Record Number:
Author, Monographic: Fortin, J. P.//Villeneuve, J. P.//Benmouffok, D.//Montminy, M.//Blanchette, C.
Author Role:
Title, Monographic: PHYSITEL 2.0 : user's guide
Translated Title:
Reprint Status:
Edition:
Author, Subsidiary:
Author Role:
Place of Publication: Québec
Publisher Name: INRS-Eau
Date of Publication: 1990
Original Publication Date: 31 janvier 1990
Volume Identification:
Extent of Work: viii, 117
Packaging Method: pages incluant 3 annexes
Series Editor:
Series Editor Role:
Series Title: INRS-Eau, Rapport de recherche
Series Volume ID: 287
Location/URL:
ISBN: 2-89146-296-3
Notes: Rapport annuel 1990-1991
Abstract: 10.00$
Call Number: R000287
Keywords: rapport/ ok/ manuel / dl

PHYSITEL 2.0
USER'S GUIDE.

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by

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Scientific Report INRS-Eau No 287

31 January 1991

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GENERAL INFORMATION

PART 1 GENERAL INFORMATION

1.1 SOFTWARE MAIN CHARACTERISTICS AND HARDWARE REQUIREMENTS

Name:	PHYSITEL 2.0
Objective:	Preparation of watershed data base for streamflow simulation by HYDROTEL
Programming language:	"C", with use of GKS for display purposes
Type of microcomputer:	IBM compatibles with mathematical co-processor. A VGA board is suggested but not mandatory.
Memory requirements:	640 k.
Written by:	Martin Montminy and Djilali Benmouffok
Developped by:	Jean-Pierre Fortin, Djilali Benmouffok and Martin Montminy

1.2 INTRODUCTION

PHYSITEL 2.0 is one of three complementary programs developped specifically for hydrological applications. As seen in figure 1.1, HYDROTEL is a software program allowing simulatiom or forecast of streamflow in rivers. The analysis of remotely sensed data for input to HYDROTEL is done by IMATEL. As for PHYSITEL, it can be considered as a special type a GIS program allowing both the integration of spatial data into hydrological units and determination of relations between these units through the drainage network derived from DEM data.

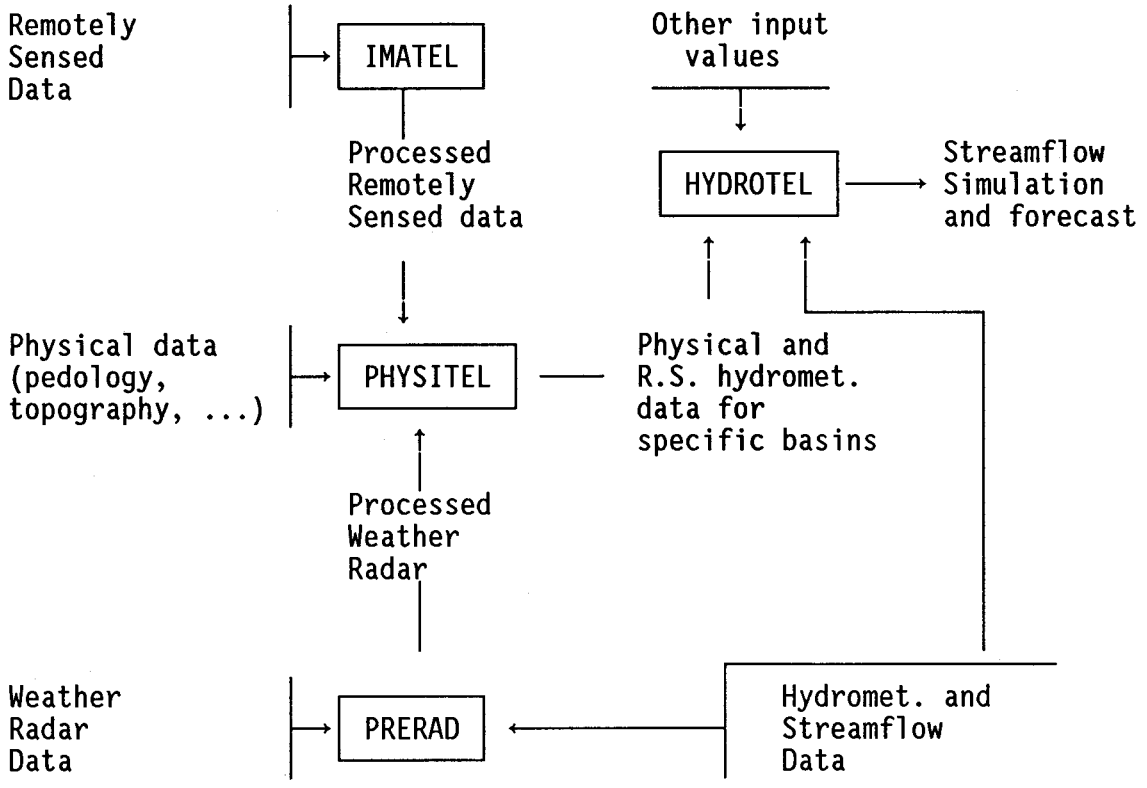

FIGURE 1.1 Integrated analysis of physical, remotely sensed and meteorological data for steamflow simulation and forecasting by PHYSITEL, IMATEL and HYDROTEL.

With PHYSITEL 2.0, raster integration is be allowed to any other larger raster resolution and to hydrological units of any shape.

1.3 ORGANIZATION OF THE MANUAL

General information on PHYSITEL 2.0 is presented in part "ONE" of the manual.

In part "TWO", the user is first told how to install the computer program. Information on the data set furnished with the program is then given. This data set is made available to the user to allow him to get acquainted with the program. Information on how to start the

program is next given. This is followed by a detailed information, window by window, on how to input and process data.

Complementary information on various topics related to the use of PHYSITEL 2.0 are given in part "THREE".

1.4 SOFTWARE AVAILABILITY AND INFORMATION

The current version (2.0) of PHYSITEL is normally available only to Environment Canada and CCRS personnel participating in the testing of that version.

For more informations on PHYSITEL 2.0, please contact:

Prof. Jean-Pierre Fortin
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2800, rue Einstein, bureau 105
Québec (Québec)
G1X 4N8
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Fax: (418) 654-2600

PART 2

THE PHYSITEL PROGRAM (2.0)

PART 2 THE PHYSITEL PROGRAM (2.0)

2.1 GENERAL STRUCTURE

As will be seen in the main menu, the program allows the preparation of regional as well as watershed data bases.

Regional data bases (RDB) will contain spatial data coming from various sources with their original spatial resolution. The only modifications made to the original data will be done to their geographical coordinates, if necessary, as all data in a particular regional data base will be referenced spatially with the same projection (UTM). Data sets whose spatial extent is larger or smaller than that of the regional data base will be accepted by PHYSITEL. In particular, PHYSITEL (V 2.0) is able to input raster data from and output data to SPANS (a TYDAC software package), and read vector data from ARCINFO.

RDB's should be considered as a way to archive data in PHYSITEL for the creation of WDB. So, their size has only to be large enough to include all watersheds on which a user would like to make simulations. As their is no restriction on the number of RDB's, apart the storage capacity on disk, there may be as many RDB's as WDB's, that is one WDB by RDB. The decision on how many WDB's should be created from a particular RDB is essentially a matter of convenience in PHYSITEL 2.0.

Data bases for particular watersheds (WDB) will be derived from regional data bases, with the spatial resolution and particular type of integration chosen by the user. Remember that the spatial resolution of the watershed data base must be greater or equal to the largest spatial resolution of the input files of the regional data base from which those files will be imported.

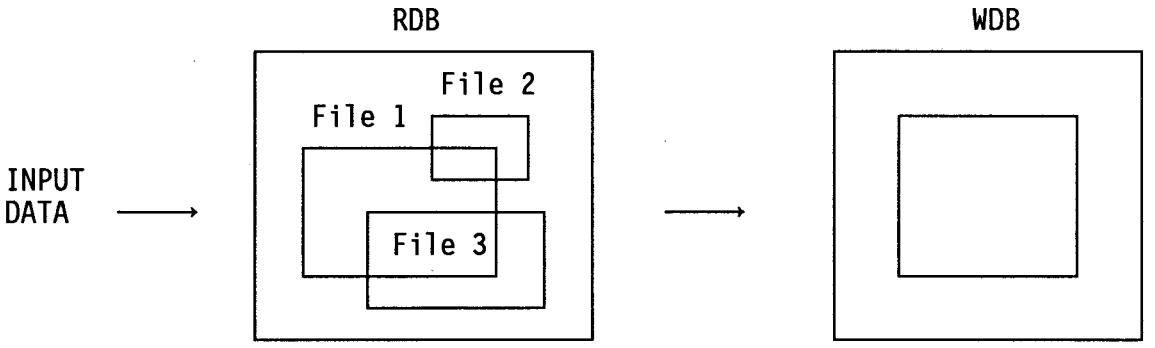

FIGURE 2.1 General structure of PHYSITEL.

2.2 GETTING STARTED

This section gives all necessary informations to install the program on your microcomputer. A data set is also furnished with the program to help the user to get acquainted with it.

2.2.1 List of files on floppy disks

PHYSITEL 2.0 is sent on two 1.2 M floppy disk.

Content:

Disk #1: Program Disk.

. CONFIG.SYS
. AUTOEXEC.BAT
. INSTALL.BAT
. INSTALL.DOC
. PKUNZIP.EXE
. PHYSITEL.ZIP

Display and printer drivers as well as GSSCGI.SYS driver controler necessary to run the program with the graphics options can be bougth from:

Graphic Software Systems Inc.
9590 SW Gemini Drive
P.O. Box 4900
Beaverton, OR 97076-4900
U.S.A.
Tel. (503) 641-2200
Fax (503) 643-8642

2.2.2 Installing PHYSITEL 1.0

The AUTOEXEC.BAT and CONFIG.SYS files on your system should first be modified to run PHYSITEL 2.0.

- modifications to AUTOEXEC.BAT file

add: SET KERNEL = path\PHYSITEL

where: "path" is the full path name including drive specification of location of the PHYSITEL subdirectory.

- modifications to CONFIG.SYS file

add: FILES = 20 (or more)
DEVICE = path\name.sys

where: "path" is the full path name of the directory where the display driver is.
"name" is the name of the display driver file.

DEVICE = path\GSSCGI.SYS

where: "path" is the full path name of the directory where the GSSCGI.SYS file is.

NOTE: the previous command may be modified to.

DEVICE = path\GSSCGI.SYS/T

In that case, only the essential parts of the GSS program are loaded when booting the computer, saving memory space for other programs run on the computer. It is then necessary to copy DRIVERS.EXE in the PHYSITEL directory and to run it prior to run PHYSITEL. Otherwise, this is not necessary.

When the AUTOEXEC.BAT and CONFIG.SYS files are modified, one may proceed with the other files.

PHYSITEL 2.0 can be installed using program INSTALL.BAT present on program disk or by following the steps given below.

2.2.2.1 Installing PHYSITEL 2.0 using INSTALL.BAT program

To install PHYSITEL follow these three steps and PHYSITEL will install itself. File "DISK1.LST" on diskette #1 list all the files that should be present in the "path" directory specified in STEP 3:

1. insert PHYSITEL diskette #1 in drive A;
2. change to that drive (A:);
3. type INSTALL drive: path (ex.: INSTALL C: \PHYSITEL).

2.2.3 Test data and structure of data files

In order to familiarize the user with PHYSITEL 2.0, a data set is included with the program. At the same time, it should be looked at as an example, for the preparation of other data sets.

Test basin: sub-basin of the Eaton river upstream of streamgauge station 030242 (located downstream of the bridge on highway 210, at Sawyerville. Figure 2.2 shows the position of the station on the map, together with those of meteorological stations and basins limits.

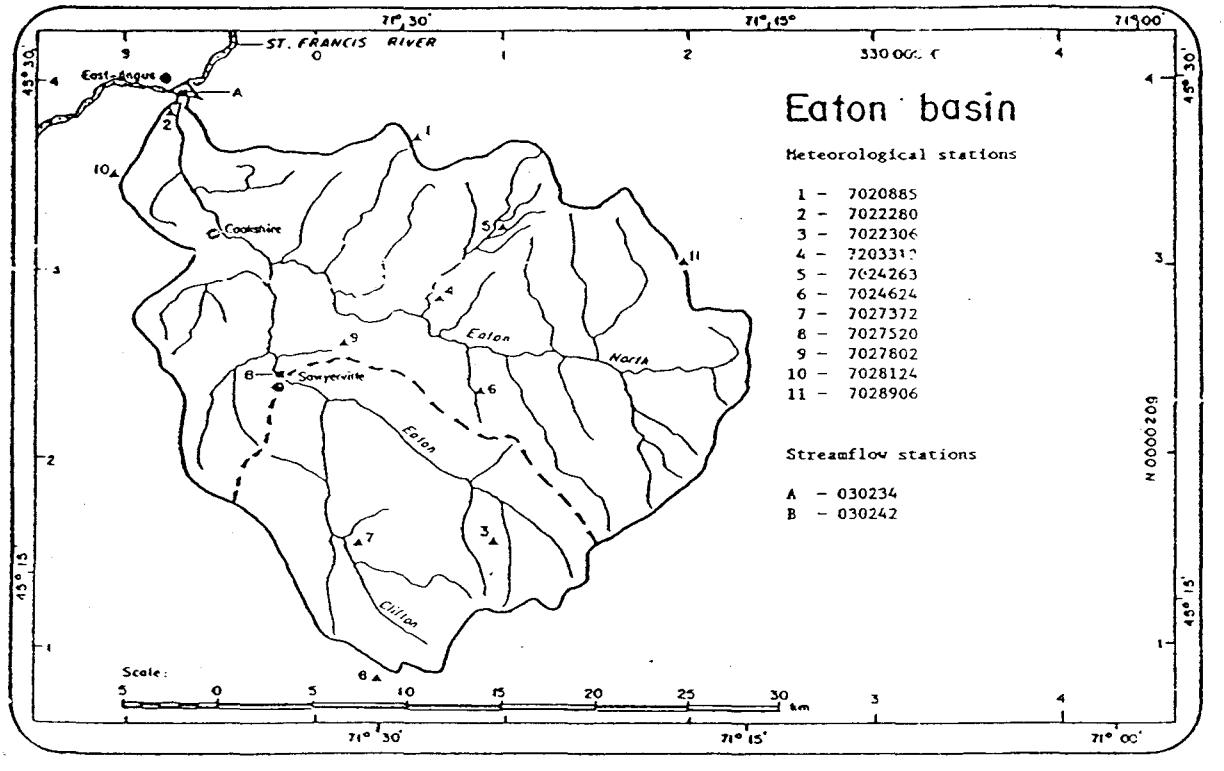

FIGURE 2.2 Geographic location of the test basin.

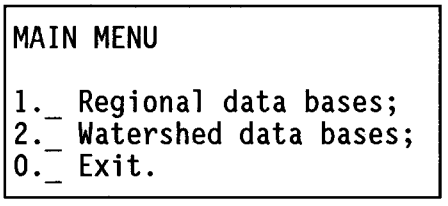

FIGURE 2.3 Main menu.

2.3.1 Sub-menu #1.0: regional data bases

Two options are offered in sub-menu 1.0 (figure 2.4). Option 1 allows the definition of a new regional data base. If the user wants to access an existing data base, he selects option 2. One can return to the "main menu" by selecting option "0" and pressing "ENTER" or typing "0".

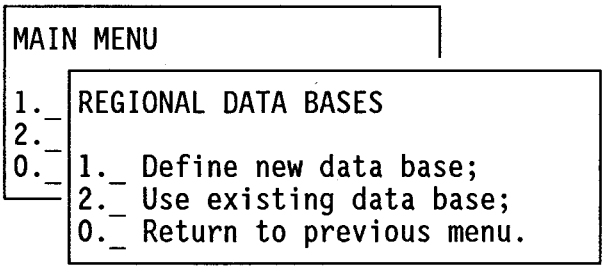

FIGURE 2.4 Sub-menu #1.0: regional data bases.

2.3.1.1 Sub-menu #1.1: define new regional data base

Sub-menu #1.1 (figure 2.5) is used to define the characteristics of a new regional data base.

First type the file name (without extension) under which the RDB will be saved. A title or comment identifying the data base more explicitely can be typed on the next lines.

The geographical area covered by the RDB is then entered, lower left corner first and upper right corner last. For each corner, the first coordinate is the longitude and the second the latitude. Both coordinates are typed as shown. For example, 71° 40' west would be typed as "7140.000W". Thousandths of a minute are used instead of "seconds" for accuracy purposes. Only portions of data sets included inside of these geographical limits will be stored in the RDB.

All data in the RDB will be spatially referenced with the UTM projection. The user has to specify the UTM zone.

One can quit the sub-menu any time by pressing "ESC" and return to the previous menu. Otherwise, once the characteristics of the new RDB are given they may be saved by pressing "F10".

A new RDB is then created and a return to the previous menu is done automatically.

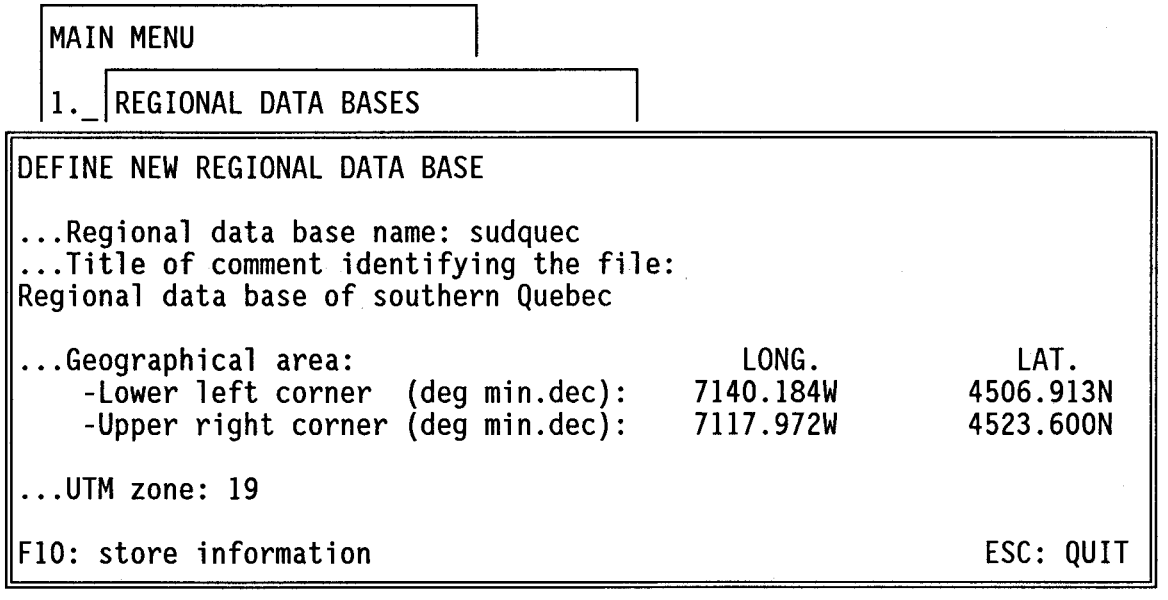

FIGURE 2.5 Sub-menu #1.1: define new regional data base.

2.3.1.2 Sub-menu #1.2: existing regional data base

Seven options are active in sub-menu #1.2 (figure 2.6). Two "user's defined tasks" are also available with PHYSITEL 2.0.

First a RDB has to be selected as the current one, by option 1.

Option 2 allows the user to see the actual content of the selected data base.

The header of the RDB, containing the characteristics of the data base defined in sub-menu #1.1, can be shown if option 3 is selected.

To input new data select option 4.

If a change in x-y coordinates is necessary it can be done by choosing option 5.

Modification of file content can be done if option 6 is chosen.

It is possible to display the data, if option 7 is selected.

If option 8 or 9 are selected a message "Sorry not implemented yet!!!" will be displayed. One can add his own functions. See appendices A and B.

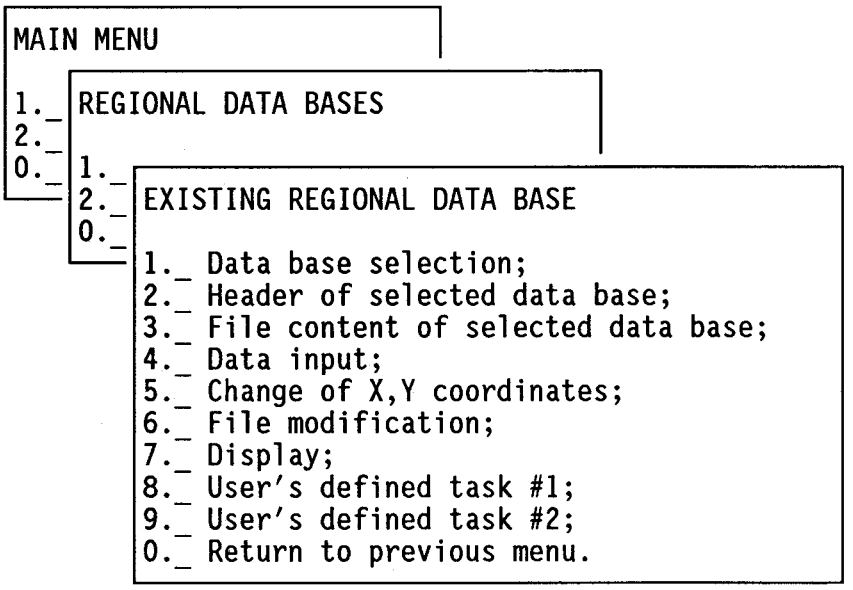

FIGURE 2.6 Sub-menu #1.2: existing regional data base.

2.3.1.2.1 *Sub-menu #1.2.1: data base selection*

A list of existing RDB is produced when sub-menu #1.2.1 is chosen (figure 2.7). Select the RDB on which you want to work by placing the cursor on that data base name and then by pressing "ENTER". The name of the current data before selection appears in the lower left corner of the menu.

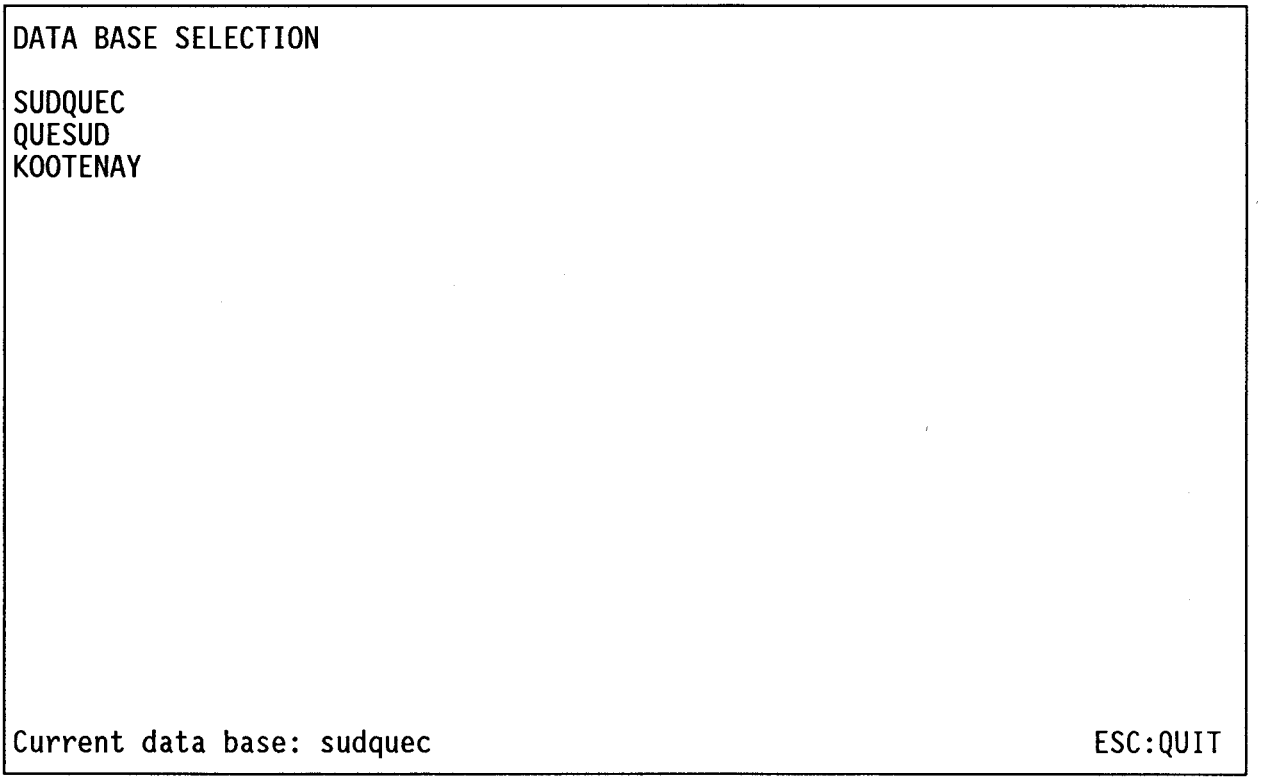

FIGURE 2.7 Sub-menu #1.2.1: data base selection.

