DAM/PR/0103/2

# DAMOCLES

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**DEBRISFALL ASSESSMENT IN MOUNTAIN CATCHMENTS FOR LOCAL END-USERS**

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**Contract No EVG1 - CT-1999-00007**

**DETAILED REPORT OF CONTRACTOR FOR FIRST ANNUAL REPORT (1 March 2000 – 28 February 2001)**

**University of Newcastle upon Tyne**
**UK**

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# DETAILED REPORT OF THE CONTRACTOR


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| Contractor: | University of Newcastle upon Tyne |
| Responsible Scientist: | Dr J C Bathurst |
| Address: | Water Resource Systems Research Laboratory<br>Department of Civil Engineering<br>University of Newcastle upon Tyne<br>Newcastle upon Tyne<br>NE1 7RU<br>UK |
| Telephone: | +44 191 222 6333/6259 |
| Fax: | +44 191 222 6669 |
| Email: | j.c.bathurst@newcastle.ac.uk |


## 3.1 OBJECTIVES OF THE REPORTING PERIOD (1/3/2000-28/2/2001)

(i) Recruitment of project research associate and familiarisation of research associate with the SHETRAN landslide model.

(ii) Selection of focus catchments in Italy and Spain for application of SHETRAN in Work Package WP4.

(iii) Initial data assembly for focus catchments.

(iv) Validation of SHETRAN for the Llobregat catchment, Spanish Pyrenees.

## 3.2 METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WORK PACKAGES

### 3.2.1 Project Staff

A research associate, Dr Ahmed El-Hames, was appointed to the project from 16 October 2000. Dr El-Hames has since undertaken a programme of familiarisation with the SHETRAN catchment modelling system and is now competent in its use.

The time taken to make the appointment represented a delay in the Newcastle work programme, which was originally due to start in month 1 of the project. However, a revised programme is in place and it is expected that the relevant project deliverables will be completed on time.

To allow progress to be made in the project before Dr El-Hames's arrival, the SHETRAN landslide erosion and sediment yield model was validated for the

Llobregat catchment in the eastern Pyrenees. This work was carried out by Mr Aidan Burton, research associate, and funded by DAMOCLES for half a month.

### 3.2.2 Work Package 4 : SHETRAN Landslide Model

The work package calls for the SHETRAN landslide erosion and sediment yield model to be applied to focus catchments in the Pyrenees and the Italian Alps. A specification for catchment selection was prepared, two catchments have been selected and the relevant data are being assembled.

*Focus catchment specification*

The full specification is given in the progress report for the October 2000 project meeting. The main points are:

(i) The catchment area should be 100-500 $km^2$.
(ii) The catchment should have some point of relevance to end-users.
(iii) Data should be available to run and validate SHETRAN's core hydrology and sediment transport components, especially time series of rainfall and river discharge and catchment soil, vegetation and topographic properties.
(iv) Data should be available to run and validate the landslide erosion and sediment yield component, especially a high resolution Digital Elevation Model and a record (or inventory) of shallow landslide activity.

The full specification is demanding and it was not expected that it would be met in full. One consequence of an inability to satisfy all the data requirements is the need to incorporate uncertainty in the presentation of simulation outputs.

*Valsassina, Lombardy Pre-Alps*

This catchment was selected with the advice of the University of Milan-Bicocca team. It discharges into Lake Como (Lake Lario) near Bellano, where the main river (Pioverna) is gauged. The total area to be modelled with SHETRAN is 185 $km^2$, which includes also a small neighbouring catchment which discharges directly into Lake Como. Two particular reasons for selecting this catchment are:

(i) It was subject to a heavy rainstorm on 28 June 1997 which triggered extensive landsliding at the lower end of the catchment and in the small neighbouring catchment. Radar images of the rainfall, a landslide inventory and other relevant data have been assembled by the Milan-Bicocca team and colleagues.

(ii) Valsassina lies in Lecco Province, which is a focus for the regional hazard assessment modelling of Work Package 2 (WP2). This will greatly help the eventual integration of the WP2 and WP4 modelling approaches.

Data available for the catchment include a 20-m resolution Digital Elevation Model (DEM), soil properties for part of the catchment, meteorological records and limited streamflow records. The Milan-Bicocca team are also preparing maps showing the occurrence of landslides at intervals of 10 years from 1951 to 1990.

SHETRAN will be validated specifically for the 1997 event (demonstrating applicability at the event scale) and more generally for the 1951-1990 period (demonstrating applicability over the longer term). As the first step, the model grid network has been set up (with a 1 km resolution) and the model topographic file has been completed using the DEM data (Fig. 1). A test to show that the core SHETRAN flow and sediment transport model will run with this topography has also been carried out using hypothetical soil, vegetation, sediment and meteorological data.

