. How can I enter other mandatory taxes in my country?

With the variable VAT. In addition to the VAT itself, you can add other direct taxes.

p. What is the difference between prices update rate and annual CPI update?

The prices update rate is just applicable to the construction costs of the infrastructure for the years of construction, whereas the annual CPI update is applicable to every income and cost from the first exploitation year.

q. What is the difference between the annual state subsidy and the vehicle state subsidy?

The annual state subsidy is a static or updatable quantity per IPC, independent from the number of vehicles, whereas the vehicle subsidy is applicable to the total number of vehicles in a year, with a static or updatable value per IPC.

r. Where can I get some information about the death and hazardousness rate?

Generally, the National Department of Traffic of the Ministry of Internal Affairs or the Ministry of Public Works or Transport include this kind of information annually or every two or three years, depending on the country.

Sometimes they not include all the roads, so you will be able to consider the connection features or to look for in specialized literature.

s. What is the time cost's weighting coefficient?

It is a coefficient which allows to consider the vehicle percentage to be used by the new connection. Here the "time reduction" plays an important role. In general, the local traffic which uses only partially the connection and, in some cases, travels for reasons other than work, can be considered travels where the time variable has not such relevance.

t. How does TADIL apply the conservation and rehabilitation costs?

The conservation costs are applicable annually to the new and former connection, if it is maintained. The rehabilitation ones, every ten years.

u. Can I modify the tables of vehicle consumption and maintenance?

Yes, you can. You can modify tables and save them.

v. Are there any standard criteria to establish weighting coefficients of the variables of each chapter?

No, there are not. You must give greater emphasis to the variables which have greater impact on the road.

w. Are there any standard criteria to establish weighting hypothesis of chapter?

No, there are not. Just as in the previous question, it will depend on the kind of construction. So, in constructions which have been projected in high-valued environmental or landscape spaces, the chapter environmental variables will be very important. In a construction with private investment, the economic variables will be highly important.

x. How can I enter my national currency?

In the section monetary units of the Database Administrator.

y. Can I just enter prices from a created database?

No, you cannot. We recommend creating new prices in concordance with the infrastructure and the land.

z. Should I consider general prices or prices which had been based in a particular study of my work?

The study quality is given by the knowledge on land and on its difficulties. So, for example, it will not be the same excavating in rock with blastings or with pneumatic hammer.

aa. Do the cut section prices consider the canon of landfill?

For cut section, we consider an only price which must be appropriate to be used in revegetation of slopes in the workplace or to be sent to the landfill.

bb. How does TADIL the earthwork balance?

TADIL looks for the maximum use of workplace materials. A granular material can be used as such and, in addition, as a substitute for any other basecourse and filling material A basecourse material will count also as filling material. Let us imagine we have 100.000 m3 of excavation in a workplace. 30.000 are graded aggregate ZA-25, 40.000 are selected soil S-2, 20.000 are tolerable soil T0 for filling and 10.000 are no usable marginal soils. You must create filling sections, esplanades and pavements by using materials coming from the excavation itself. If you specified to create granular layers with ZA-25, esplanades with S-2 and embankments and filling with T0, then you would have the following data:

- For granular roadbase layers: 30,000
- For basecourse layers: 70,000
- For fill sections: 90,000

First of all, TADIL assigns use materials to the granular layers, then to the basecourse ones and finally to fill sections.

Each time that TADIL assigns materials, it updates the available earth bank. Therefore, for example, if it used only 20.000 m3 of granular layers, in the the bank it would remain 50.000 for basecourse and 70.000 for fill sections. In each action, use materials are affected by the swelling coefficient whereas the landfill materials are affected by the embankment coefficient.

Following the example, if TADIL needs 40.000 m3 for roadbase material, it will remain 50.000 for fill sections. If we had a total of 120.000 m3 of fill sections while measuring, we would need 70.000 m3 to be borrowed.

cc. Which units are considered in pavement materials from treatment plants?

Every unit to be used in pavement and which comes from treatment plants such as concrete, asphalt conglomerate, pavers, etc.

dd. How can I differentiate two structures or tunnels with equal geometry but lands which have very different geotechnical properties?

In a qualitative way, by differentiating both foundations. In a quantitative way, by considering different prices.

ee. Does the macro price include the measuring of ditches?

No, it does not. The measuring of ditches is made by linear metre. The macro-price refers to the transversal drainage works, canalizations and longitudinal works.

ff. How is health and safety quantified?

Per percentage, with regard to the Material Execution.

gg. Where are the land production and patrimonial evaluation used?