2.3.1.2.2 *Sub-menu #1.2.2: header of selected regional data base*

The content of the header of the selected RDB is shown in sub-menu #1.2.2 for information only. No action can be taken. Return to the previous menu is done by striking any key.

```
HEADER OF SELECTED DATA BASE

Regional data base name: sudquec

Description of data base:
Regional data base from southern Quebec

Cartographic projection: UTM
        characteristics: zone : 19

Geographical area:      EASTING    NORTHING
   Lower left corner :   290000     4999000
   Upper right corner:   319999     5028999

Please strike any key to continue
```

```
0._ Return to previous menu.
```

FIGURE 2.8 Sub-menu #1.2.2: header of selected regional data base.

2.3.1.2.3 *Sub-menu #1.2.3: file content of selected regional data base*

Sub-menu #1.2.3 shows the name of the RDB together with a list of files actually in the RDB (figure 2.9). A return to the previous menu is obtained by striking any key.

```
CONTENT OF CURRENT REGIONAL DATA BASE : QUESUD

QUESUD.ID   : Base de donnee du sud du Quebec
QUESUD.SR8  : LAND-USE FROM INRS.SR8 FILE
QUESUD.MNT  : M.N.T. De la Eaton
QUESUD.VEC  : ??????????
QUESUD.PTS  : ??????????
QUESUD.LIG  : ??????????
QUESUD.PT   : ??????????









Please strike any key to continue!
```

FIGURE 2.9 Sub-menu #1.2.3: file content of current regional data base.

2.3.1.2.4 *Sub-menu #1.2.4: data input*

Sub-menu #1.2.4 (figure 2.10) is used to access specific menus for input of various types of data. With PHYSITEL 2.0 it will be possible to input:

- land-use classes pixel by pixel IN *.SR8 format;
- raster data formatted as defined in sub-menu #1.2.4.3;
- vector data formatted as defined in sub-menu #1.2.4.4.

Two more user's defined data input formats are available with PHYSITEL 2.0. See appendices A and B for more information.

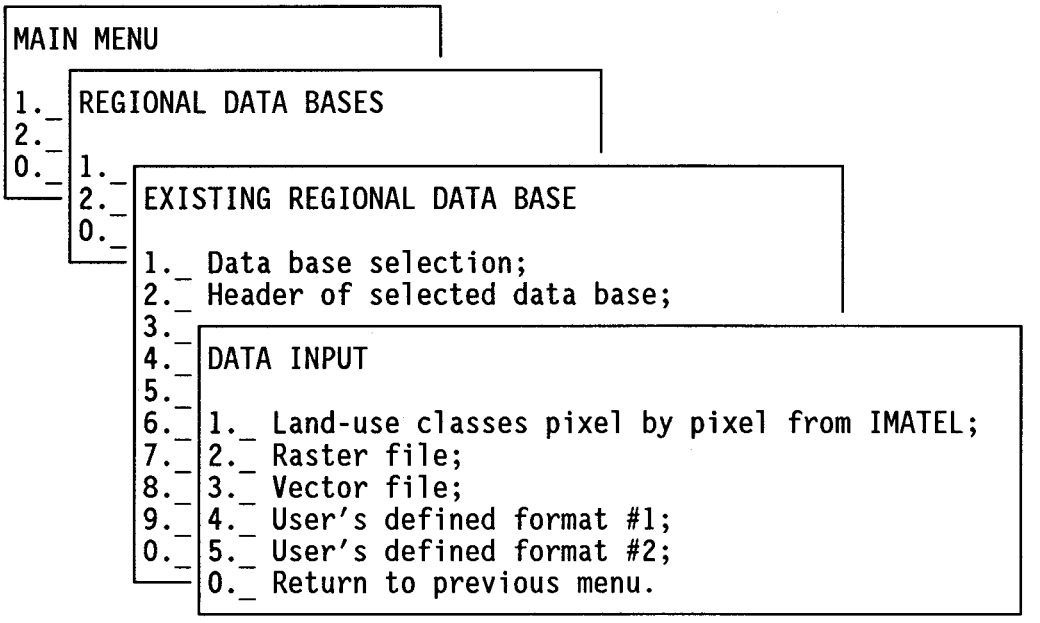

FIGURE 2.10 Sub-menu #1.2.4: data input.

2.3.1.2.4.1 Sub-menu #1.2.4.1: land-use classes pixel by pixel from IMATEL

Land-use classes on a pixel by pixel basis can be input from IMATEL. The land-use file, as output by IMATEL, should contain all needed informations on class identification (see appendix A for more details).

Type the full path name of the IMATEL file and the extension of the regional file name. Press "F10" to store the file and display a window in which a comment describing the file may be added. Press "RETURN" after.

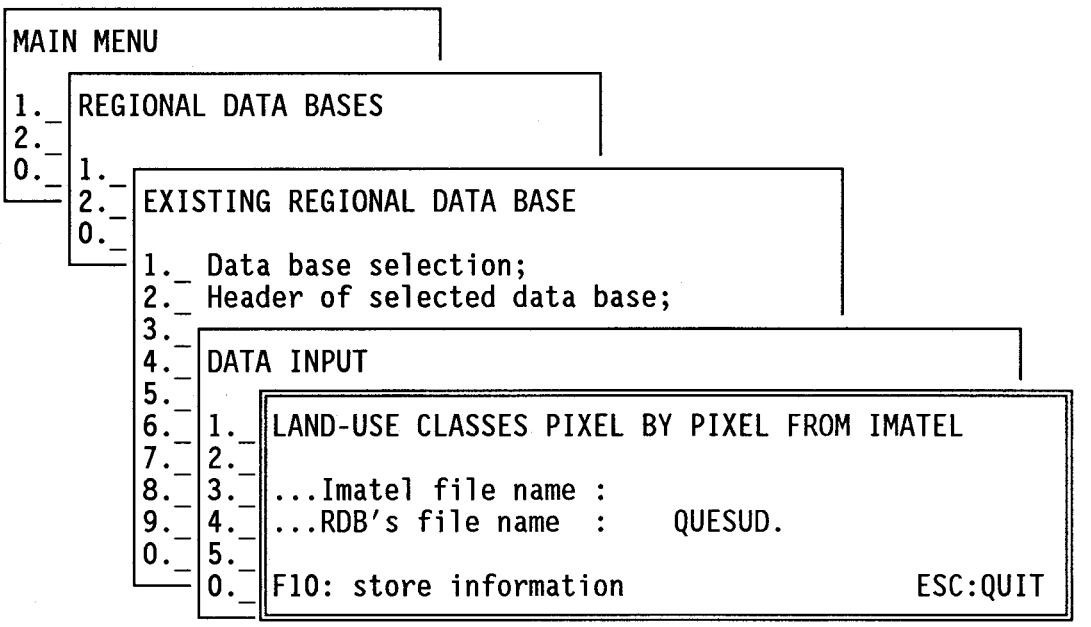

FIGURE 2.11 Sub-menu #1.2.4.1: land-use classes pixel by pixel from IMATEL.

2.3.1.2.4.2 Sub-menu #1.2.4.2: raster file

Two input raster formats are available in PHYSITEL 2.0 (figure 2.12). The first option is a general raster format and the second one allows compatibility with SPANS raster files. Select the one you need.

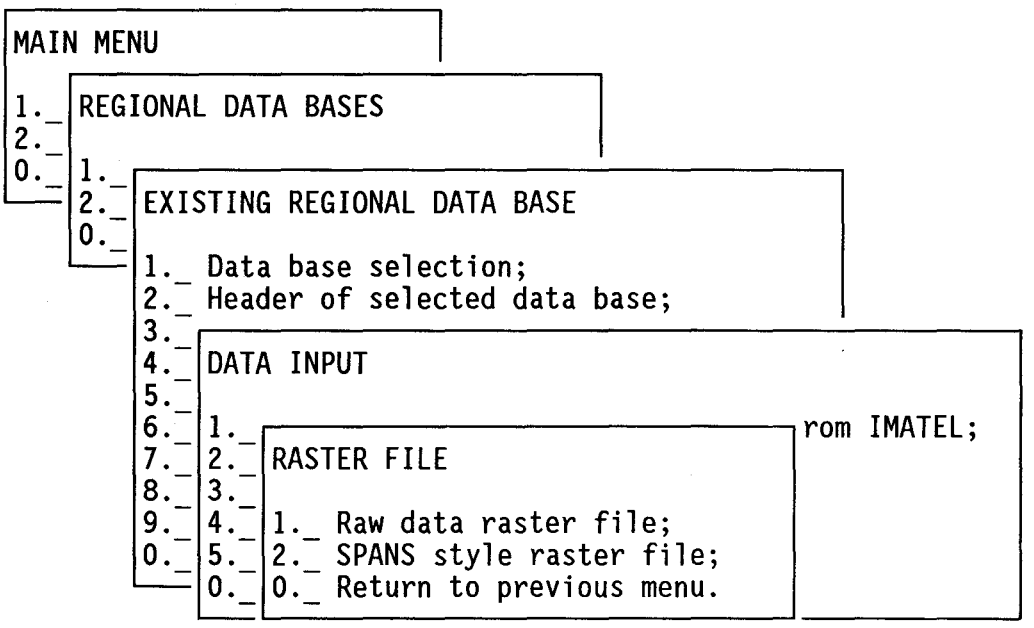

FIGURE 2.12 Sub-menu #1.2.4.2: raster file.

2.3.1.2.4.2.1 Sub-menu #1.2.4.2.1: raw data raster file

A general purpose raster format is available with PHYSITEL 2.0 (see appendix A for more details) (figure 2.13). It is provided to read D.E.M. data primarily, but could be used to read similar types of data as well.

Type first the original full path file name of the raster data. Then, enter the type of data: 0 for "ASCII", 1 for binary coded on two bytes (type "SHORT" in C). Continue by entering the extension to the regional file name under which the data will be saved.

Indicate the UTM coordinates of the lower left corner and the upper right corner (easting first). Finally, enter the grid size, in meters, in the X and Y directions.

The raster file is read and saved by pressing "F10". When "F-10" is pressed a new window appears in which a comment describing the file may be added. Press "RETURN" after ward.

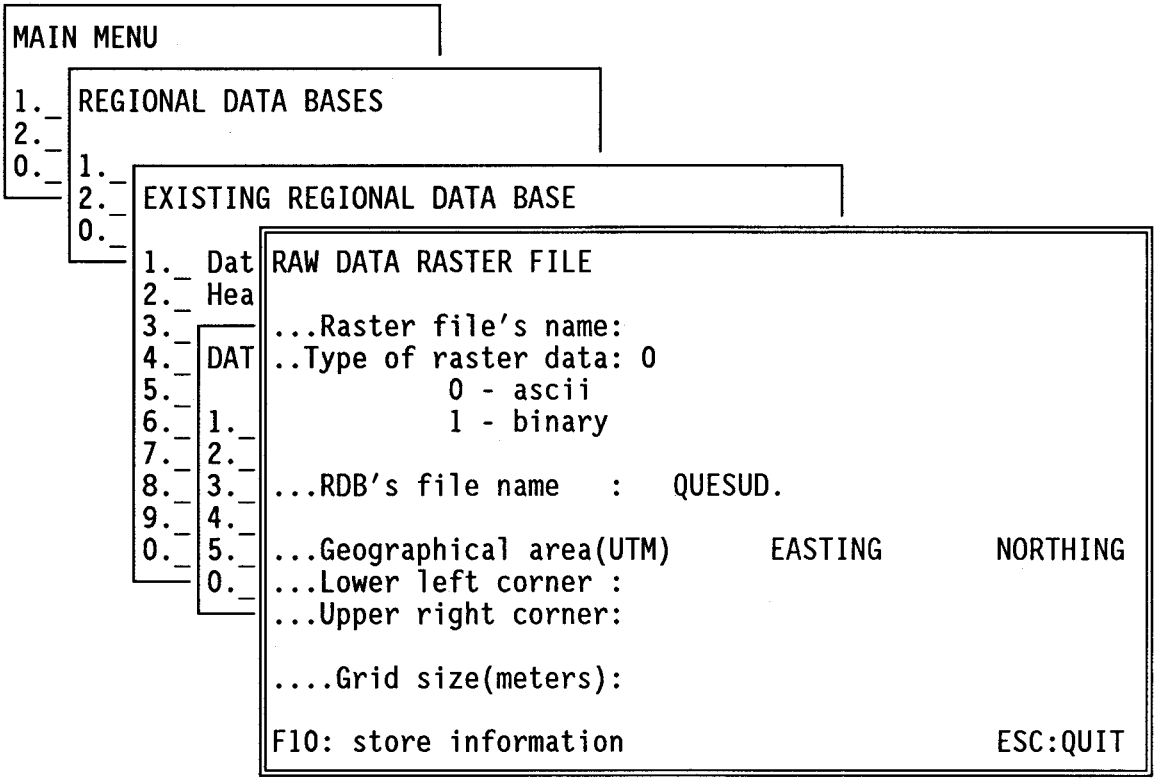

FIGURE 2.13 Sub-menu #1.2.4.2.1: raw data raster file.

2.3.1.2.4.2.2 Sub-menu #1.2.4.2.2: SPANS style raster file

Type the full paths for the header and image files from SPANS (*.RNL and *.RHN file formats). Next, type the extension to the regional file name under which the data will be saved. Press "F10" to store the information and display a window in which a comment describing the file may be added. Press "RETURN" afterwards.

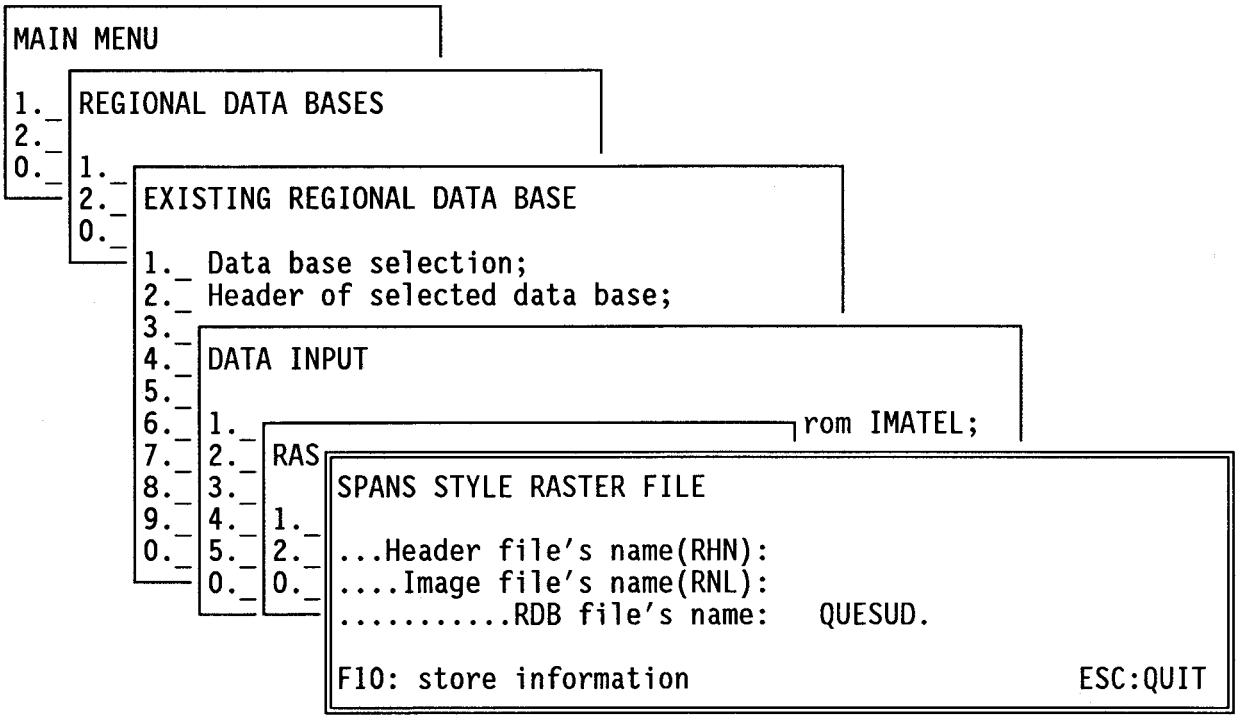

FIGURE 2.14 Sub-menu #1.2.4.2.2: SPANS style raster file.

2.3.1.2.4.3 Sub-menu #1.2.4.3: input data from vector file

A general purpose vector format, allowing input of vector files produced with the ARCINFO function UNGENERATE (ARCINFO user's guide, January, 1989), is available with PHYSITEL 2.0 (figure 2.15). It is provided to read vector data representing various types of variables, like a river network subdivided in reaches or homogeneous units.

Type the full path of the original vector file, as well as the extension to the regional file name under which the data will be saved. Then, using the "SPACE BAR" identify the type of data contained in the vector file as "points" or "lines". Press "F10" to store the informations and display a window in which a comment describing the file may be added. Press "RETURN" afterwards.

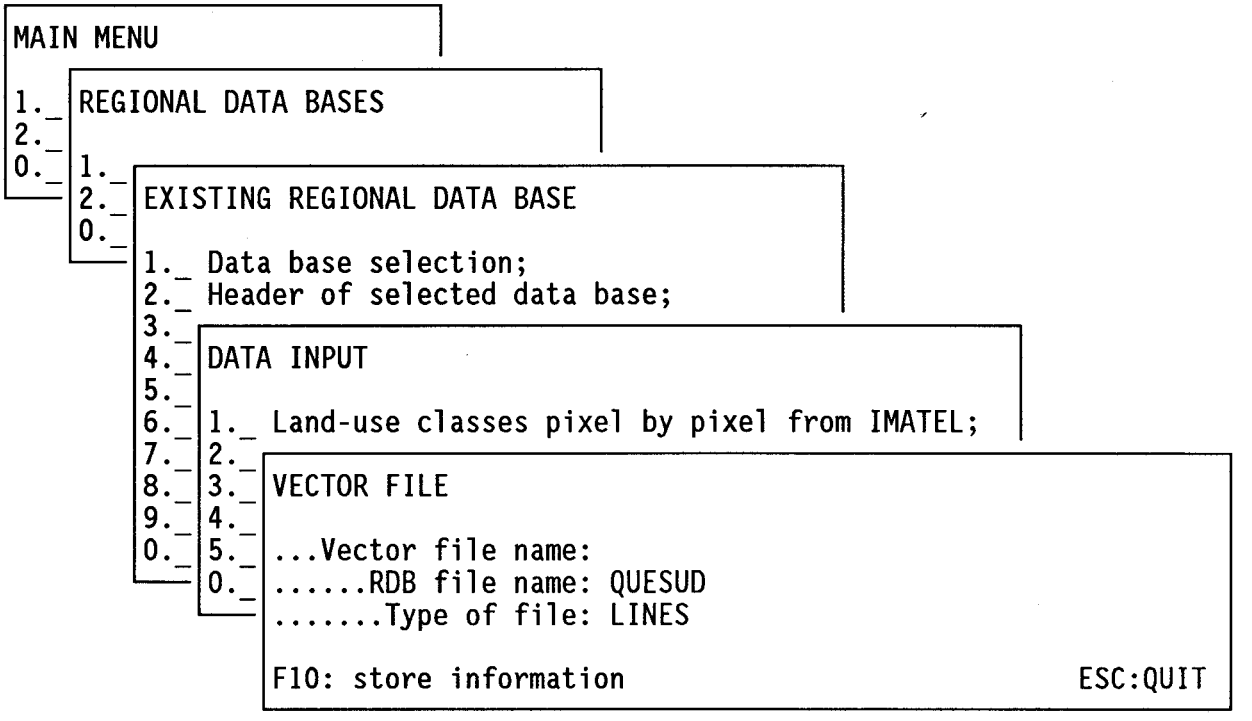

FIGURE 2.15 Sub-menu #1.2.4.3: input data from vector file.

2.3.1.2.5 *Sub-menu #1.2.5: change de X, Y coordinates*

This menu leads to two sub-menus where it is possible to obtain the UTM equivalent of a LONG-LAT coordinate(option 1) and vice-versa(option 2).

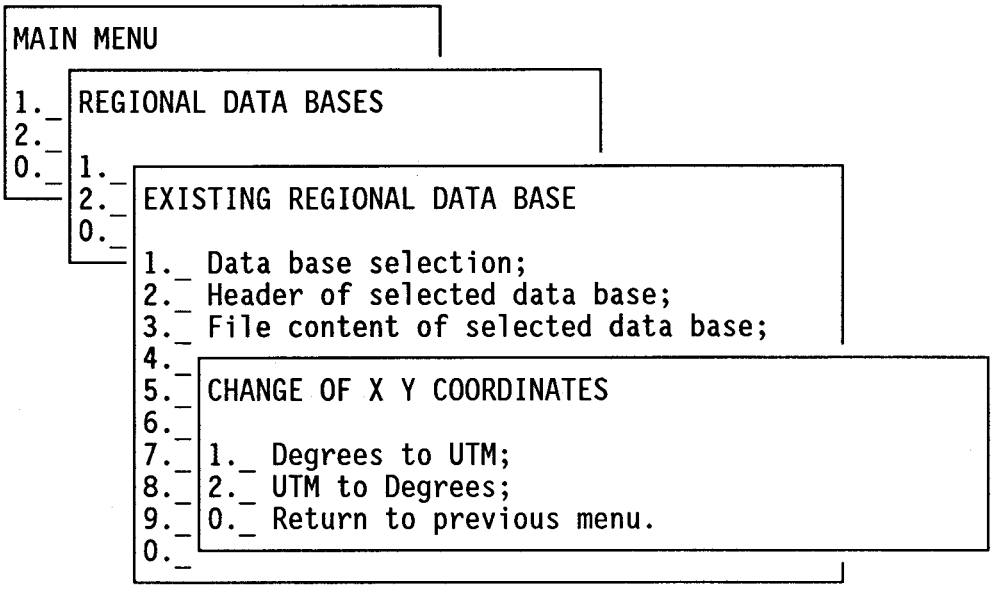

FIGURE 2.16 Sub-menu #1.2.5: change of X, Y coordinates.