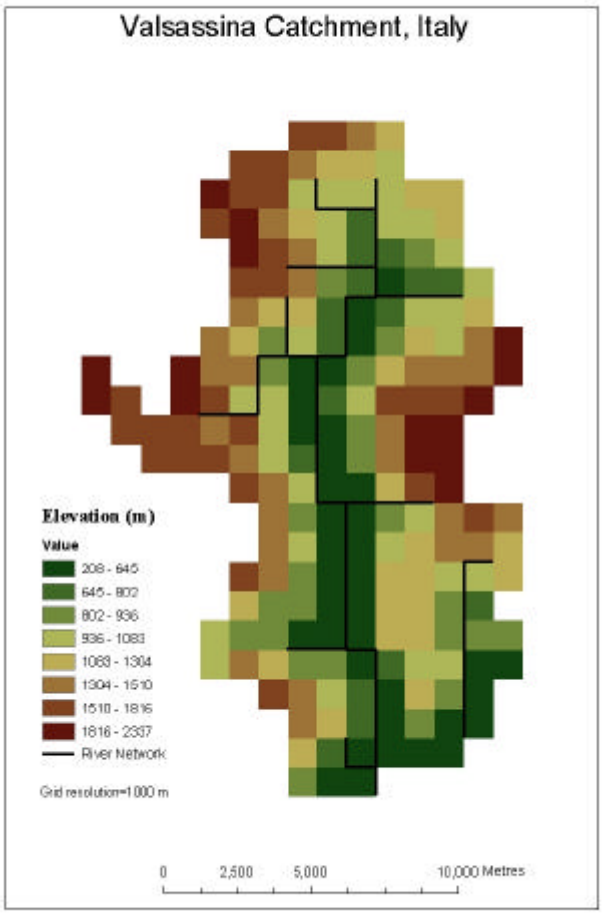



**Figure 1 SHETRAN grid network, channel system and elevation distribution for the Valsassina focus area.**

The next stage is to assemble the available catchment data and to set up the remaining SHETRAN files, including that for the landslide component. As not all the necessary data are currently available, a field visit will be made to Valsassina in mid May, to measure soil properties in particular.

*Ijuez, Central Spanish Pyrenees*

This catchment was selected with the advice of the Pyreneen Institute of Ecology. The Ijuez is a tributary of the Aragón river and the catchment is 10 km from the city of Jaca. The area to be modelled is 45 $km^2$, the altitude range is 850-2200 m, the main lithology is calcareous flysch and the natural vegetation is mainly pines, shrubs and, in the highest parts, meadows. Two particular reasons for selecting this catchment are:

(i) It contains 60-100 debris flow sites.

(ii) It lies in the focus area for the regional hazard assessment modelling of Work Package 2.

A 20-m resolution DEM is available and provides the basis for the SHETRAN topographic file, set up with a 500-m resolution (Fig. 2). Daily meteorological data have been recorded for a station in the catchment since 1970. These can be distributed on a sub-daily basis using records collected in Jaca.

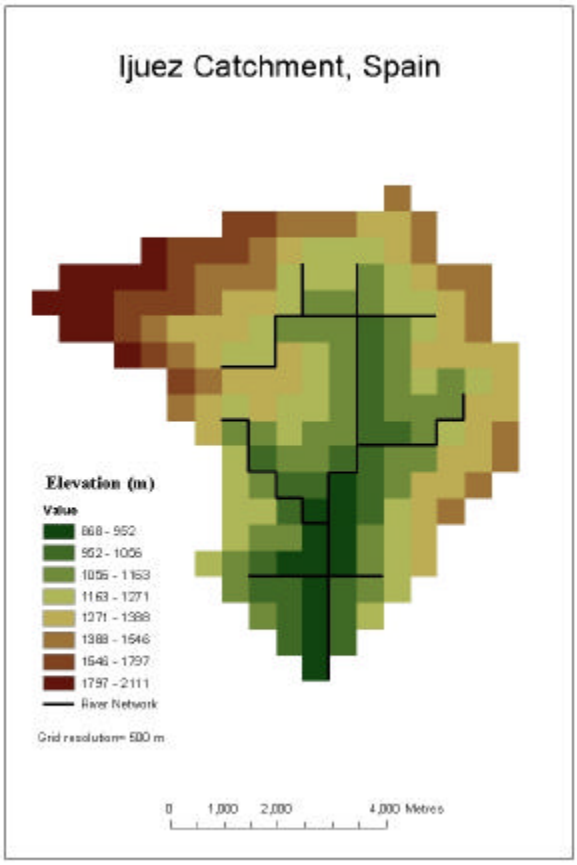



**Figure 2 SHETRAN grid network, channel system and elevation distribution for the Ijuez focus area**

The next stage is to assemble the available catchment data and set up the SHETRAN files. A field visit is planned for mid-June to measure soil properties.