In the expropriations consisting of land production compensation and land patrimonial value.

hh. How can I reflect geological groups which include several lithological groups in my map?

A easy way is to use the same colour for different lithological groups.

ii. How is the coefficient for embankment applied, and the coefficient of swelling?

The coefficient of swelling entails changing the volume of measured material in profiles to fill sections, whereas the coefficient for embankment affects to the volume of the landfill material; both coefficients have a clear influence in the budget from chapter "Earthwork".

jj. How is the parameter "Recommended maximum land slope" considered?

It is a qualitative parameter. The higher the slope, the more stable the land is.

kk. How does the cut materials' thickness affect?

The cut materials' thickness affects to the Earthwork measures. Fill sections or cut sections will be made on cut lands, hence a higher cut section increases embankments and decreases cut sections.

ll. How does the assignment of materials for exploitation affect?

In the excavation use. I would be senseless that excavations would produce a great range of materials and, however, we would scale embankments, basecourse and roadbase layers with other materials since it would entail an general increase in construction.

mm. What is the parameter "Maximum Slope without Step" for?

From this slope TADIL includes steps in the scaling.

nn. How should I enter the roadbase and basecourse layers?

You should enter them from top to bottom.

oo. May several areas which represent different parameters of a environmental variable classification cross? How are these areas evaluated?

Yes, they may. It is normal, for example, that several protected species cohabit in an area. In that case, the evaluation can be added up to 10.

pp. Is it necessary to fill out all the GIS chapters?

No, it is not. Only those regarding the geotechnics of earthwork, structures, tunnels and foundations. You can specify if you do not want to project with structures and/or tunnels in some areas or in the whole land.

qq. What should I do to obtain the expropriations?

You should enter compensation values for production in the socioeconomic variables and the land value evaluation in the patrimonial variables as well as specify in the budget data the margin of the rights of way areas.

rr. What happens if I modify the database file after having calculated several alternatives and I continue calculating new solutions in the same project administrator?

It would keep on calculating but you should take into account that the alternatives are not homogeneous when you compare them.

ss. Can I assign different evaluations to two GIS areas of a same variable?

No, you cannot. If you have the same GIS variable and, for any reason, in one place of the cartography it holds a value and in another place it holds a different one, two subgroups need to be created, one with each value and a closed polyline needs to be assigned to each of them.

tt. Can I assign to two GIS areas of a same variable one with banned areas and the other one different?

No, you cannot. Two subgroups need to be created and a closed polyline needs to be assigned to each of them.

uu. If I have created a GIS area and calculated several alternatives, and I edit and modify that GIS area, do the data get updated?

Yes, they do, but the sign created firstly will not.

vv. Can two areas of public hydraulic domain cut?

No, they cannot.

ww. Can I select any radial in the calculation of the manual basic axis, even if that radial fails to comply with the design criteria?

Yes, you can. In the calculation of the manual basic axis you will be able to select any radial, but it does not make sense to establish some restrictions that are not going to be respected.

xx. All radials of the manual basic axis calculation cannot be selected and TADIL does not allow me to continue the calculation, is that right?

Yes, it is. If no radial is feasible, TADIL will automatically stop calculating the basic axis.

yy. If my design cut another previous linear infrastructure and flyover is required, when will it do it over it and when will it do it under it?

In the cutting point, the grade lines are measured. When the grade line of the new road is bigger than the old one, it will do it over it and when the grade line is smaller, it will do it under it.

zz. If my design cuts simultaneously an area of public hydraulic domain and an area of public infrastructure domain, when will it do it over and under it?

It will never do it under it. And the most restrictive of both clearance values will be taken.

aaa. If a point's grade line in the design is affected by different conditions due to its passage through an area of public hydraulic domain, which grade line will TADIL give to it?

TADIL will always give the highest one, for greater safety.

bbb. Why is no polygon drawn in the layer _Tadil_AnalisisPendiente with a higher slope than the specified when created the TDM?

That might have happened either because there is no slope equal or higher than the specified in the TDM or because the slope has been entered in percentage instead of parts per unit.

15. ALGORITHMS OF CALCULATION

The algorithms used by TADIL are structured as follows:

- Algorithms for creating the Digital Terrain Model.
- Algorithms for simplifying polylines.
- Algorithms for searching local and land itineraries.
- Algorithms for generating the basic axis.
- Algorithms for generating the route plan axis.
- Algorithms for generating the grade line.
- Algorithms for calculating the linear work.
- Algorithms for obtaining the earthwork balance.
- Algorithms for evaluating the works and the profitability study.
- Algorithms for evaluating the alternatives.