2.3.1.2.5.1 Sub-menu #1.2.5.1: degrees to UTM

The user enters the longitude and latitude of the coordinates in degrees using the same format as in sub-menu #1.1 plus the UTM zone relative to which the transformation will be performed.

The result will appears after "F10" is pressed.

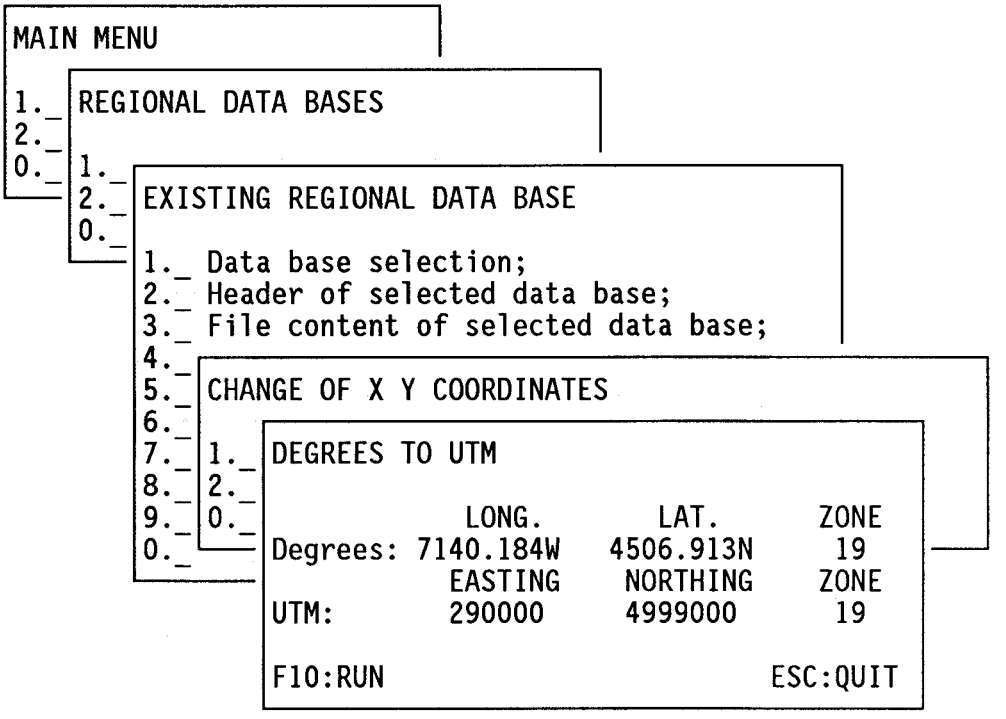

FIGURE 2.17 Sub-menu #1.2.5.1: degrees to UTM.

2.3.1.2.5.2 Sub-menu #1.2.5.2: UTM to degrees

Sub-menu #1.2.5.2 (figure 2.18) is the conterpart of sub-menu 1.2.5.1 and is used to obtain the degree equivalent of a geographical coordinate expressed in UTM.

The user enters the easting and northing coordinates as well as the zone of the UTM projection and press "F10" to get the result.

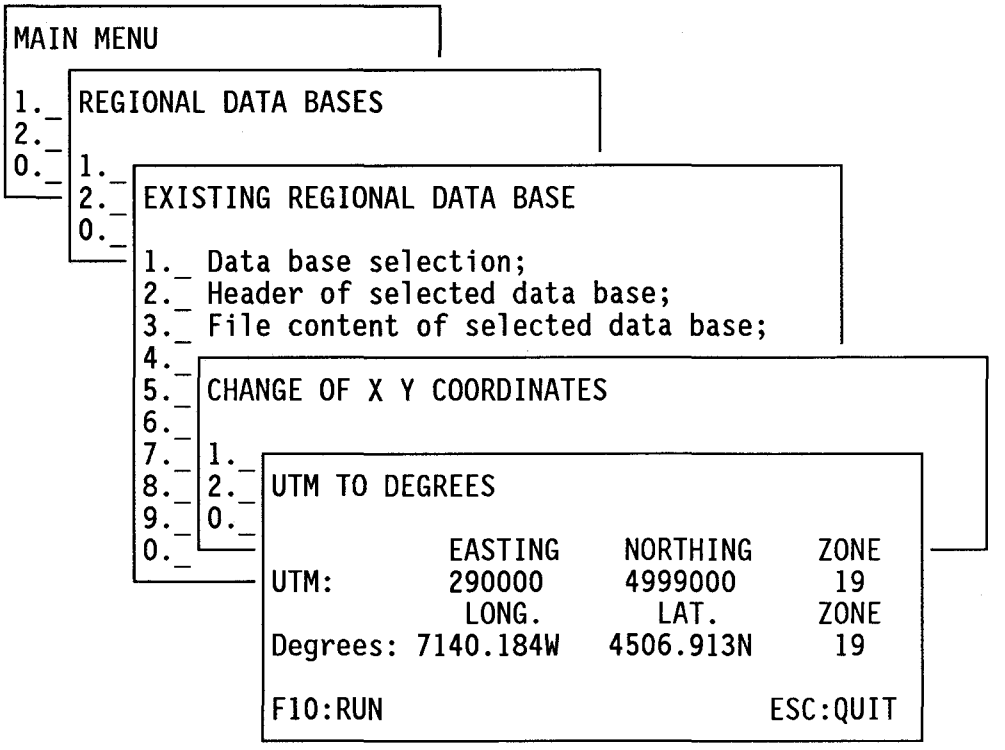

FIGURE 2.18 Sub-menu #1.2.5.2: UTM to degrees.

2.3.1.2.6 *Sub-menu #1.2.6: file modification*

If a user wants to modify a file without leaving PHYSITEL, he may use this menu (figure 2.19). He has access to DOS and may use the program of its choice to edit the file. When this is done, he comes back to PHYSITEL by typing "EXIT". Note that what will appear on your screen will differ from figure 2.19 depending on your computer, your operating system and the directory where physitel is located. Note also that it is very important to return to that directory before returning to PHYSITEL.

```
Type "exit" to return to PHYSITEL.

Ordinateur personnel HP Vectra  MS-DOS Version 3.30 - C.01.01

(C)Copyright Hewlett-Packard 1986-1988
(C)Copyright Microsoft Corp  1981-1988

C:\PHYSITEL>
```

FIGURE 2.19 Sub-menu #1.2.6: file modification.

2.3.1.2.7 *Sub-menu #1.2.7: display*

Display of digital elevation model data or land-use classes on a pixel by pixel basis in the RDB are available in PHYSITEL 2.0.

Choose option 1 for DEM display and option 2 for land-use classes (figure 2.20).

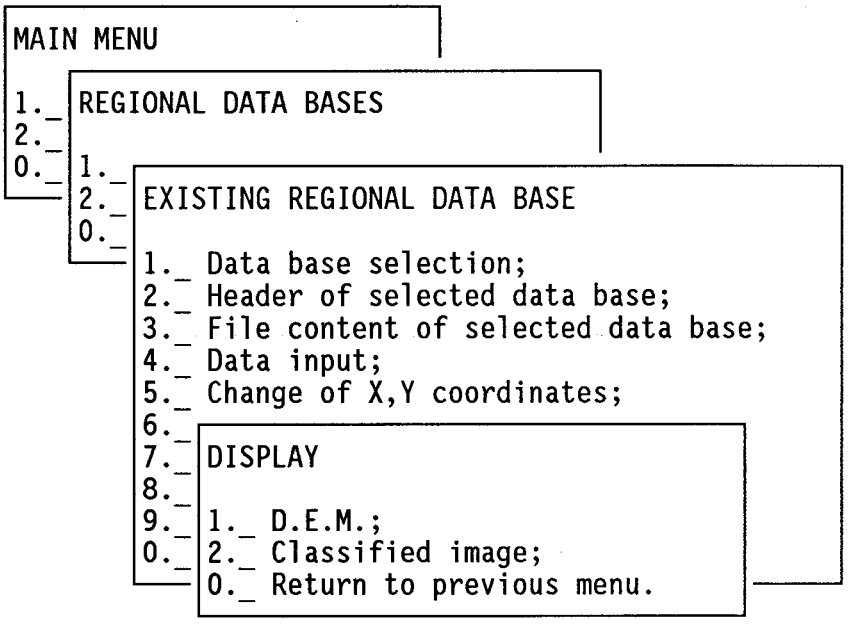

FIGURE 2.20 Sub-menu #1.2.7: display.

2.3.1.2.7.1 Sub-menu #1.2.7.1: DEM

Type the extension of the file name of the digital terrain model you want to display, as well as the UTM coordinates of the upper left corner of the matrix. Press "F10" to display the DEM.

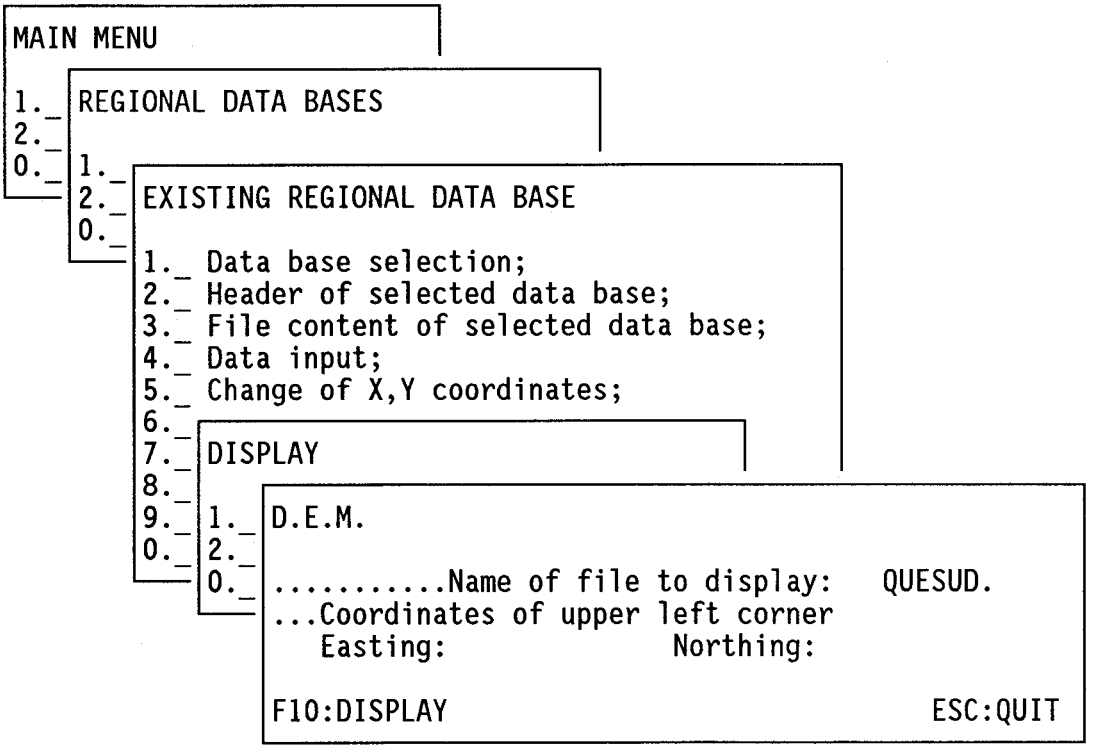

FIGURE 2.21 Sub-menu #1.2.7.1: DEM.

2.3.1.2.7.2 Sub-menu #1.2.7.2: classified image

Type the extension of the file name of the classified image you want to display, as well as the coordinates of the upper left corner of the image. Press "F10" to display the image.

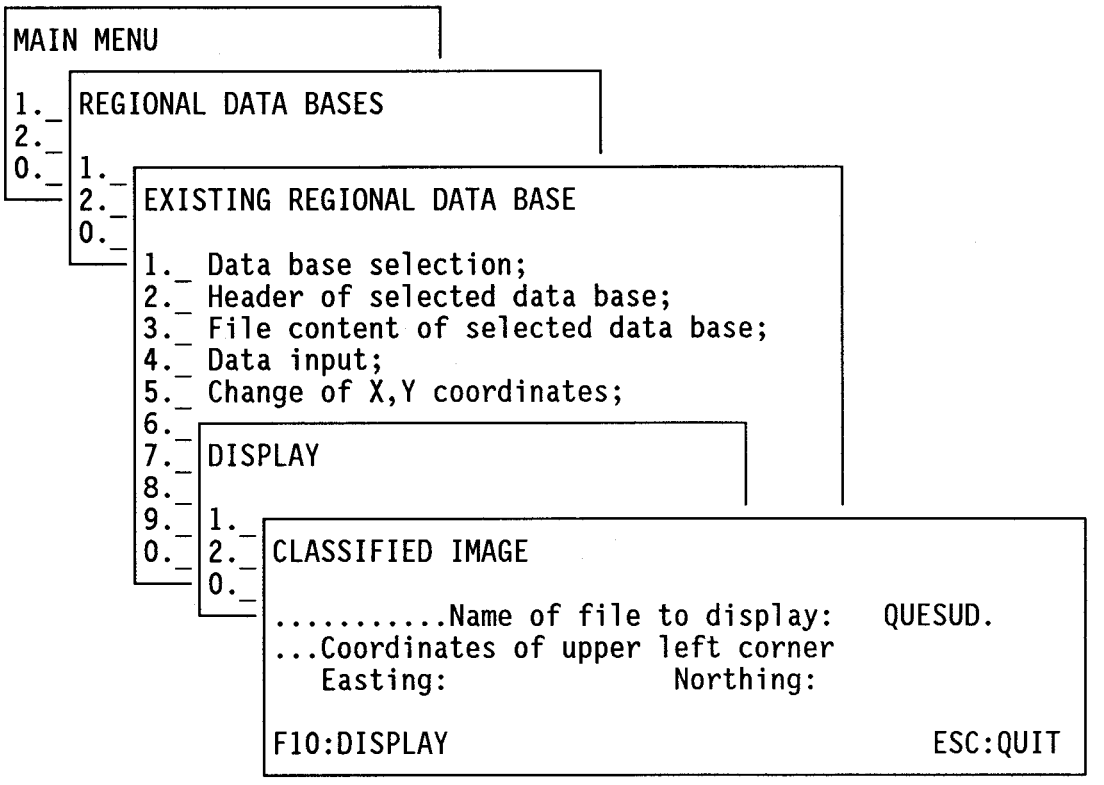

FIGURE 2.22 Sub-menu #1.2.7.2: classified image.

2.3.2 Sub-menu #2.0: watershed data bases

It should be noted immediately that the structure of menus permitting to work on the watershed data bases (WDB) will be similar to those of the regional data bases (RDB).

Two options are offered in sub-menu #2.0 (figure 2.23). Option 1 allows the definition of a new watershed data base. To have access to an existing WDB, option 2 has to be selected. One can return to the "main menu" by typing "0" or selecting option "0" and pressing "ENTER".

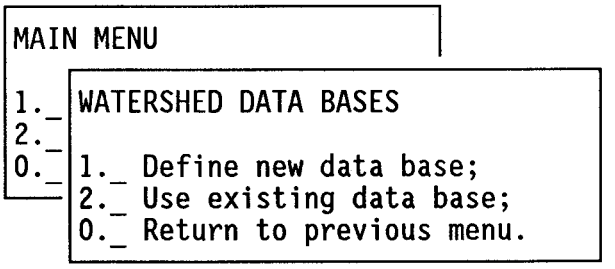

FIGURE 2.23 Sub-menu #2.0: watershed data bases.

2.3.2.1 Sub-menu #2.1: define new watershed data base

Sub-menu #2.1 (figure 2.24) is used to define the characteristics of a new watershed data base.

First type the file name (without extension) under which the WDB will be saved and the file name (without extension) of RDB from which it will be created. A title or comment identifying the data base may be added next.

The geographical area within which all pertinent data should be has also to be entered. All subsequent operations in the WDB will be performed only on the data within that geographical area rather than on the larger RDB geographical area, in other words, on a subset of the RDB data set. Enter the longitude and latitude of the lower left corner and of the upper right corner of the area. Since PHYSITEL works exclusively with a UTM projection, the UTM zone is necessary to transform the coordinates of the corners into that projection.

The grid size (in meters) used for spatial integration is given next. Remember that the grid size must be greater or equal to the resolution of every file of the regional data base you plan to import in the watershed data base. The cells obtained from that process will be the basis for the second spatial integration into homogeneous hydrological units available with PHYSITEL 2.0.

Once the characteristics of the new WDB are given, they may be saved by pressing "F10".

```
DEFINE NEW WATERSHED DATA BASE

...Watershed data base name:
...From regional data base :
...Title or comment identifying the data base:


...Geographical area:                          LONG.          LAT.
    -Lower left corner  (deg min.dec):    0.000W          0.000N
    -Upper right corner (deg min.dec):    0.000W          0.000N

...UTM zone: 0
                              X              Y
.....grid size(m):          0              0

F10: store information                                      ESC:QUIT
```

FIGURE 2.24 Sub-menu #2.1: define new watershed data base.

2.3.2.2 Sub-menu #2.2: existing watershed data base

Apart from two user's defined tasks, five options are offered in sub-menu #2.2 (figure 2.25).

First, a particular WDB has to be selected as the current data base, using option 1.

The header of the WDB, containing the characteristics of the data base defined in sub-menu #2.1, can be shown if option 2 is selected.

Option 3 allows the user to see the actual content of the selected data base.

Options 4 and 5 lead to a series of other menus permitting to add or edit files or display them.

Option 6 should be selected if the user wants to export files.

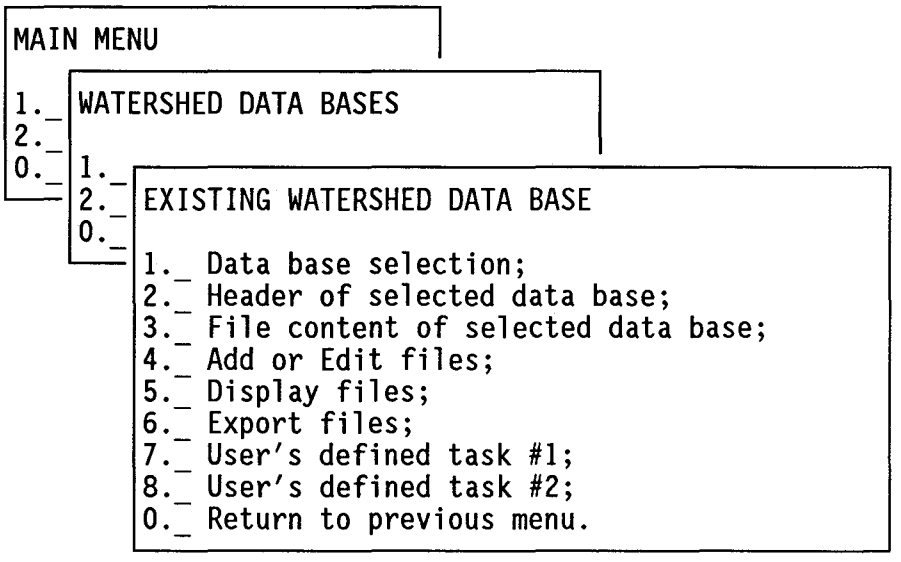

FIGURE 2.25 Sub-menu #2.2: existing watershed data base.

2.3.2.2.1 *Sub-menu #2.2.1: data base selection*

A list of existing WDB is produced when sub-menu #2.2.1 is chosen (figure 2.26). Select the WDB on which you want to work by placing the cursor on that data base name and then pressing "ENTER". The name of the current data base before selection appears in the lower left corner of the menu.

Are included in the data set:

- File names and content for INPUT files:

  - Clifton.ASC: mean altitude of each square (m), ASCII file. This file has 227 rows by 280 columns. Each all is 78 m by 78 m. The UTM coordinate of the lower left corner is 297295,5008010 and the coordinate of the upper right corner is 319135,5025716;

  - Clifton.SR8: land-use data for each square; imatel file/SR8 format). This is not a classification of the Clifton basin and it's purpose is only to provide the user with a file in the correct format so that be can test the program.

- File structure for ASCII file (Clifton.ASC):

  - matrix of altitudes of each square entered row by row. Each value is separeted by one or more space, a tab or a new line. There is no header.

- File structure for land-use data (Clifton.SR8):

  - this is the SR8 format used by IMATEL 1.0.

- Header: 2048 bytes:

  The first 256 bytes contain informations on the number of lines and columns in the image, the pixel size and the origin of the image in metric coordinates. The following 768 bytes contain the look-up table used to display the image. The final 1024 contain the image histogram.

- Image data: m lines by n columns.

- File names and content for OUTPUT files:

  - Clifton.ALT: mean altitude of each square (m);
  - Clifton.ORI: aspect of each square to eight points of the compass, identified 1 to 8 counterclockwise from East (=1);
  - Clifton.PTE: slope of each square (m/m);
  - Clifton.MSK: basin mask;
  - Clifton.CLA: land-use data;
  - Clifton.REL: downstream link file name;
  - Clifton.SB (≡ Clifton.ZON): sub-basin (homogeneous hydrological units) file name.

- File structure for *.ALT, *.ORI, *.PTE, *.MSK, *.REL, *.ZON; see appendix B.

2.2.4 Starting PHYSITEL 2.0

Change to the directory in which you have your program files and type "PHYSITEL - e" to access the English version of PHYSITEL. When "PHYSITEL" appears on the screen, push any key and the main menu will appear. You are now ready to start your session with PHYSITEL 2.0.

2.3 USING PHYSITEL 2.0

The main menu of PHYSITEL 2.0 contains 2 options (figure 2.3) allowing access to either regional or watershed data bases.

You can select either option by using the arrows on the key board and pressing "ENTER". It is also possible to select an option by typing its number directly. At the end of a session, it is possible to exit PHYSITEL 2.0 by selecting "EXIT" and pressing "ENTER" or by typing "0".

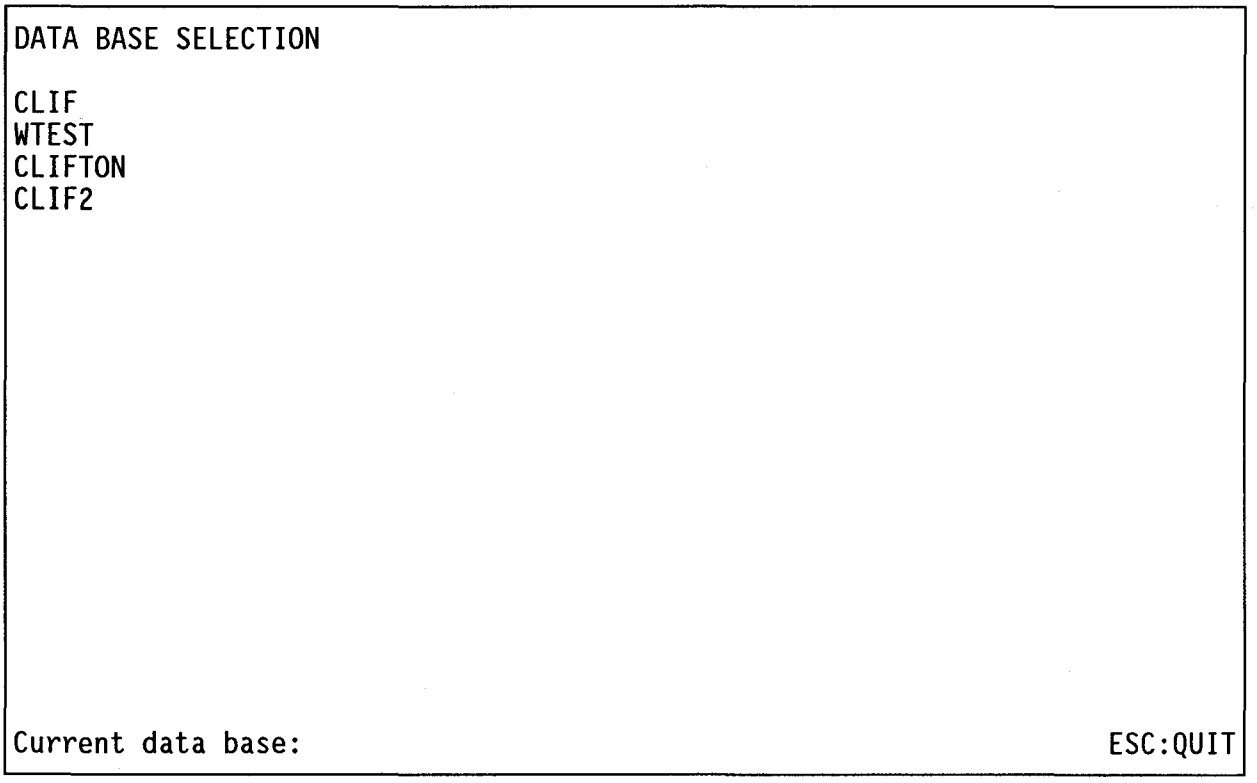

FIGURE 2.26 Sub-menu #2.2.1: data base selection.