*Llobregat validation*

The SHETRAN landslide model is being validated for a major landsliding event which occurred in the 500-km$^2$ Llobregat catchment, eastern Spanish Pyrenees, in November 1982. The work is being carried out in collaboration with a team from the Institute of Earth Sciences (Consejo Superior de Investigaciones Cientificas), Barcelona, building on a preliminary validation from the EC MEDALUS III (Mediterranean Desertification and Land Use) project. Full details are given in the progress report for the October 2000 project meeting and are summarized as follows.

It is generally accepted that evaluation of model parameters and other inputs for complex physically based systems like SHETRAN involves uncertainty. For the Llobregat application the aim, therefore, is not to reproduce the observed occurrence of landslides as exactly as possible with one simulation but to bracket the observed pattern with several simulations. Between them, these simulations should represent the uncertainty in the key input conditions. Defining the principal sources of uncertainty will indicate where attention most needs to be devoted in parameter evaluation for the DAMOCLES applications.

As the first stage in the application, the event hydrological response was simulated, so as to obtain the soil saturation and water flow data which form the input to the landslide simulation. Next the sediment transport component was run, providing the mechanism for transporting eroded sediment to the catchment outlet. Finally the landslide component was applied, investigating two particular sources of uncertainty:

(i) Model parameterization assumes an initially complete soil cover across the catchment. In reality, though, some of the cover would have been removed by debris flows in earlier years. In the simulation the November 1982 rainfall event was therefore preceded by a rainfall event with the same temporal distribution but a reduced volume. The reduction scale was based on limited rainfall records for the region for the period from the 1940s to 1970. A reduction to 30 - 40% of the November 1982 total was considered appropriate. The slope failures triggered by the first event were removed from the map of failures triggered by the principal event.

(ii) Several of the landslide model parameters are estimated from limited field measurements or data in the literature and may provide inaccurate descriptions of some parts of the catchment. Sensitivity tests were therefore carried out to investigate the effect of parameter uncertainty. In particular, the vegetation root cohesion was halved and doubled relative to its baseline values and the soil angle of friction was increased and decreased by 5º.

At the time of writing, the full range of simulations had not been completed. However, the general effect of the above modifications can be seen from the following:

(i) Figure 3 shows the simulated debris flow pattern for the November 1982 event on its own. The number of debris flows is much greater than observed.

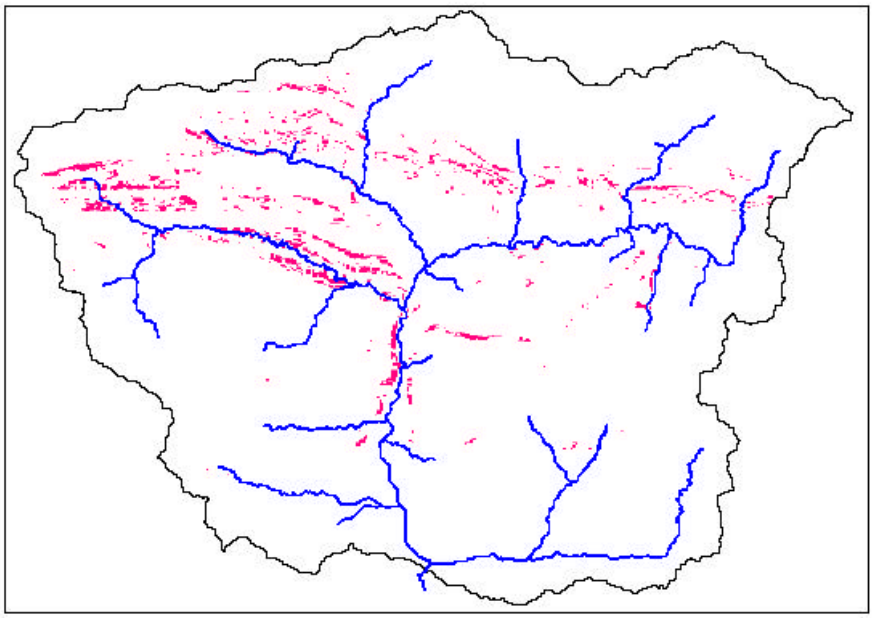


**Figure 3 Simulated debris flow pattern for the November 1982 event on its own.**

(ii) Figure 4 shows the effect of preceding this simulation with a rainfall event equal to 40% of the principal event and removing the debris flows triggered by the preceding event. The number of debris flows triggered by the principal event is then considerably reduced.