2.3.2.2.2 *Sub-menu #2.2.2: header of selected data base*

The header content of the selected WDB is shown in sub-menu #2.2.2 (figure 2.27) for information purposes only. No action can be taken. Return to the previous menu by striking any key.

```
HEADER OF SELECTED DATA BASE

Watershed data base name: clif
From regional data base:  sudquec

Description of data base:
 Base de donnee pour le bassin de la riviere clifton

Cartographic projection: UTM
         Caracteristics: zone : 19

Geographical area:      EASTING    NORTHING
   Lower left corner :   290000    4999000
   Upper right corner:   320001    5029001

Grid size(m):              1000       1000

Please strike any key to continue
```

FIGURE 2.27 Sub-menu #2.2.2: header of the selected data base.

2.3.2.2.3 *Sub-menu #2.2.3: file content of selected watershed data base*

Sub-menu #2.2.3 shows the name of the WDB, together with a list of files currently in the WDB (figure 2.28). A return to the previous menu is obtained by striking any key.

```
FILE CONTENT OF SELECTED DATA BASE: clif

CLIF.ASP    : Ori. corrigees en determinant reseau .net avec fichier .db
CLIF.DB     : DATABASE avec .fil, .pte et .ori
CLIF.DEP    : DEPRESSIONS avec base de donnees .db et OUTLETS .out
CLIF.DLK    : DOWNSTREAM LINKS de .asp, .net, .sb
CLIF.FI2    :
CLIF.FIL    : D.E.M. filtre a partir du fichier clif.mnt
CLIF.FLA    : FLAT AREAS avec base de donnees .db et .lpt
CLIF.HIG    : HIGH VALUES du fichier clif.fil
CLIF.ID     :  Base de donnee pour le bassin de la riviere clifton
CLIF.LOW    : LOW VALUES DU FICHIER CLIF.FIL
CLIF.LPT    : local pits avec fichier .fil, *ori
CLIF.LU     : LAND-USE land-use land-use
CLIF.MNT    : D.E.M. obetenue a partir du fichier sudquec.mnt
CLIF.NET    : NETWORK a partir de la BD .db et ex:299000, 5022000
CLIF.OR2    : orientation du fichier clif.fil avec differences finies
CLIF.OR3    : ASPECTS
CLIF.OR4    : Orientations corrigees a la main
CLIF.OR5    : ASPECTS orientation
CLIF.OR6    : ASPECTS orientations du fichier clif.or6

Please strike any key for more
```

FIGURE 2.28 Sub-menu #2.2.3: file content of selected watershed data base.

2.3.2.2.4 *Sub-menu #2.2.4: add or edit files*

Sub-menu #2.2.4 (figure 2.29) gives access to the main tasks related to the preparation of a WDB.

Option 1 is selected if raster data have to be spatially integrated according to the grid spacing specified when the database was defined (sub-menu #2.1).

Option 2 is selected to import vector files from the RDB into the WDB.

Option 3 leads to a series of tasks used to define the drainage network uptream of a particular point on a river, and thus the watershed area uptream of that point. All points belonging to the watershed are subsequently identified using a mask of the watershed.

Option 4 can be used to define and process sub-basins.

Option 5 is to be used for the spatial integration of land-uses classes from various sources.

Option 6 allows editing of the files.

Options 7 and 8 allow the user to add his own tasks, see appendices.

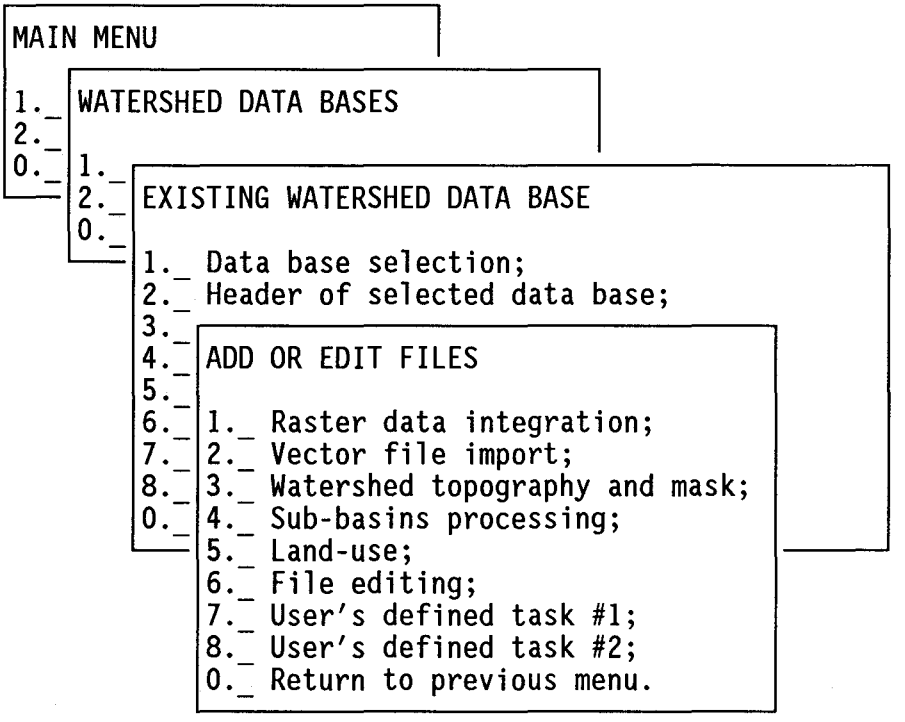

FIGURE 2.29 Sub-menu #2.2.4: add or edit files.

2.3.2.2.4.1 Sub-menu #2.2.4.1: raster data integration

If raster data have to be spatially integrated, sub-menu #2.2.4.1 is chosen (figure 2.30). This may be the case for a D.E.M. data file.

The extensions of the file name of the RDB raster file (file which already exists) and of the file name of the WDB raster file (which will be created) have to given first.

Then an integration process is chosen. Only one integration process in which the mean areal value is computed is available in PHYSITEL 2.0. Two user's defined processes can be added (see appendices).

Type "F10" to run the task. All other needed informations are obtained from the header file of the WDB.

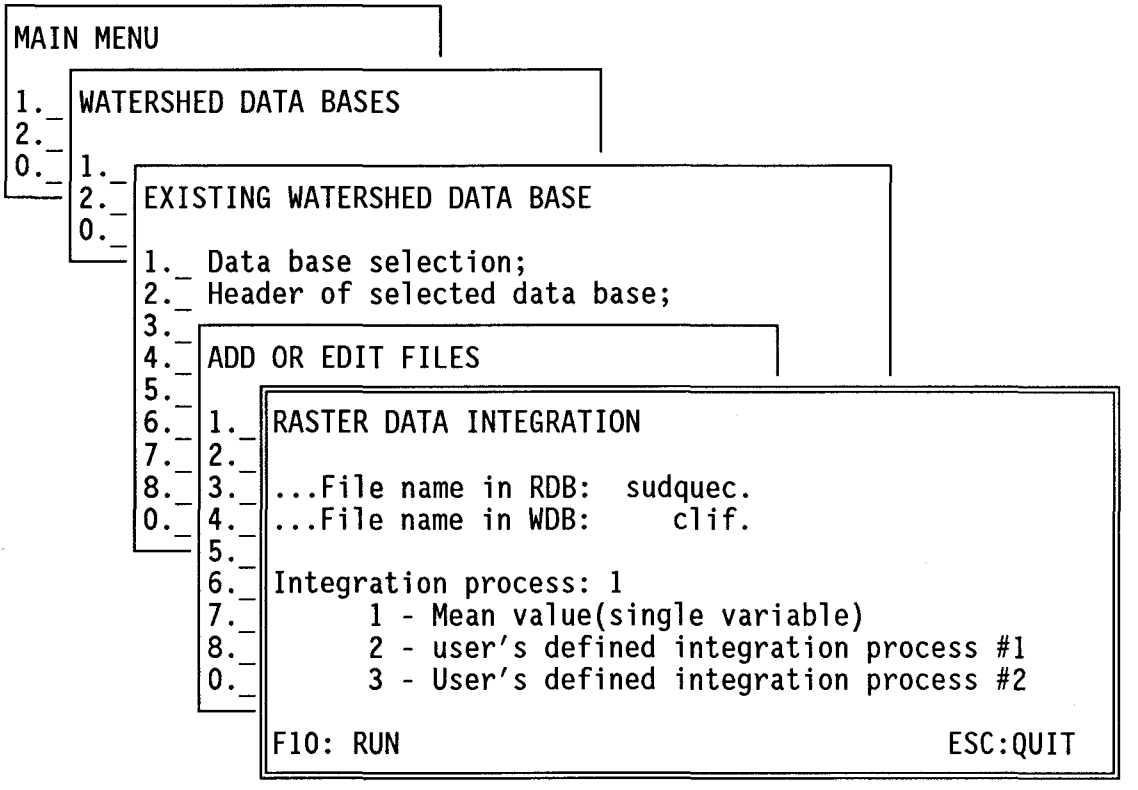

FIGURE 2.30 Sub-menu #2.2.4.1: raster data integration.

2.3.2.2.4.2 Sub-menu #2.2.4.2: vector file import

It is possible to import vector files from the RDB to the WDB by type the extensions of the files names in those bases. Press "F10" to store the information. Note that no task is programmed to use vector files in PHYSITEL 2.0.

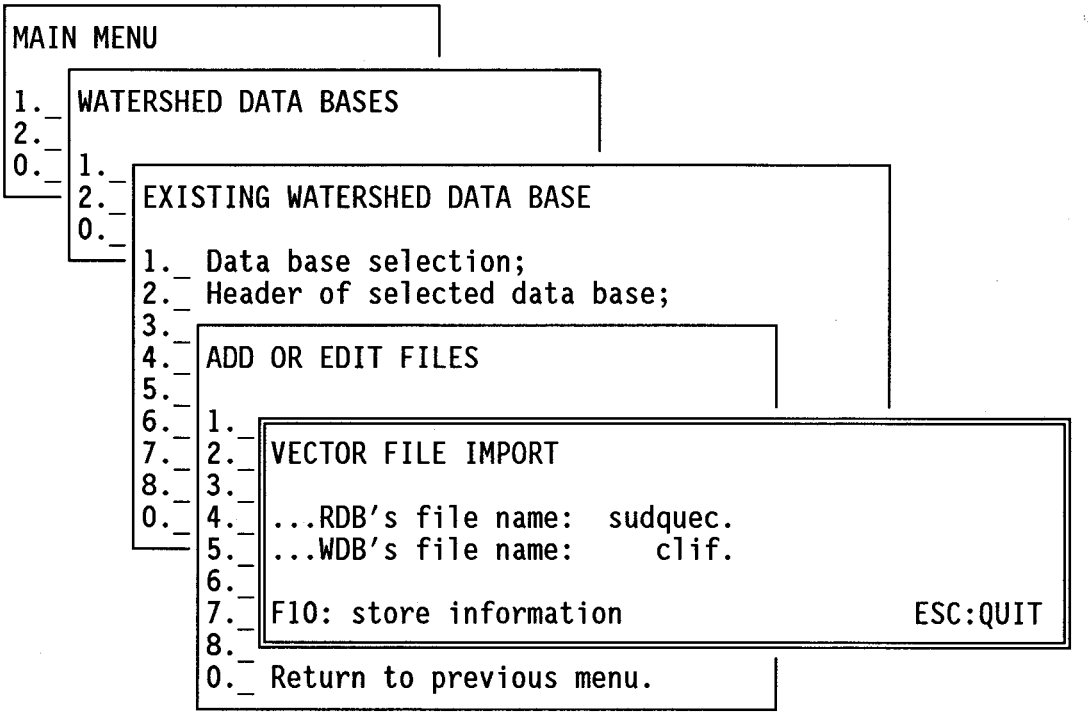

FIGURE 2.31 Sub-menu #2.2.4.2: vector file import.

2.3.2.2.4.3 Sub-menu #2.2.4.3: watershed topography and mask from WDB files

Sub-menu #2.2.4.3 (figure 2.32) gives access to all tasks necessary to defined the drainage network upstream of a particular point on a river and thus the area covered by the watershed corresponding to that network.

Option 1 is selected to pre-process the DEM file in order to obtain a smoother variation of elevation from point to point.

Option 2 is used to determine slopes, whereas option 3 is used for aspect treatment.

Option 4 is a special group of tasks permitting to make the necessary modifications for points or groups of points causing interruptions in the drainage network.

Option 5 allows determination of the drainage network. This option should be selected when all necessary modifications have been done.

Two more user's defined functions can be added with PHYSITEL 2.0 (see appendices).

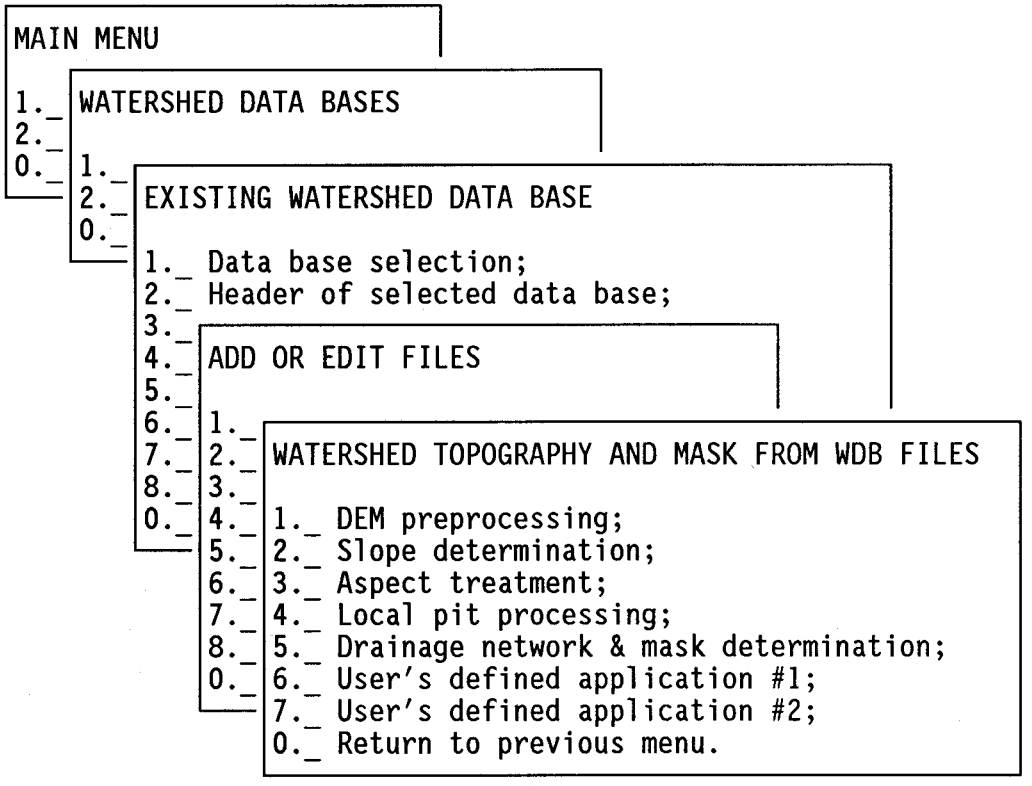

FIGURE 2.32 Sub-menu #2.2.4.3: watershed topography and mask from WDB files.

2.3.2.2.4.3.1 Sub-menu #2.2.4.3.1: DEM preprocessing

Two options are accessed by sub-menu #2.2.4.3.1 (figure 2.33) for pre-processing purposes of the original DEM file.

Option 1 is selected if filtering of the original file is wished. Erroneous values in the file resulting in extreme (minima or maxima) values can be removed if option 2 is selected.

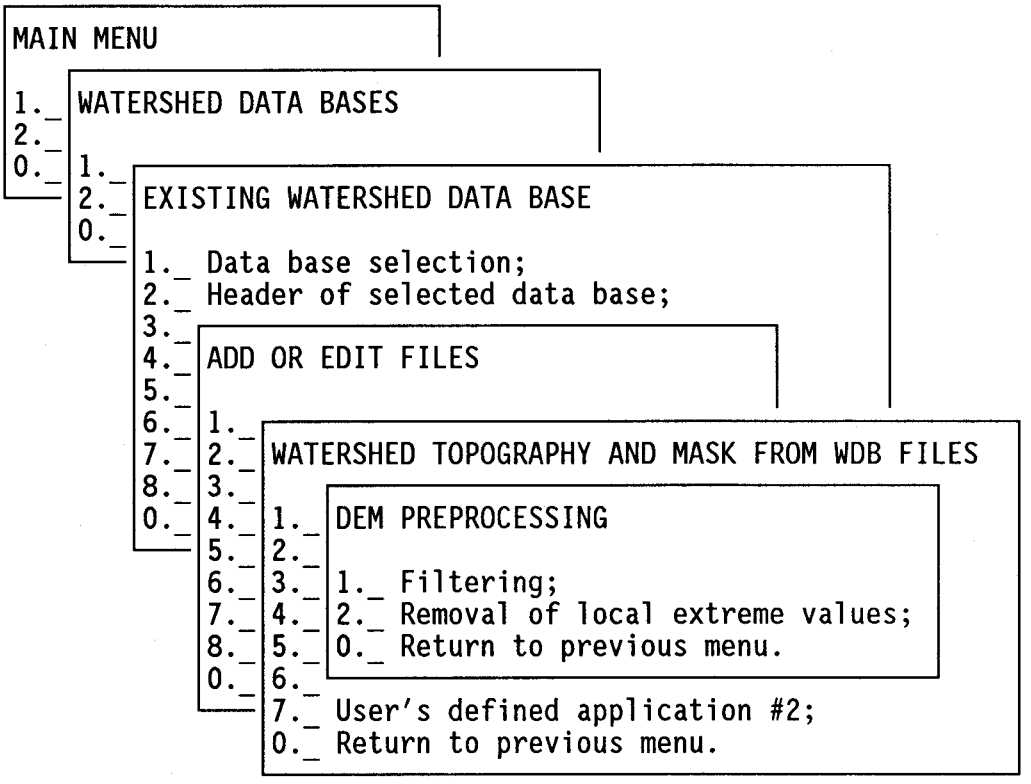

FIGURE 2.33 Sub-menu #2.2.4.3.1: DEM preprocessing.

2.3.2.2.4.3.1.1 Sub-menu #2.2.4.3.1.1: filtering

First enter the name of the file to be filtered (usually the original filename) and that of the filtered file (figure 2.34). In practice, only extensions to the filenames have to be given as all file in the WDB differ only by their extensions.

With PHYSITEL 2.0, only a 3 X 3 filter is used, but the user can add two other methods to filter the image (see appendices).

Press "F10" to execute the task. It is also possible to display either the file to be filtered or the filtered file by pressing "F1". The name of the file to be displayed is then asked for. Press any key to come back to menu.

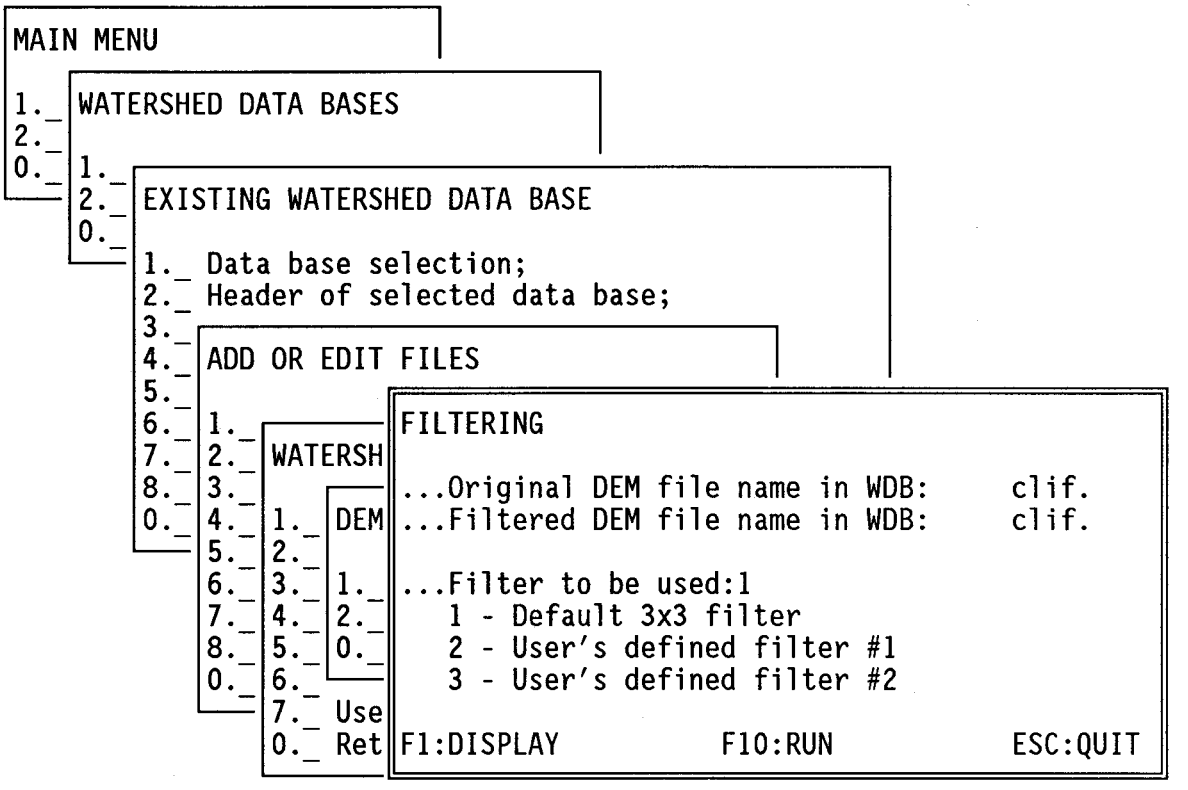

FIGURE 2.34 Sub-menu #2.2.4.3.1.1: filtering.

2.3.2.2.4.3.1.2 Sub-menu #2.2.4.3.1.2: removal of local extreme values

Local extreme values which are effectively wrong values may be removed from the DEM file by task 2.2.4.3.1.2 (figure 2.35).

Enter the name of the DEM file (filtered or unfiltered) from which you want to remove those extreme values. Next, enter the filename under which you want to store the maxima and that for the minima. Storing the extreme values gives the user the possibility to decide that a particular value is not a wrong value but corresponds to a true value on the terrain.

Press "F10" to execute the task and "F1" to display the file before and/or after removal of the extreme values.

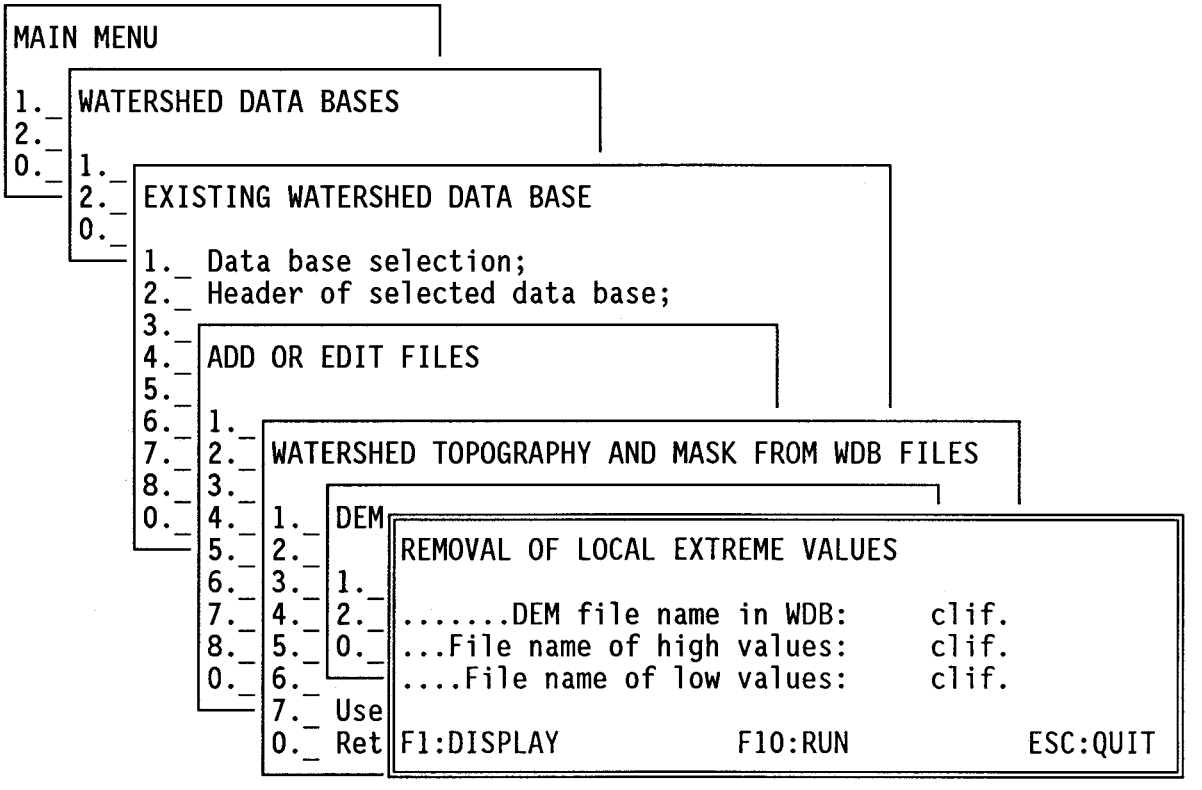

FIGURE 2.35 Sub-menu #2.2.4.3.1.2: removal of local extreme values.

2.3.2.2.4.3.2 Sub-menu #2.2.4.3.2: slope determination

The slopes are determined by using task 2.2.4.3.2 (figure 2.36). Enter the filename of the DEM file in the WDB, followed by the filename you want to give to the slope file. Remember that only extensions need be given.

The method used to determine the slope is chosen next. With PHYSITEL 2.0, only option 1 is available but it is possible to add user's defined methods of determination (see appendices).

Press "F10" to run the task and "F1" to display the slope file.

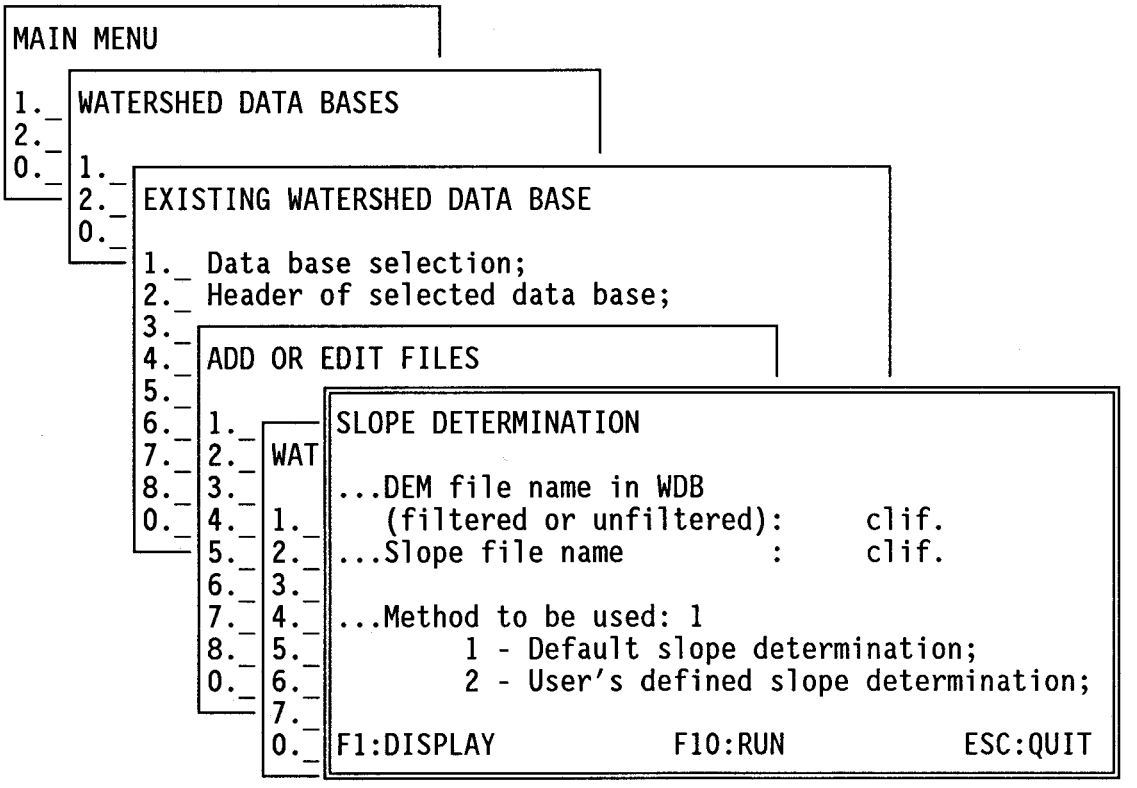

FIGURE 2.36 Sub-menu #2.2.4.3.2: slope determination.

2.3.2.2.4.3.3 Sub-menu #2.2.4.3.3: aspect treatment

In sub-menu #2.2.4.3.3 (figure 2.37) two options are offered. A first determination of aspect is obtained by using option 1. Then option 2 may be used, more or less as a filter, to correct particular aspect directions with the help of both the slope and the DEM files. This happens, for instance, if two contiguous slopes are in opposite direction, as computed previously.

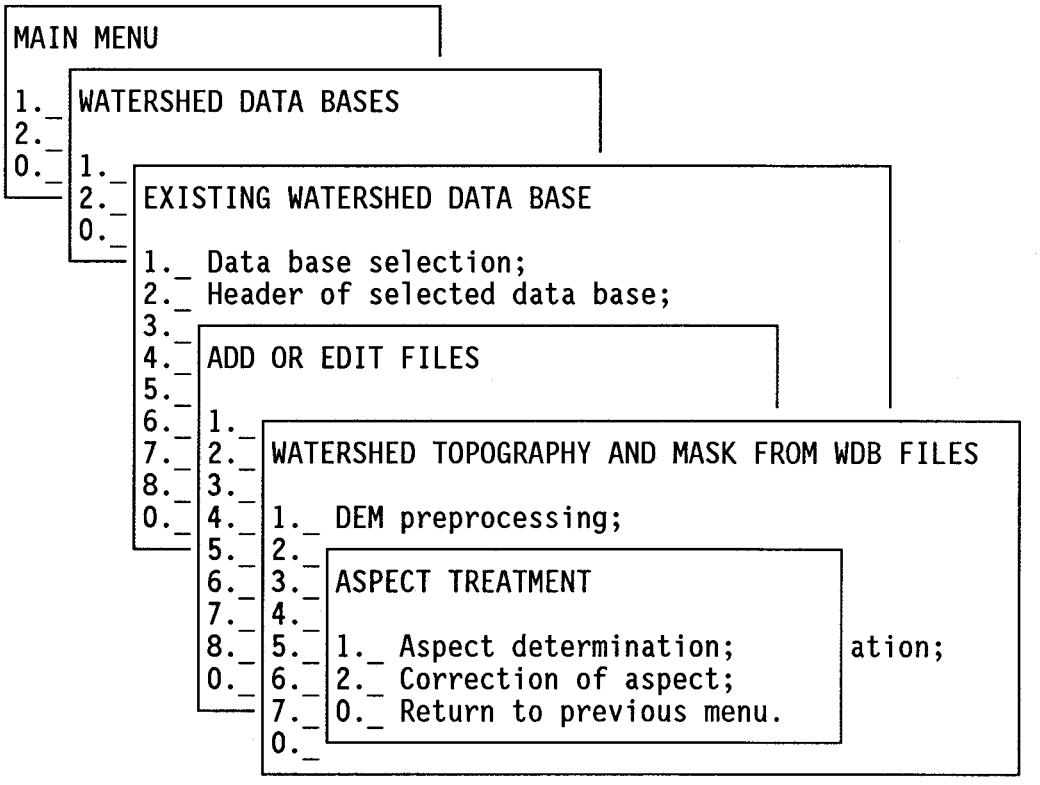

FIGURE 2.37 Sub-menu #2.2.4.3.3: aspect treatment.

2.3.2.2.4.3.3.1 Sub-menu #2.2.4.3.3.1: aspect determination

In order to compute aspect directions, enter the filename of the DEM file you want to use and then the filename of the aspect file that will be created (figure 2.38).

Two options are available to compute the aspects, plus one that can be defined by the user himself (see appendices).

Option 1 uses finit differences.

Option 2 chooses the lowest of the 8 nearest neighbors of a pixel as the aspect of that pixel.

Press "F10" to run the task and "F1" to display the aspect file.

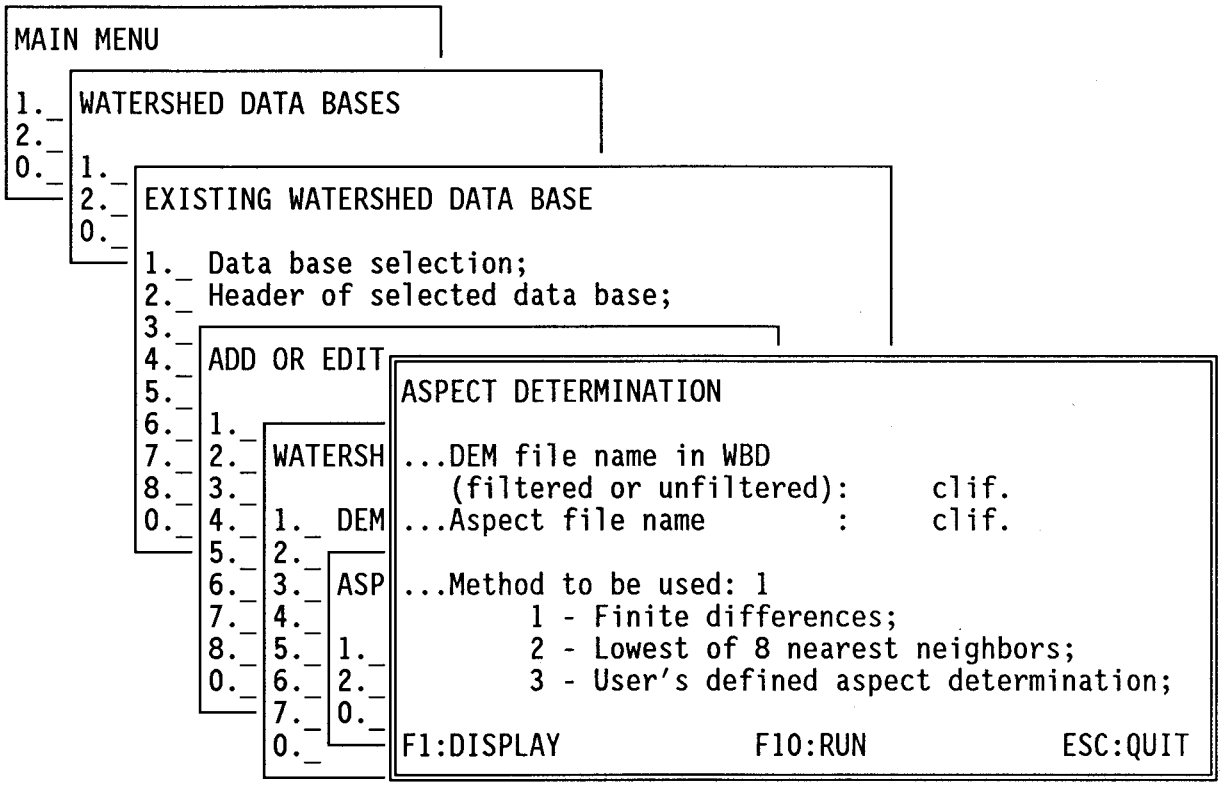

FIGURE 2.38 Sub-menu #2.2.4.3.3.1: aspect determination.

2.3.2.2.4.3.3.2 Sub-menu #2.2.4.3.3.2: correction of aspect

If a few aspect directions have to be corrected, it is possible to do so. The following task will make use of informations coming from the DEM, slope and aspect files to check conflicting directions that make the correction necessary. Enter the filenames of the previously created DEM, slope and aspect files (figure 2.39), as well of the file name under which the corrected aspect file will be saved, and press "F10" to run the task. The corrections are made directly to the aspect file. The corrected aspect file may be displayed by pressing "F1".

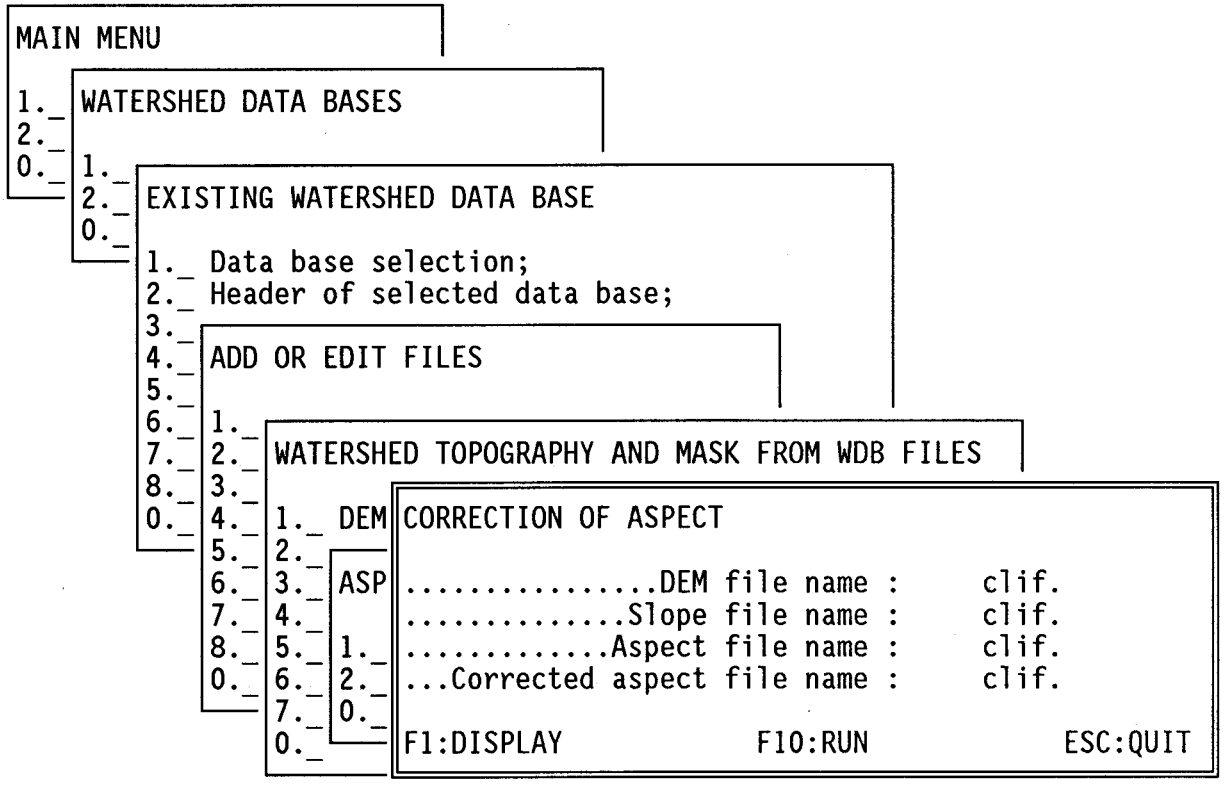

FIGURE 2.39 Sub-menu #2.2.4.3.3.2: correction of aspect.

2.3.2.2.4.3.4 Sub-menu #2.2.4.3.4: local pit processing

Normal drainage from different parts of a watershed may be blocked by a point whose altitude is lower than all surrounding points or by a group of such points, all at the same altitude and forming a flat area. The tasks accessed by sub-menu #2.2.4.3.4 (figure 2.40) are designed to find an outlet for such points or flat areas.

Option 1 is used to locate all local pits (single point).

A temporary working data base regrouping all information on each point must be created with option 2 to facilitate the other options.

Option 3 give access to the task permitting to find an outlet from local pits or flat areas blocking normal drainage.

Option 4 is used to complete the work for all uptream points whose normal drainage was blocked previously.

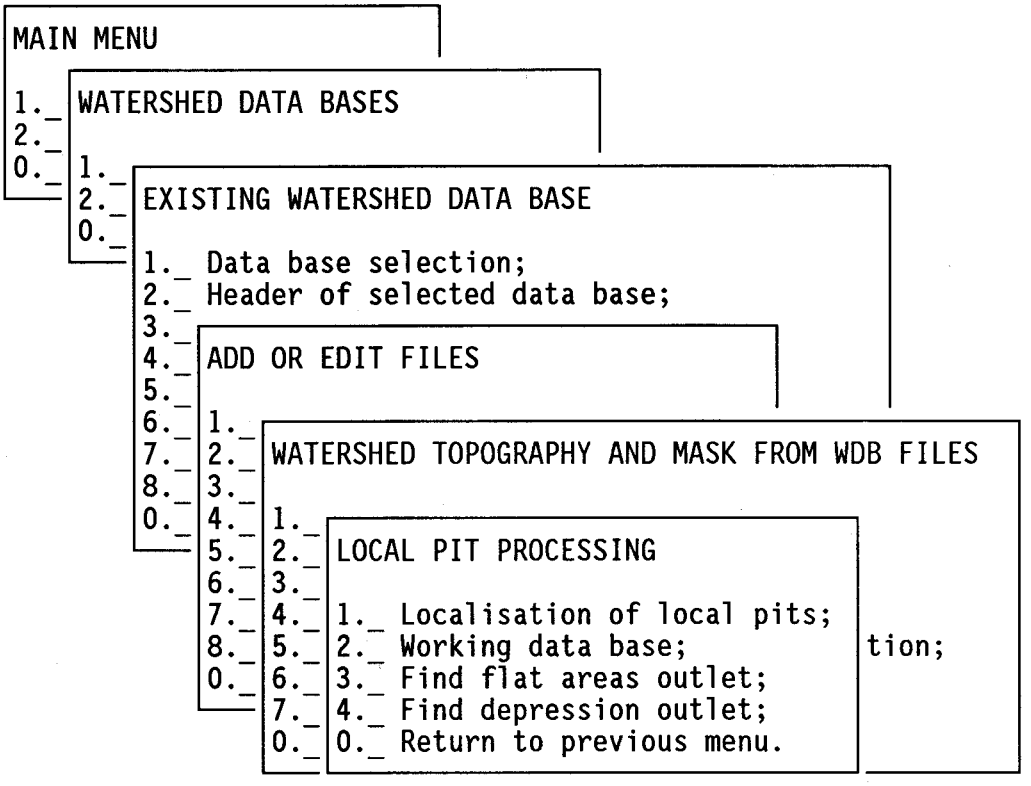

FIGURE 2.40 Sub-menu #2.2.4.3.4: local pit processing.

2.3.2.2.4.3.4.1 Sub-menu #2.2.4.3.4.1: localisation of local pits

Enter the filenames of the DEM and aspect files, as well as the filename of the file to contain informations on local pits (figure 2.41). Press "F10" to run the task.

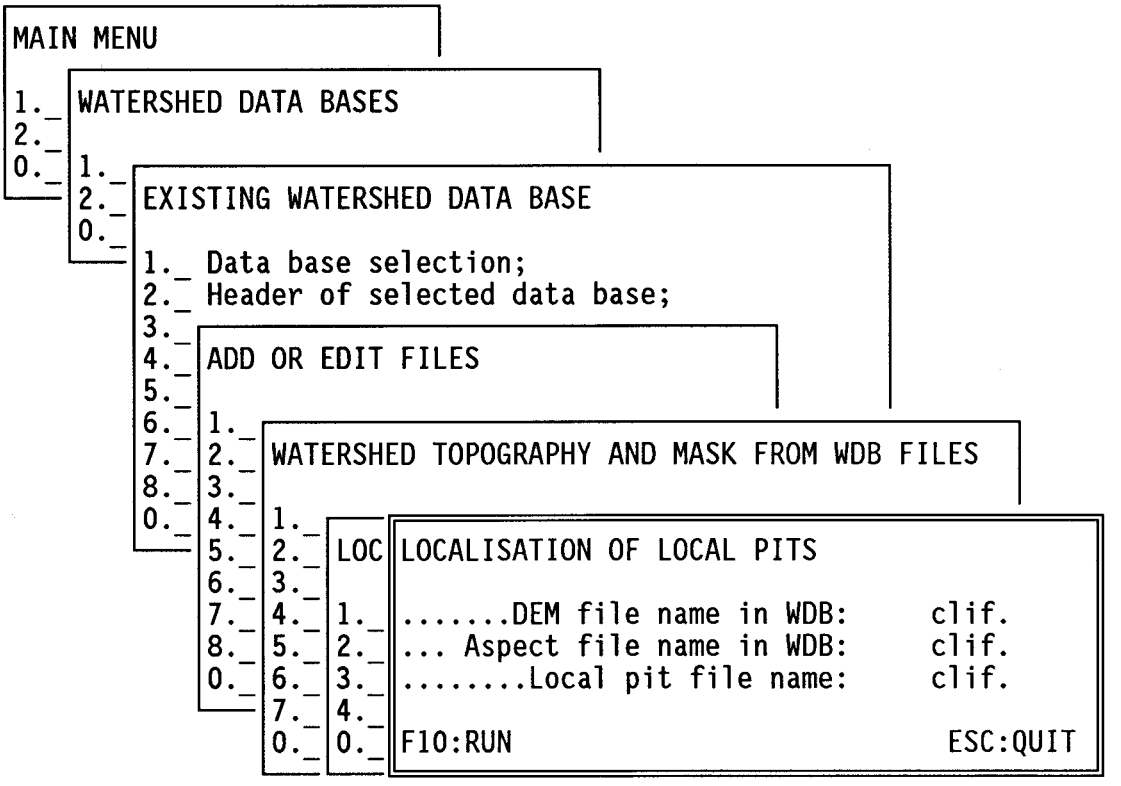

FIGURE 2.41 Sub-menu #2.2.4.3.4.1: localisation of local pits.