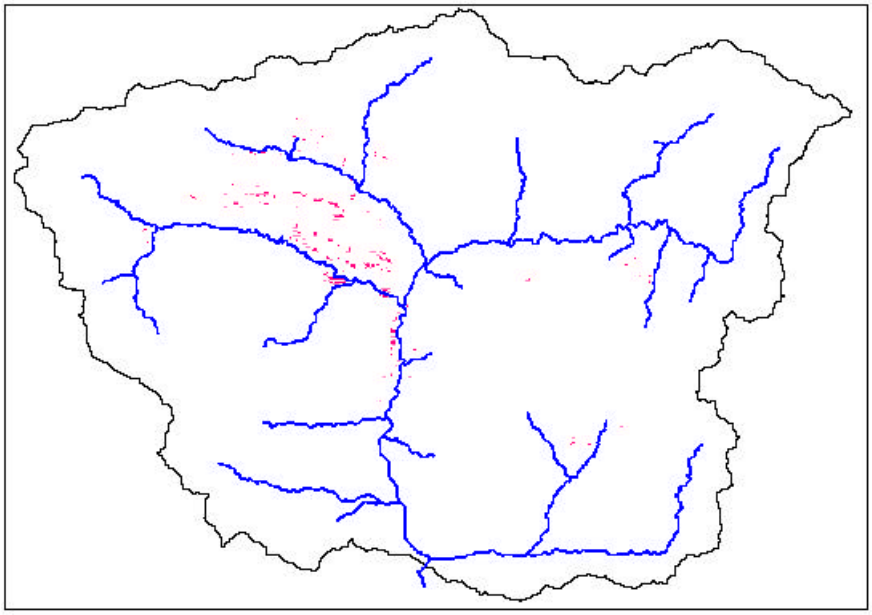


**Figure 4 The simulation of Figure 3, removing debris flows triggered by a preceding rainfall event equal to 40% of the principal event.**

(iii) Doubling the root cohesion completely eliminates the slope failures. Increasing the soil angle of friction by 5º also significantly reduces the occurrence of failures.

These results are very encouraging as they clearly demonstrate an ability to bracket the observed landslide pattern. The remaining simulations will refine the bracketing runs, including allowing for the uncertainty in the hydrological simulation. Finally the sediment yields from the landslide erosion will be calculated and compared with the yields derived from raindrop impact and overland flow erosion.

### 3.2.3 Workpackage 5 : Dissemination

The Newcastle Contractor has supplied basic information for the website which has been established by CNR-IRPI, Perugia.

## 3.3 SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

Through meetings with the Project Coordinator, the interests of the project end-users have been defined. The practical relevance of the Newcastle project is clear from the ability of the SHETRAN landslide model to satisfy many of these interests, including:

- scenarios for altered hazard as a function of land use and climate change, for a 25-year planning horizon;
- catchment sediment yield (e.g. for public works)
- event-based responses (e.g. for different frequency rainfall events);
- rainfall thresholds for landslides;
- peak water discharge and total discharged volume for storm events;
- peak sediment discharge and total discharged volume for storm events.

## 3.4 DISCUSSION AND CONCLUSION

(i) The selection of the Valsassina and Ijuez catchments and the creation of the SHETRAN grid networks and topography files are important first steps in the simulation programmes for those catchments.

(ii) The Llobregat validation is providing experience in model parameter evaluation and validation technique which will greatly benefit the Valsassina and Ijuez applications.

## 3.5 PLAN AND OBJECTIVES FOR THE NEXT PERIOD

The following activities in WP4 are required to meet the Newcastle team's obligations to deliver preliminary simulation data to WP2 in Month 18 (August 2001) and final simulation data in Month 24 (February 2002). A timetable is attached.

(i) Assembly of Valsassina and Ijuez catchment time series and property data, including field measurements and laboratory analysis of soil samples.

(ii) Creation of SHETRAN files.

(iii) Enhancement of SHETRAN landslide model with relationships from WP1. (Preliminary relationships available in Month 15 (May 2001); final relationships available in Month 21 (November 2001).)

(iv) Validation of SHETRAN for the focus catchments. (Preliminary validation for Month 18; final validation for Month 24).

(v) Development of scenarios for future land use and climate.

(vi) Demonstration of application of SHETRAN for scenario conditions.

(vii) Scenario applications for Valsassina to provide a basis for a revised regional hazard assessment model, as input to WP2.

(viii) Initial SHETRAN applications to develop guidelines for land management to mitigate debris flow occurrence and impact, for the Valsassina and Ijuez focus catchments.

The preliminary validation and scenario simulation results due in Month 18 will be simply demonstrations of capability, showing the type of output that will be available to WP2. Refinement of the simulations, including feedback from WP2, will take place over the following six months.

## 3.6 REFERENCES

None

**Timetable for Newcastle WP4 activities, March 2001 – February 2002**