2.3.2.2.4.3.4.2 Sub-menu #2.2.4.3.4.2: working data base

To simplify the next sub-menus a working data base containing all pertinent information on each point is prepared. Enter the filenames of the DEM, slope and aspect files, as well as the filename of the temporary working data base. Then, press "F10" to run the task (figure 2.42).

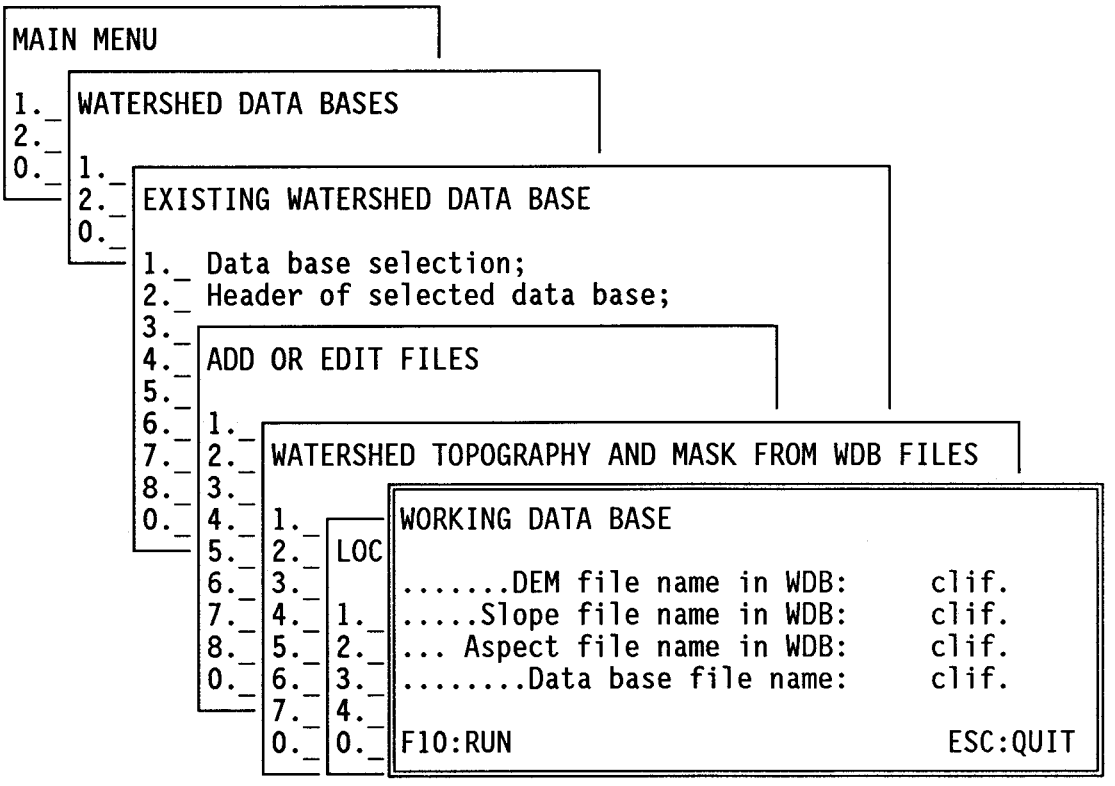

FIGURE 2.42 Sub-menu #2.2.4.3.4.2: working data base.

2.3.2.2.4.3.4.3 Sub-menu #2.2.4.3.4.3: flat area outlets

Sub-menu #2.2.4.3.4.3 gives access to the task permitting to find an outlet from local pits or flat areas blocking normal drainage from upstream points. Enter the filenames of the working data base and local pit files as well as those of the files in which informations on outlets and flat areas will be stored (figure 2.43). The flat area file is prepared for informations only. It can be used to localise flat areas on a map.

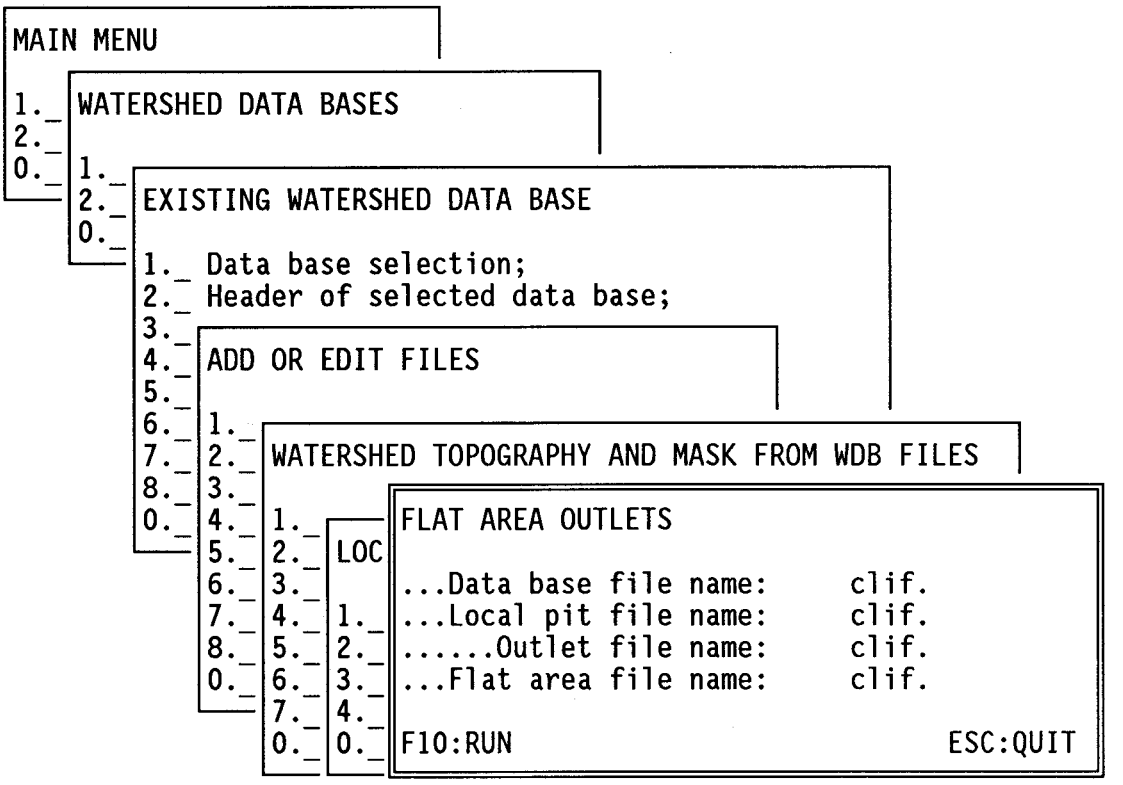

FIGURE 2.43 Sub-menu #2.2.4.3.4.3: flat area outlets.

2.3.2.2.4.3.4.4 Sub-menu #2.2.4.3.4.4: depression outlets

With the previous task, an outlet is found for each local pit or flat area, the task accessed from sub-menu #2.2.4.3.4.4 does the same for all points upstream of those local pits or flat areas in order to restore normal drainage everywhere. The depressions are made of local pits or flat areas, plus all points upstream of those discontinuities.

Enter the filenames of the working data base and of the depression files as well as that of the outlet file obtained with the previous task (figure 2.44). Press "F10" to run the task.

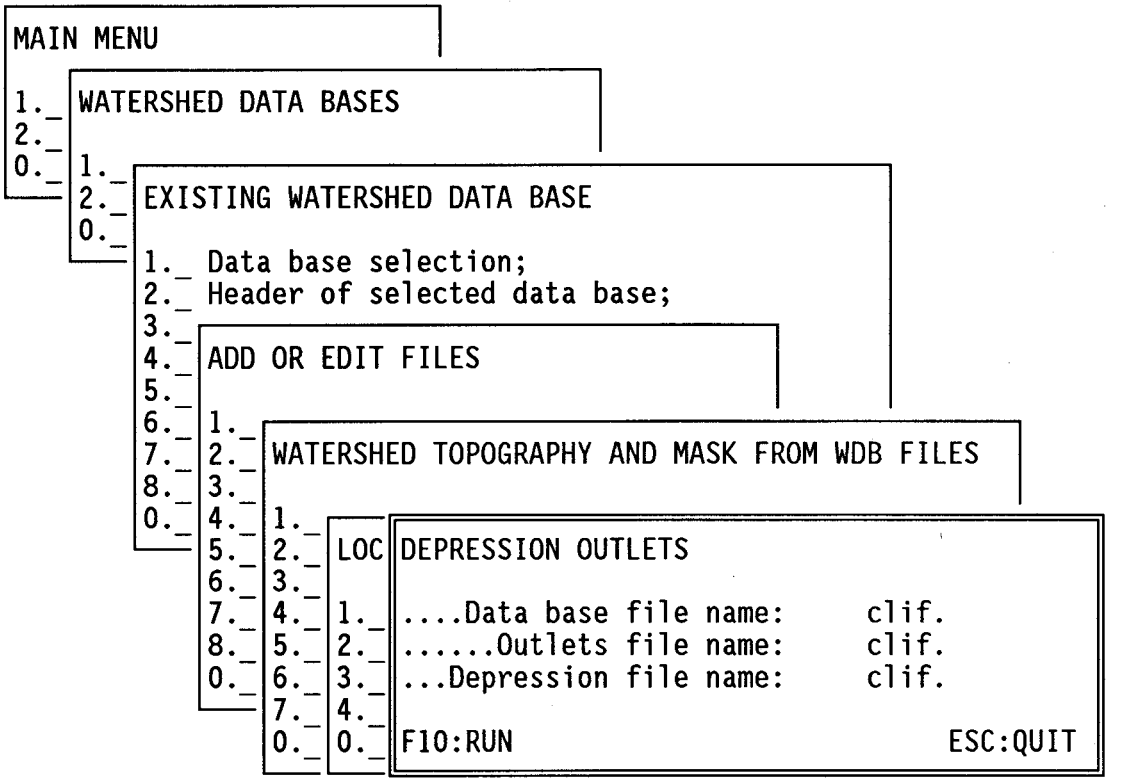

FIGURE 2.44 Sub-menu #2.2.4.3.4.4: depression outlets.

2.3.2.2.4.3.5 Sub-menu #2.2.4.3.5: drainage network determination

Once all previous operations have been done successfully, it is possible to determine the drainage network. Enter the filename of the working data base and the geographical position of the basin outlet (figure 2.45). Only method #1 is available to determine the drainage network and the mask of the watershed, but it is possible for someone to add his own method (see appendices). The right point has to be chosen as the basin outlet. Otherwise, an erroneous watershed will be obtained. Press "F10" to run the task and "F1" to display the results.

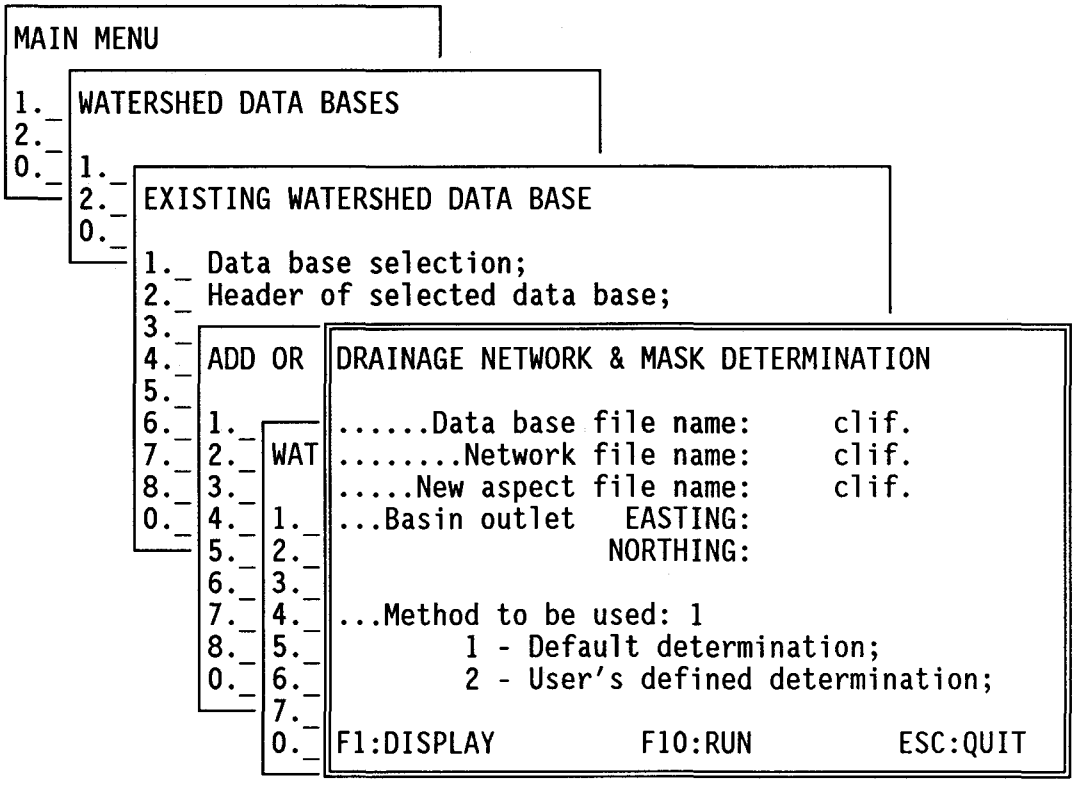

FIGURE 2.45 Sub-menu #2.2.4.3.5: drainage network determination.

2.3.2.2.4.4 Sub-menu #2.2.4.4: sub-basins processing

Once a basin has been determined, it is possible with sub-menu #2.2.4.4 (drainage network determination (figure 2.46)) to subdivide that basin semiautomaticaly into sub-basins and then to process them.

Option 1 is used to define those sub-basins based on an area threshold.

Option 2 provides a way to modify the sub-basins with supervision.

Option 3 will establish the links between the sub-basins.

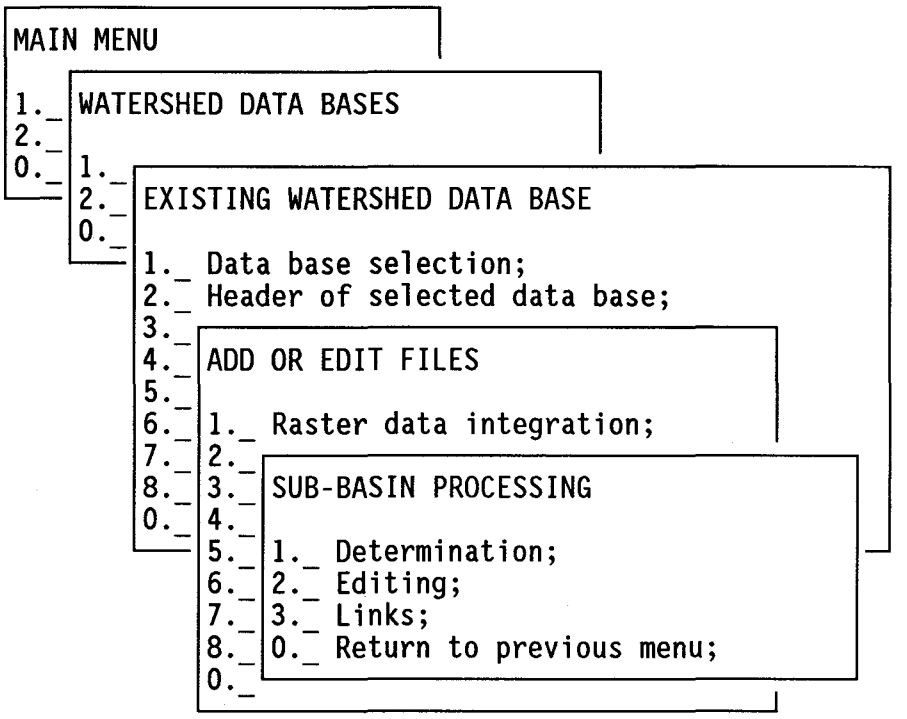

FIGURE 2.46 Sub-menu #2.2.4.4: sub-basin processing.

2.3.2.2.4.4.1 Sub-menu #2.2.4.4.1: determination

This menu (figure 2.47) lets you determine sub-basins semiautomaticaly, using an area threshold. Enter the filenames of existing aspect and network files, then give a name for the sub-basin file to be created. Finally, specify the area threshold (minimum number of cells) for a sub-basin to be considered as such. The method starts by determining the highest sub-basins then proceeds toward the basin outlet. Note that the outlet sub-basin may be smaller then the specified area threshold. This task must be run even if the user chooses to work with cells. The output file contains the order of evaluation of each sub-basin (or each cell if the area threshold is 1) for HYDROTEL.

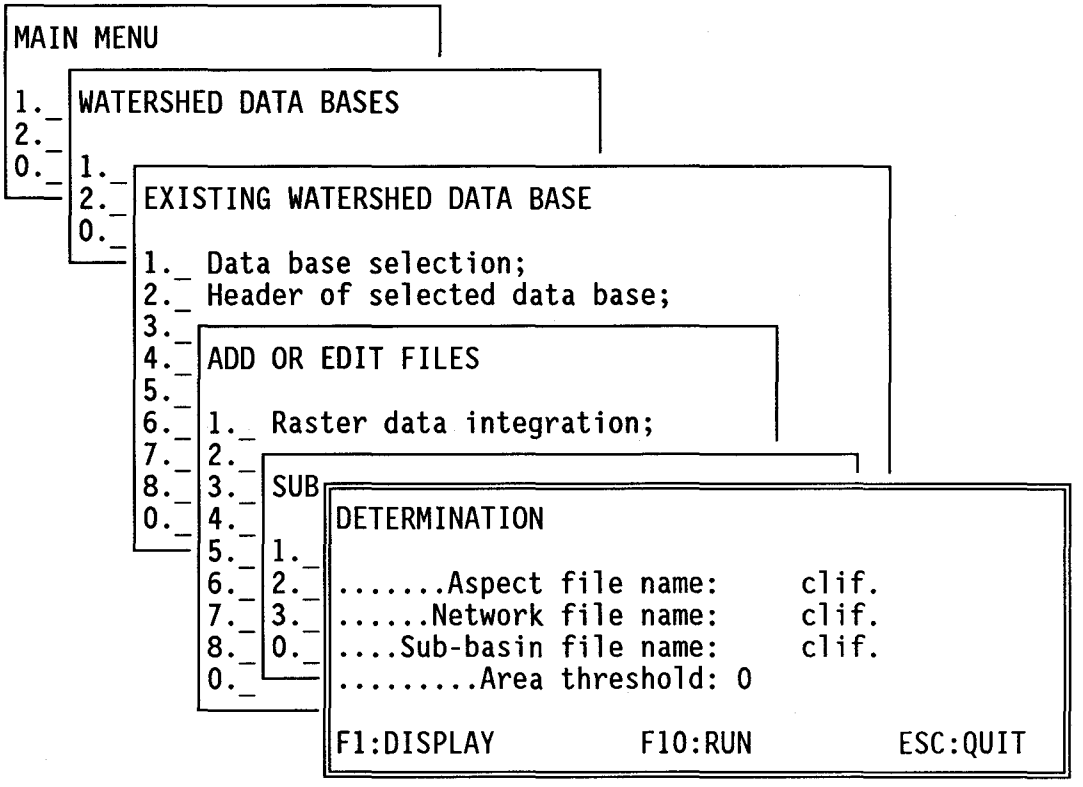

FIGURE 2.47 Sub-menu #2.2.4.4.1: determination.

2.3.2.2.4.3.2 Sub-menu #2.2.4.4.2: editing

Once a set of sub-basins has been defined one may wish to modify them. The "editing" function (figure 2.48) described next can help the user to do so. Enter the filenames of the aspect, network and sub-basin files, then press "F10". A map of the sub-basins with the aspect of each cell on top will be displayed with a menu on the right. Use the arrows on the keypad to choose one of the options of the menu. If the "group" function is chosen, the user will be asked to mark two contiguous sub-basins that he wishes to group. The task will be executed only if one of the sub-basins do drain into the other. Otherwise, a message will be issued and the screen refreshed. If the "split" function is selected, the user will be asked to point the outlet of the new sub-basin. One can always quit without saving modifications by selecting the "cancel" option. If the "SAVE & QUIT"

option is chosen, the system will ask for a filename under which to save the modifications.

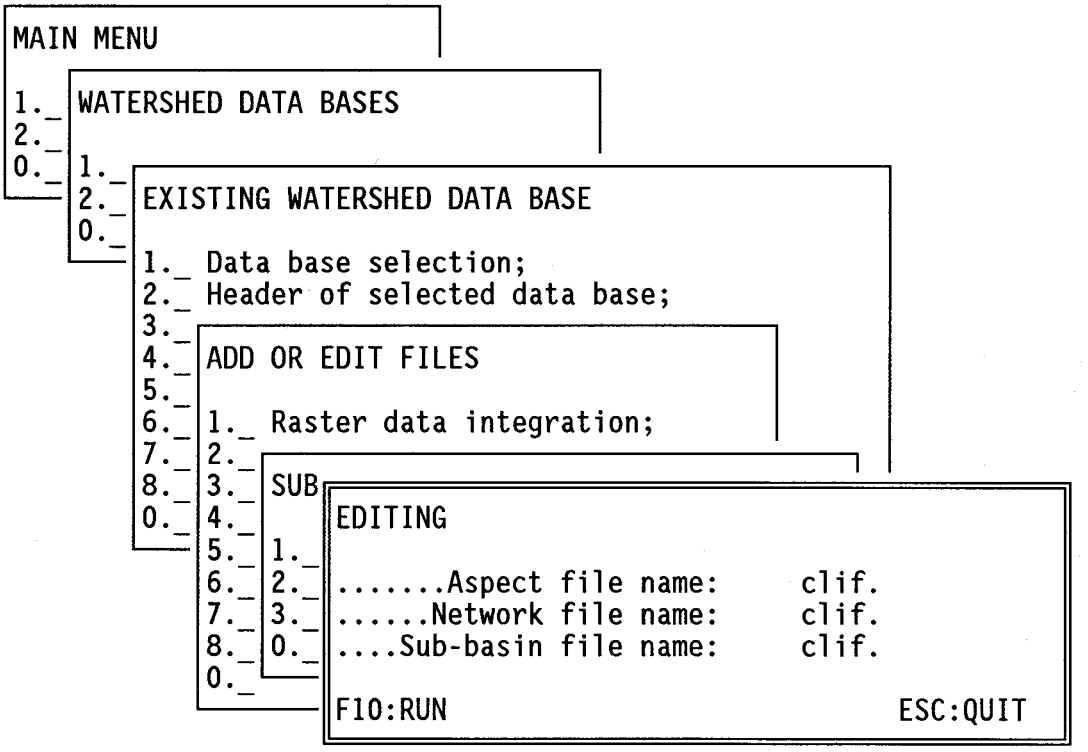

FIGURE 2.48 Sub-menu #2.2.4.4.2: editing.

2.3.2.2.4.4.2 Sub-menu #2.2.4.4.2: links

The purpose of "links" sub-menu (figure 2.49) is to produce a file which will specify downstream links between sub-basins. This file will give for every sub-basin a reference to the sub-basin into which it flows.

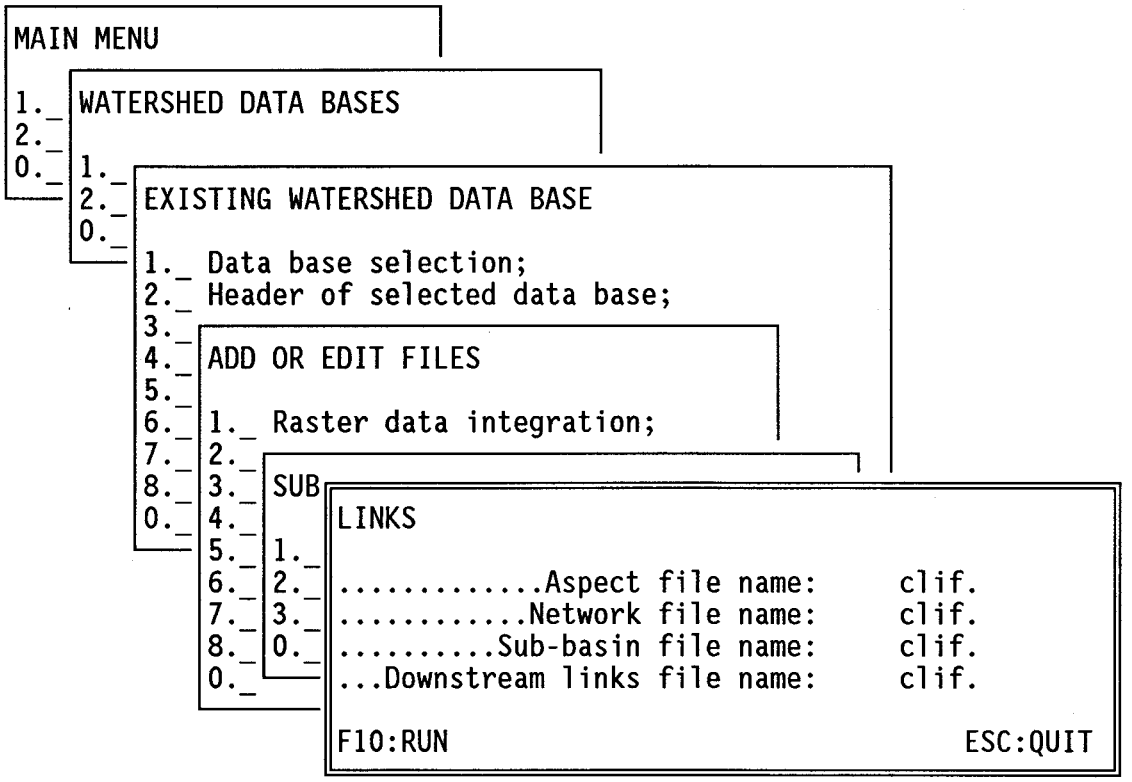

FIGURE 2.49 Sub-menu #2.2.4.4.3: links.

2.3.2.2.4.5 Sub-menu #2.2.4.5: land-use integration for grid intervals

When integration of a raster file containing a single variable (e.g. DEM data) is wished, one should use sub-menu #2.2.4.1. However, when the raster file refers to a number of variables, as it is the case for land-use, sub-menu #2.2.4.5 is to be used (figure 2.50). Only option 1 is implemented in PHYSITEL 2.0, but one may add his own options using the informations given in the appendices.

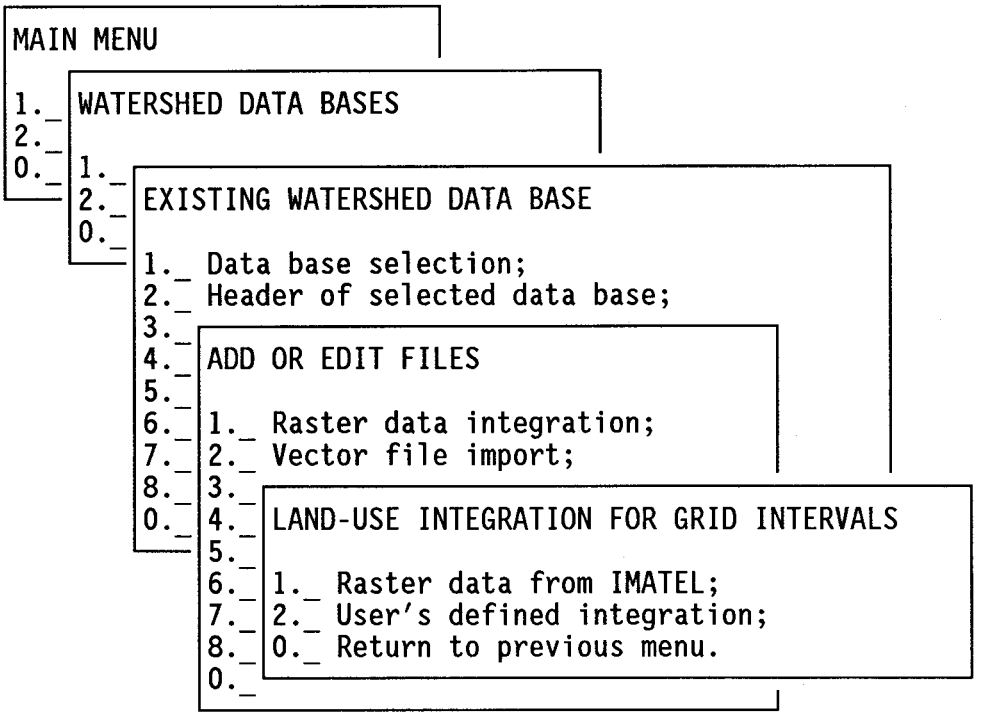

FIGURE 2.50 Sub-menu #2.2.4.5: land-use integration for grid intervals.

2.3.2.2.4.5.1 Sub-menu #2.2.4.5.1: raster data from IMATEL

Enter the file names (extensions only) of the files to integrated and of the file where to store the result. Press "F10" to run the task.

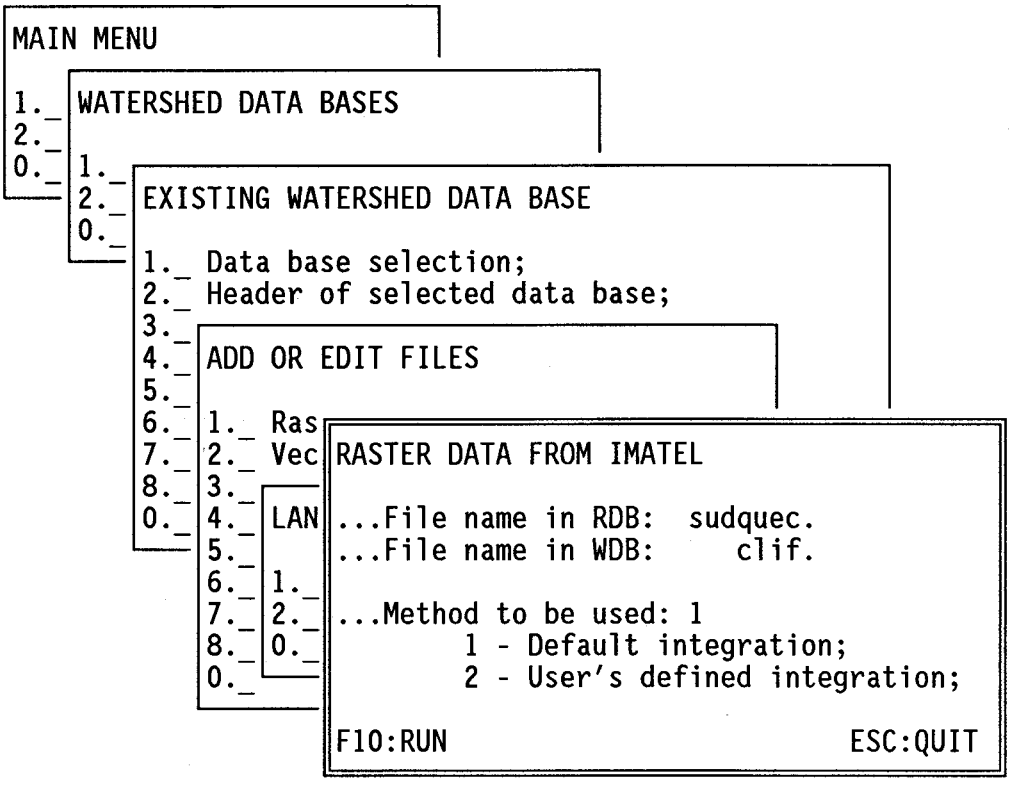

FIGURE 2.51 Sub-menu #2.2.4.5.1: raster data from IMATEL.

2.3.2.2.4.6 Sub-menu #2.2.4.6: file editing

Sub-menu "file editing" (figure 2.52) can be used for two purposes. First, to visualize and modify the aspect values computed earlier. Second, to go to DOS level without leaving PHYSITEL completely.

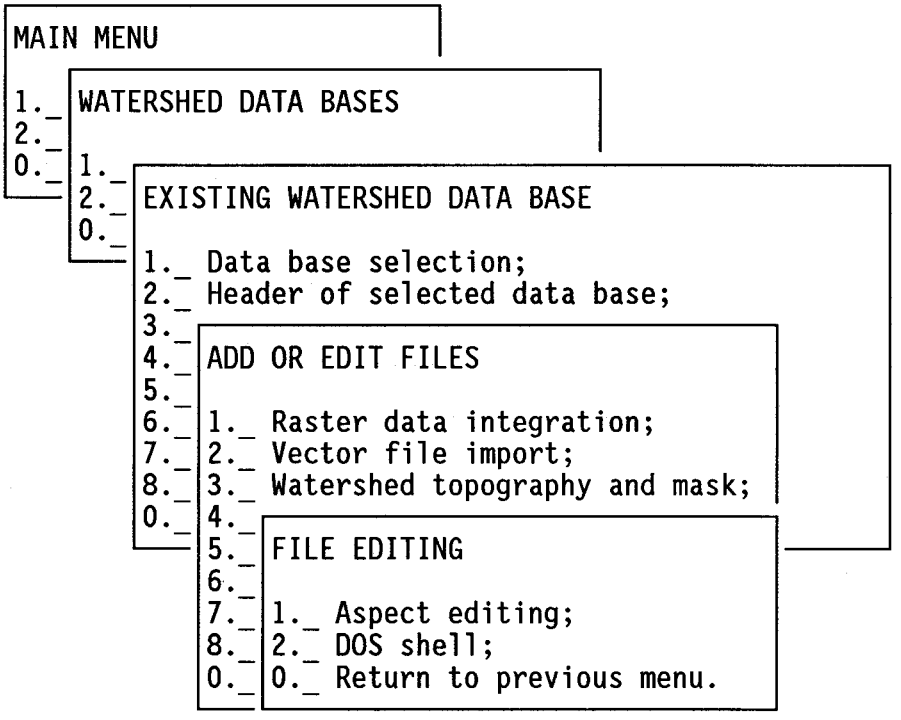

FIGURE 2.52 Sub-menu #2.2.4.6: file editing

2.3.2.2.4.6.1 Sub-menu #2.2.4.6.1: aspect editing

Enter the name of the file you wish to edit and press RETURN. You should see a map of the aspect values using arrows for aspect directions and asterisks for flat cells. Note that the aspect of the upper left corner is of a different color (blue), that is the position of the cursor. You can move the cursor using the arrows on the keypad. To change an aspect direction, move the cursor to that cell and press "1" to change it to an EAST (E) aspect, "2" for NORTHEAST (NE) etc... It is not possible to enter a flat cell. When the modifications are done, simply press ESC and you will be asked to give a name for the new file. If you do not want to save the modifications, press ESC one more time and the aspect file will remain unchanged.

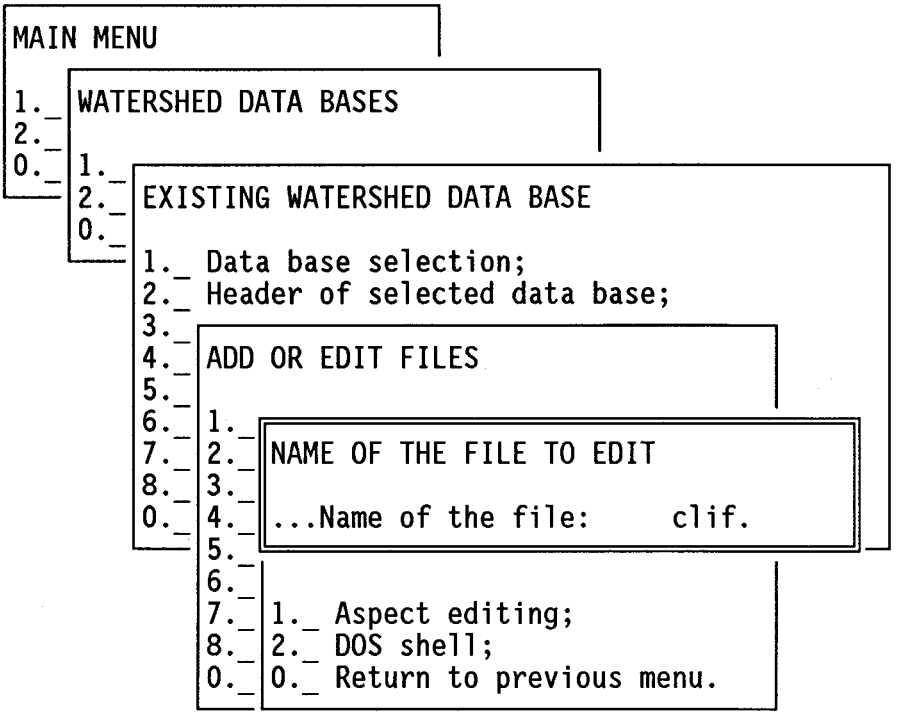

FIGURE 2.53 Sub-menu #2.2.4.6.1: aspect editing

2.3.2.2.4.6.2 Sub-menu #2.2.4.6.2: DOS shell

If a user wants to modify a file without leaving PHYSITEL, he may use this menu (figure 2.54). He has access to DOS and may use the program of its choice to edit the file. When this is done, he comes back to PHYSITEL by typing "EXIT". Note that what will appear on your screen will differ from figure 2.54 depending on your computer, your operating system and the directory where PHYSITEL is located. Note also that it is very important to return to that directory before returning to PHYSITEL.

```
Type "exit" to return to PHYSITEL.

Ordinateur personnel HP Vectra  MS-DOS Version 3.30 - C.01.01

(C)Copyright Hewlett-Packard 1986-1988
(C)Copyright Microsoft Corp  1981-1988

C:\PHYSITEL>
```

FIGURE 2.54 Sub-menu #2.2.4.6.2: DOS shell

2.3.2.2.5 *Sub-menu #2.2.5: display files*

Sub-menu #2.2.5 (figure 2.55) lets you display most files present in the WDB. A window appears prompting you to give the name of the file to display. PHYSITEL uses the information present in the header of the file to decide what type of graphic to display. This prevents the user from trying to display a non-displayable file.

A DEM file is displayed with colors corresponding to different classes of altitudes.

A SLOPE file is displayed with different colors for different classes of slopes.

An ASPECT file is displayed with 9 different colors 8, for the aspect directions to 8 points of the compass, plus one for flat cells noted as "FL" in the legend.

A BASIN file shows the mask of basin using blue for cells inside the basin and black for outside cells.

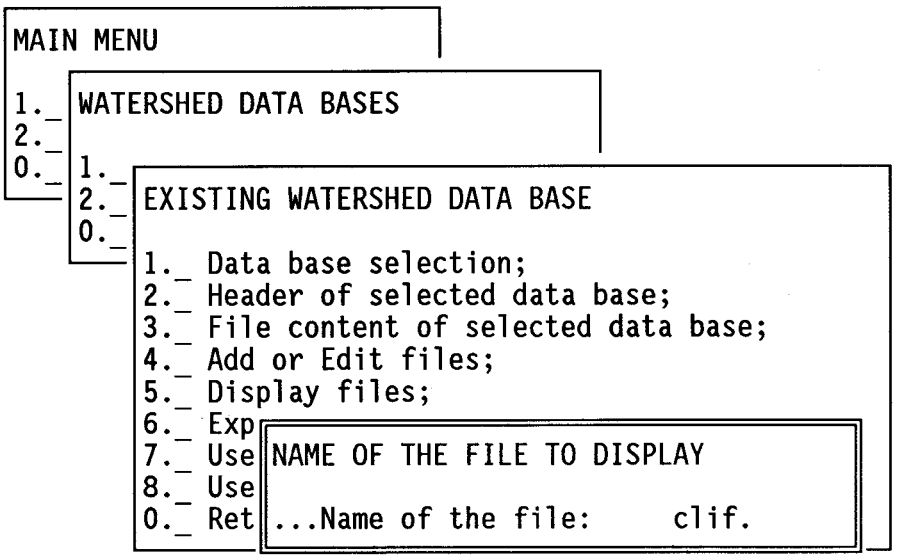

FIGURE 2.55 Sub-menu #2.2.5: display files.

2.3.2.2.6 *Sub-menu #2.2.6: export files*

Sub-menu #2.2.6 (figure 2.56) lets the user export files by changing the format of those files. PHYSITEL 2.0 export files to HYDROTEL or to SPANS (raster files). One can also add his own export formats by following the informations given in the appendices.

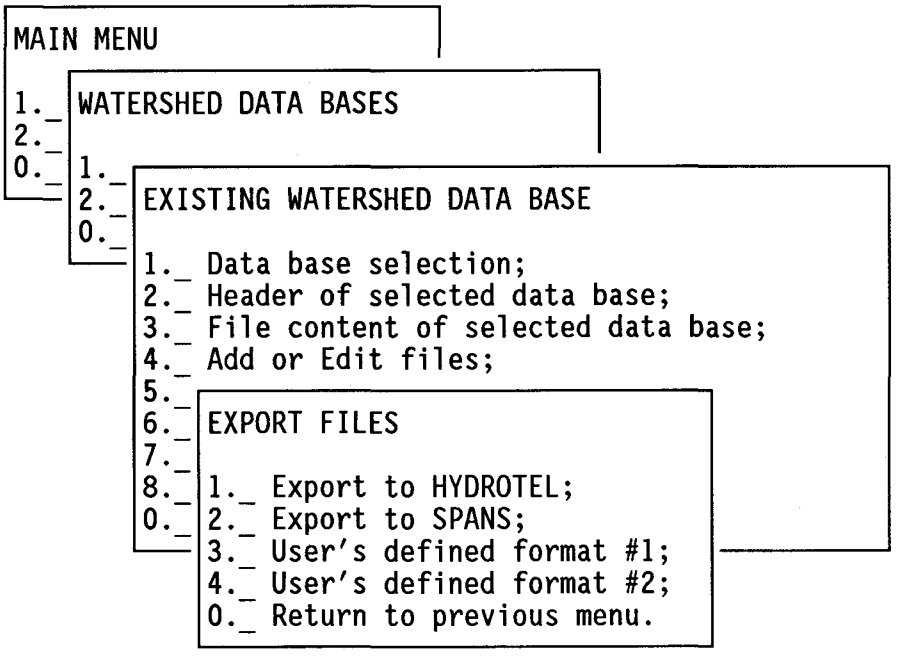

FIGURE 2.56 Sub-menu #2.2.6: export files.

2.3.2.2.6.1 Sub-menu #2.2.6.1: export to HYDROTEL

In sub-menu #2.2.6.1 (figure 2.57), the user can export files to HYDROTEL. The name of the file to export and the path of the new file must be given. We recommend to store the new file in a directory different from RDB or WDB. Press "F10" to run the task.

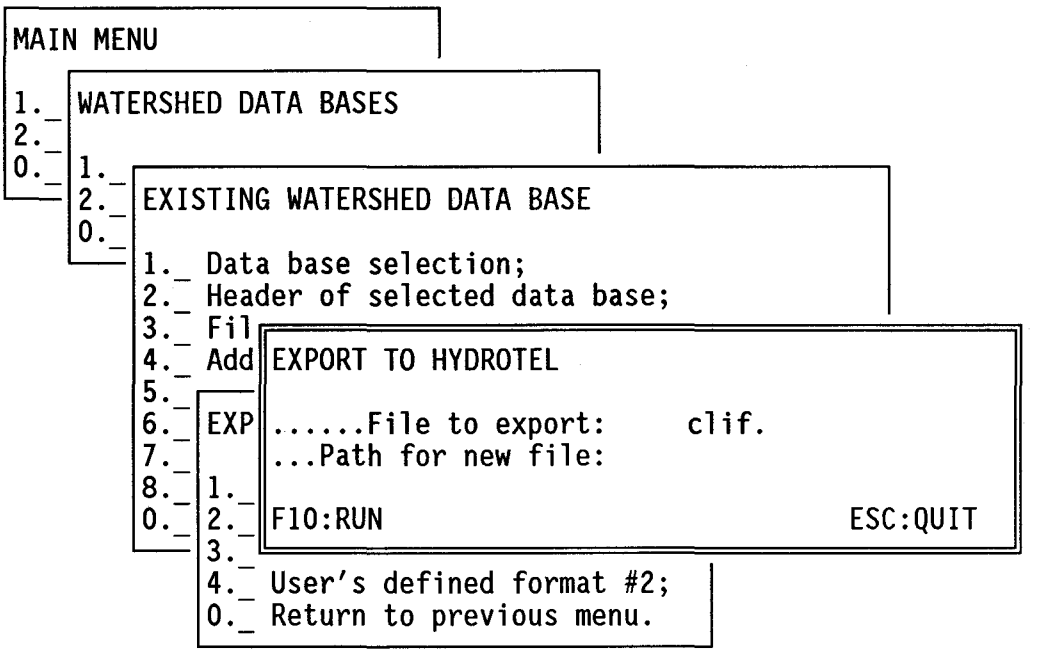

FIGURE 2.57 Sub-menu #2.2.6.1: export to HYDROTEL.

2.3.2.2.6.2 Sub-menu #2.2.6.2: export to SPANS

It is also possible to export raster files to SPANS, using sub-menu #2.2.6.2 (figure 2.58). Type first the file name (extension only) of the file you wish to export. Next, type the path of the new file. It is recommended to store the new file in a directory different from either RDB or WDB. The name of the new file must be given without extencion. press "F10' to run the task.

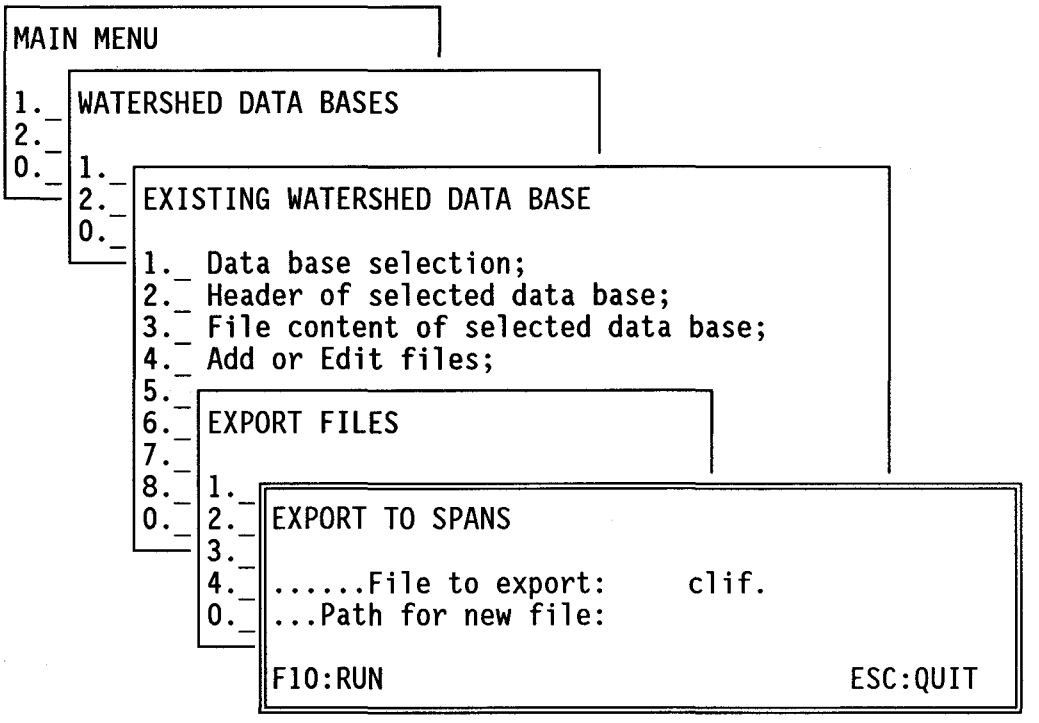

FIGURE 2.58 Sub-menu #2.2.6.2: export to SPANS.

PART 3

COMPLEMENTARY INFORMATION

PART 3 COMPLEMENTARY INFORMATION

3.1 ACCURACY OF MAP PROJECTIONS

Only UTM projections can be used with PHYSITEL 2.0 and HYDROTEL 2.1. As a regional data base or even a watershed may lie on two contiguous UTM zones, one may wonder about the mapping accuracy in some parts of a RDB or WDB.

To answer, it should be known that the error increases from the central meridian in a specific UTM zone to the eastern and western limits of that zone. That error continues to increase regularly as the East-West distance between a particular point on the Earth and the central meridian of a specific zone increases, such that a point lying just outside a zone will have an error just a little over that of the points close to it but inside the zone, when it is positionned in the UTM units of that zone. In other words, there is no abrupt change in accuracy at the limit of a zone and point lying outside a specific zone can be located in the units of that zone with an error that depends essentially on its distance to the central meridian of that zone.

As it may be assumed that the mapping accuracy at the limits of a zone is acceptable for most, if not all purposes, it should be acceptable to have RDB's to WDB's lying on two or even three contiguous UTM zone, provided that the parts of the DB do not extend too far into the secondary zones.

3.2 FROM DIGITAL ELEVATION MODELS TO HOMOGENEOUS HYDROLOGICAL UNITS

In the following lines, informations will be given on the transformation of DEM values into HHU's. Each step in the process will be explained briefly so as to show more cleary the effect and relative importance of each of the tasks accessed by sub-menus #2.2.4.3 (watershed topography and mask from WDB files) and #2.2.4.4 (sub-basin processing).

3.2.1 Preprocessing of DEM data

Due to a number of reasons (human errors, interpolation algorithms, grid size, ...) there may be erroneous data in the DEM, which should be corrected.

3.2.1.1 Removal of extreme values (sub-menu #2.2.4.3.1.2)

First, erroneous local extreme values must be removed (sub-menu #2.2.4.3.1.2). This can be done by moving a 3 X 3 window over the DEM matrix. It should be understood at this point that the spatial accuracy of a DEM should be sufficient to represent the essential topographic features of a watershed. The following tasks have been developed with that assumption. Each central value in the window which is higher than its eight surrounding values is considered as a maximum and is replaced by the highest value of these eight values. The X - Y coordinates of that point, together with the elevation values are also stored in a file so that the user may decide later on not to correct a particular value. The same is done for minimum values. The window is moved over the matrix as long as at least one extreme value is detected and corrected on a specific pass.

i - 1 j - 1	i - 1 j	i - 1 j + 1
i j - 1	i j	i j + 1
i + 1 j - 1	i + 1 j	i + 1 j + 1

FIGURE 3.1 3 X 3 window used for removal of extreme values.

3.2.1.2 Filtering of DEM data (sub-menu #2.2.4.3.1.1)

If it is felt that the DEM data should be smoothered before computing slopes and aspects, then, it is possible to use a filter to do so.

Remember that significant information could be lost by over filtering DEM data, so be careful. Note that the central value has a weight much higher than those of the surrounding values to limit over filtering.

i - 1	.052	.073	.052
i	.073	.50	.073
i + 1	.052	.073	.052
	j - 1	j	j + 1

FIGURE 3.2 Weights used to filter DEM data.

Once, the extreme values are removed and filtering has been applied to the corrected data, a relatively error-free DEM should result. However, as it will be shown with the other tasks, that does not mean that problems will not be encountered. In certain cases, it will be necessary to filter the DEM data more than one time.

3.2.2 Determination of slopes (sub-menu #2.2.4.3.2)

A finite difference approach is used to compute slopes. The slope S_{ij} associated with point (i,j) is given by:

$$S_{ij} = [(\Delta Z_x/2\Delta X)^2 + (\Delta Z_y/Z\Delta Y)^2]^{½} \quad (3.1)$$

where:

$\Delta Z_x = Z_{i,j+1} - Z_{i,j-1}$

$2\Delta X = X_{i,j+1} - X_{i,j-1}$

$\Delta Z_y = Z_{i+1,j} - Z_{i-1,j}$

$2\Delta Y = Y_{i+1,j} - Y_{i-1,j}$

Z = elevation (m)

X and Y: coordinates

This method assumes that the values taken by the elevations at the points sourrounding the central points can be taken to compute the slope. In the case of a DEM with a low spatial accuracy, that may not be the case. A more suitable method should be added as a user's defined task if such a DEM is the only one available. In that case, a slope value could be estimated between a central cell and its eight neighours. The largest value should be kept as the slope associated with the central point.

3.2.3 Determination of aspect (sub-menu #2.2.4.3.3)

As this determination of aspect is crucial for all further data processing to get the drainage structure of a watershed, a first estimation of aspect is made first. Correction of the aspect directions resulting from this estimation can be done, if necessary.

3.2.3.1 First determination of aspect (sub-menu #2.2.4.3.3.1)

The normal way of estimating aspect directions in PHYSITEL 2.0, is with a finite difference approcah, as with the slopes. Then, the aspect $A_{i,j}$ of cell ij is given by:

$$A_{ij} = \arctan (\Delta Z_y / \Delta Z_x) \quad (3.2)$$

where ΔZ_y and ΔZ_x are the same values as those estimated for equation 3.1.

As a cell is surrounded by only eight neighours, the aspect is given to only eight directions of the compass (figure 3.3), coded counterclockwise from 1 (EAST).

4	3	2
5	0	1
6	7	8

FIGURE 3.3 Aspect directions.

Too 8 (South-East). If $\Delta Z_x = \Delta Z_y = 0$, then the slope $S_{ij} = 0$ and the cell is horizontal. No flow direction is associated with such a cell and a correction will have to be made.

If the available DEM data have a low spatial accuracy, it may be necessary to estimate the aspect direction as being that of the highest slope between a central cell and its neighbours.

That method should be chosen if the first one does not seem to give aspect directions suitable for the next tasks and the spatial accuracy of the DEM is low (course representaiton of the topography).

3.2.4 Automatic correction of aspect (sub-menu #2.3.4.3.3.2)

It is possible that conflicting aspect directions result from the application of the previous task, as aspect directions are computed for each individual cell, without looking at the aspects of the surrounding cells. Examples of such conflicting directions are shown in figure 3.4.

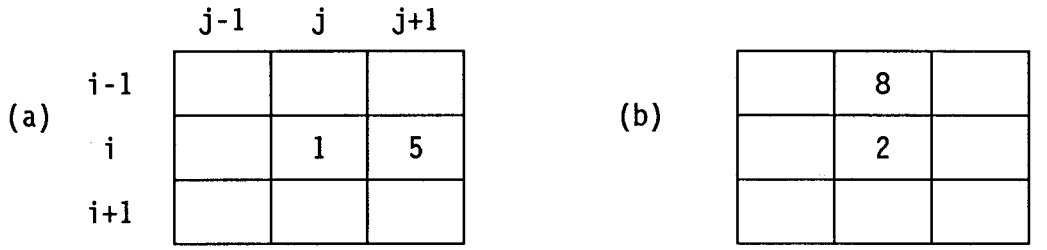

Figure 3.4 Conflicting aspect directions
a) cells oriented toward each other
b) crossed drainage.

The aspect of cell (i,j) is toward cell (i,j+1) and that of cell (i,j+1) is toward cell (i,j). This will cause an interruption in the drainage network. Also, crossed drainage (fig. 3.4b) is likely to cause problems.

In order to correct the aspect of cell (i,j) the aspect, altitude and slope values of that cell and of surrounding cells can be checked to find out an aspect direction compatible with these additionnal informations on the local topography. As an example, let us assume that there is crossed drainage, as shown in figure 3.4b. In that case, only the altitudes and aspect directions are checked. If $h_{i,j} > h_{i-1,j}$ and $h_{i-1,j} < h_{i,j+1}$ and $A_{i,j+1}=5$, then the corrected aspect is 3. All possibilities are looked at to correct the aspect.

3.2.5 Interactive correction of aspect (sub-menu #2.2.4.6)

If, after removal of extreme values, filtering of the DEM data and automatic correction of aspect direction, these are still problems, which are not solved by the tasks on local pits, flat areas and depressions, when trying to determine a drainage pattern, it is possible to change the aspect direction interactively. This will happen if a number of cells do have aspect directions such that the drainage pattern is a close loop. In those cases, it should be sufficient to change the aspect direction of only one of the cells to return to normal drainage.

3.2.6 Processing of local pits, flat areas and depressions (sub-menu #2.2.4.3.4)

As mentionned above, horizontal cells may be encountered. The aspect of such cells may be changed so that the flow direction is toward the lowest adjacent cell. This applies to both local pits (one cell) and flat areas (two or more contiguous horizontal cells). In the latter case a pour point out of the flat area is first found out and a drainage pattern inside the flat area restored.

A "depression" is made out of all the cells whose normal drainage is blocked by a local pit or flat area. After normal drainage is restored for local pits or flat areas, then "depression" can be processed to restore normal drainage for all parts of a DEM.

As informations are available in PHYSITEL 2.0 for all those operations, it is possible for the user to check if the local pit or flat area should be corrected or if it is a real topographic feature that should not be changed.

3.2.7 Drainage network and basin determination (sub-menu #2.2.4.3.5)

Once all previous operations have been done successfully, it is possible to go one step further and process the informations contained in the working data base (elevations, aspects, and slopes) to obtain the drainage network and identify all cells in the watershed. A recursive algorithm is used to define the drainage from cell to cell, starting at the cell considered as the outlet of the watershed.

3.2.8 Sub-basin processing to get homogeneous hydrological units (sub-menu #2.2.4.4)

Processing of the final aspect file and network file to define sub-basins is the first step toward the definition of homogeneous hydrological units. The area threshold must be chosen in relation with the size of the homogeneous units defined from analysis of the

spatial variability of the characteristics of the watershed (criteria on which to base such an analysis will be defined in an ongoing PhD thesis and should be available by the end of 1991). Once sub-basins and homogeneous units are defined, it is possible to sub-divide or group the initial sub-basins according to the homogeoneous units in order to get homogeneous hydrological units.

APPENDIX A

INTERNAL FILE FORMAT

APPENDIX A

INTERNAL FILE FORMAT

Before reading what follows it is suggested that you get familiar with PHYSITEL and its menus. The goal of this section is to describe the formats of the files that are created and manipulated internally by PHYSITEL. This does not include files that are imported or exported by PHYSITEL. Another way to see it is to say that it includes all files that one will find in the **RDB** and **WDB** directories. One needs to understand these formats if he wants to program his own functions through the user's defined options available in PHYSITEL. There are two main categories of files, **identification** and **database** files which are explained in the next two sections.

IDENTIFICATION FILE FORMAT

Identification files (easily differentiable with the extension "id") are created by PHYSITEL when a new database is defined either in the RDB or WDB directories. These files contain general information on the database, which is used when a file is imported in the database. An identification file is an ASCII file which can be displayed with any text editor. There are two types of identification files, RDB and WDB identification files. WDB identification files identify watershed database and will be found in the WDB directory.

RDB IDENTIFICATION FILE

RDB identification files identify regional databases and will be found in the RDB directory. This type of files carries informations on the geographic projection, the characteristics of that projection and the geographic area that this database will cover.

FILE FORMAT OF A RDB IDENTIFICATION FILE

Line	Format	Description
#1	1 char	Type of file: '0'
#2	[1-8]char	Name of the RDB database
#3	[1-65]char	General comment on the database, for information purposes only
#4	1 char variable UTM:[1-2]char	Geographic projection UTM: '1' Characteristic_of_projection UTM: zone[1-60]
#5	variable UTM: 6 char UTM: 7 char	Coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the geographic region, considered as rectangular. UTM: EASTING UTM: NORTHING
#6	variable UTM: 6 char UTM: 7 char	Coordinates, expressed in the projection specified in the **projection** field, of the upper right corner of the geographic region, considered as rectangular. UTM: EASTING UTM: NORTHING

Example of RDB identification file (using UTM projection)

```
0
Sudquec
Regional database of southern Quebec
1    19
290000        4999000
320000        5029000
```

WDB IDENTIFICATION FILE

WDB identification files identify watershed databases and will be found in the WDB directory. This type of files carries informations on the geographic projection and the characteristics of that projection and the geographic area that this database will cover.

FILE FORMAT OF WDB IDENTIFICATION FILE

Line	Format	Description
#1	1 char	Type of file: '0'
#2	[1-8]char	Name of the WDB database
#3	[1-8]char	Name of the RDB database from which the WDB will be derived
#4	[1-65]char	General comment on the database, for information purposes only
#5	1 char variable UTM:[1-2]char	Geographic projection UTM: '1' Characteristic_of_projection UTM: zone[1-60]
#6	variable UTM: 6 char UTM: 7 char	Coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the geographic region, considered as rectangular. UTM: EASTING UTM: NORTHING
#7	variable UTM: 6 char UTM: 7 char	Coordinates, expressed in the projection specified in the **projection** field, of the upper right corner of the geographic region, considered as rectangular. UTM: EASTING UTM: NORTHING
#8	variable UTM:[1-n]char	Grid size in the **x** direction Grid size in the **y** direction UTM: in meter

Example of an identification file (using UTM projection)

```
0
Clifton
Sudquec
Watershed database for Clifton basin
1    19
290000        4999000
320000        5029000
1000          1000
```

DATABASE FILE FORMAT

Database files (with any extension with the exception of "id") are any other files which can be found in the RDB or WDB directories. The terminology **database file format** is used to designate all files that are not **identification** files. A database file is constituted of two basic parts, the **header** and the **data**.

The header part is a block of 512 ASCII characters grouped in a variable number of fields, separated by "blanks", "tab" or "new line" characters, depending on the type of file. Those fields give informations which help in the interpretation the data part. Throughout this section, header formats will be presented as made out of a certain number or lines. This presentation is more practical than essential. The only restriction is that all the fields must be there, in the correct order, separated by "blanks", "tab" or "new line" characters with the exception of the **comment** field which must be alone on its line.

The data part is of variable size depending on the type of file and on other variables which will be explained later. Figure 1 gives a general representation of the database file format.

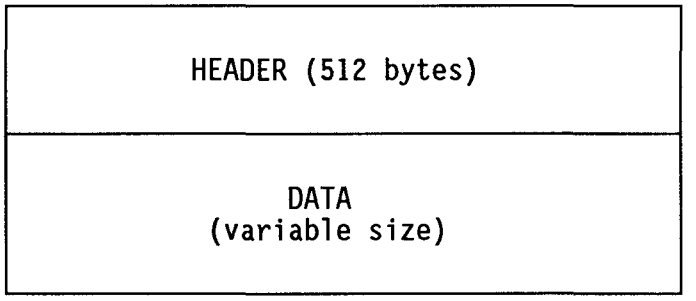

FIGURE 1. Database file format.

There is a total of 16 different types of database files which can be separated in two groups, those found in the RDB and the other found in the WDB.

REGIONAL DATABASE(RDB) FILE FORMAT

There are three different types of database file formats in the **REGIONAL DATABASE**. Those are **digital elevation model(DEM)** format and **land-use** format.

DEM FILE FORMAT

As stated above, this format is made out of two parts, the header and the data.

HEADER FORMAT FOR A DEM FILE

Line	Format	Description
#1	1 char	Type of file: '1'
#2	1 char	Geographic projection UTM: '1'
	variable	Characteristic_of_projection
	UTM:[1-2]char	UTM: zone[1-60]
#3	[1-n] char	Number of rows
	[1-n] char	Number of columns
#4	variable	Coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the upper left cell of the rectangular geographic region.
	UTM: 6 char	UTM: EASTING
	UTM: 7 char	UTM: NORTHING
	variable	Grid size in the **x** direction Grid size in the **y** direction
	UTM:[1-n]char	UTM: in meter
#5	[1-65]	Comment on the file

Example of header for a DEM file (using UTM projection)

```
1
1    19
30   30
290000    502800    1000    1000
Dem for database of southern Quebec
```

Data part format for a DEM file

The data part is a series of **two-byte integers** (type short in C language) starting at byte 512 (first byte is byte 0). The number of elements in the data part is the product of the **number of rows** times the **number of columns** which are read in the header. Each value represents the altitude, in meters of a cell. The values are entered from east to west and from north to south, so the first values is the elevation of the upper left cell and the last value is the elevation of the lower right cell.

LAND-USE FILE FORMAT

This format is used when land-use data are imported from IMATEL to the RDB.

HEADER FORMAT FOR LAND-USE FILE

Line	Format	Description
#1	1 char	Type of file: '7'
#2	1 char	Geographic projection UTM: '1'
	variable	Characteristic_of_projection
	UTM:[1-2]char	UTM: zone[1-60]
#3	[1-n] char	Number of rows
	[1-n] char	Number of columns
#4	variable	coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the upper left cell of the rectangular geographic region.
	UTM: 6 char	UTM: EASTING
	UTM: 7 char	UTM: NORTHING
	variable	Grid size in the **x** direction Grid size in the **y** direction
	UTM:[1-n]char	UTM: in meter
#5	[1-65] char	Comment on the file
#6	[1-7] char	Land-use theme 0
	.	.
	.	.
	[1-7] char	Land-use theme n, where n is between 0-15

Data part format for LAND-USE file

The data part is a series of **two-byte integers** (type short in C language) starting at byte 512 (first byte is byte 0). The number of elements in the data part is the product of the **number of rows** times the **number of columns** which are read in the header. The values are entered from east to west and from north to south, so the first values is the land-use class of the upper left cell and the last value is the land-use class of the lower

right cell. The value of a cell corresponds to the land-use class to which it belongs. This value corresponds to the rank of the land-use themes in the header. For example, if "land-use theme 0" is "water" then to all cells with value "0" is associated the class "water".

VECTOR FILE FORMAT

This format is used when you import ARC/INFO vector files (produced by ARC/INFO function UNGENERATE) into the RDB. Vector files are ASCII files, so you can look at them and even edit them with a standard text editor.

HEADER FORMAT FOR VECTOR FILE

Line	Format	Description
#1	1 char	Type of file: '8': LINES '9': POINTS
#2	1 char	Geographic projection UTM: '1'
	variable	Characteristic_of_projection
	UTM:[1-2]char	UTM: zone[1-60]
#3	[1-65] char	Comment on the file
#4	variable	Number of objects(LINES OR POINTS)

Example of header for VECTOR file (using UTM projection)

```
8
1    19
LINE VECTOR FILE WITH 4 OBJECTS
4
```

Data part format for VECTOR file

Depending on the type of files specified in the header (LINES OR POINTS) the data part will take different forms as described below.

Data part format for VECTOR files (LINES type)

In the case of a LINES file the following pattern will repeat itself as many times as there are objects specified in the header.

Format	Description
variable	LINE identifier (should be unique)
variable	Number of points defining the line
6 char	EASTING coordinates of first point of the line
7 char	NORTHING coordinates of first vertex of the line
.	.
.	.
6 char	EASTING coordinates of last point of the line
7 char	NORTHING coordinates of last point of the line

Example of data part for VECTOR file (LINES)

```
101  4
      299003    5013010
      300113    5020666
      310778    5015111
      315000    5020000

102  2
      298011    5002333
      312889    5012223
```

Data part format for VECTOR file (POINTS type)

In the case of a POINTS file the following pattern will repeat itself as many times as there are objects specified in the header.

Format	Description
variable	POINT identifier (should be unique)
6 char	EASTING coordinates of first point
7 char	NORTHING coordinates of first point
.	.
.	.
6 char	EASTING coordinates of last point
7 char	NORTHING coordinates of last point

Example of data part for VECTOR file (POINTS)

```
1      299003    5013010
12     300113    5020666
21     310778    5015111
35     315000    5020000
```

WATERSHED DATABASE (WDB) FILE FORMAT

There are 14 different types of file in the WDB from which 6 have the same format. Those files are basin **TOPOGRAPHY** (integrated DEM, slope and aspect), **NETWORK** and **SUB-BASIN** (definition and downstream links) files. The other eight which include **LAND-USE**, **HIGH VALUE**, **LOW VALUE**, **LOCAL PIT**, **DATABASE**, **OUTLET**, **FLAT AREA** and **DEPRESSION** files will be treated individually.

Step 2 - Go into file PHYSITEL.ENM to get code for that menu

Once you have the title of the menu where to insert your function, you have to find the related code associated with it. Use any text editor and load file PHYSITEL.ENM. Locate the menu of interest. Note that some menus are very much alike so be sure to get the right one. The code you are looking for is the string appearing on the line above the title of the menu. Note that the series of numbers does not belong to the code. For example, the code associated with the menu EXISTING REGIONAL DATABASE is "ruse".

Step 3 - Build file name using the code of step 2

To build the name of the file where you are going to add the code of your function, you add to the code the letter 'u' as in user, a number (1 or 2) to identify which user's defined function and the extension ".c" because the file is a C source file. The number you add is '1' if it is the first or only user's option in the menu and '2' if it is the second. With our example we have: "ruse + u + 1 + .c = ruseu1.c". One way to check that result is to verify if that file exists. If it does, go to step 4, if not, go back to step 2.

Step 4 - Insert function in file corresponding to the name built in step 3

You are now ready to program your own application. Use any text editor and load the file with the name you have built in step 3. In that file you will find the skeleton of your function. Depending on the context and the type of function, parameters (file name, dimension of matrix, etc.) might be passed to the function. Before calling the user function, PHYSITEL closes the menuing system and it is now to the user's function to take control. When finished with that function, return control to PHYSITEL, which resume.

IMPORTANT: it is the responsibility of the user (programmer) to:

- manage interaction with the user(get filename and others);
- open and close files;
- read and write header and content of files;
- handle upcoming errors.

Step 5 - Rebuild PHYSITEL

The last step consists in compiling the file(s) you have modify and link it (them) with the rest of PHYSITEL. If you followed step 1 to 4 and did not create other source files, this step is made easy with the use of a "MAKE description file" called PHYSITEL.MAK which comes with PHYSITEL 2.0. To use that file, you need the following tools: MICROSOFT C compiler version 6.0 along with a linker and the MICROSOFT program maintenance utility NMAKE. The NMAKE utility with the compiler, the linker and the description file will compile your file and link it with the rest of PHYSITEL. To do that, simply type "NMAKE PHYSITEL.MAK". If you are using version 5.0 or 5.1 with the program maintenance utility MAKE, minor changes have to be made to the file PHYSITEL.MAK. If you are familiar with the use of MAKE files, those changes should cause no problem. If not, contact us.

EXAMPLE OF INSERTION OF A USER'S DEFINED FUNCTION

Goal: implement another type of DEM filtering function. "FILTERING".

Step 1: Name of the menu is "FILTERING".

Step 2: Code for that menu is "wdmfil".

Step 3: File name is "wdmfil + u + 1 + .c = wdmfilu1.c". The name "wdmfilu2.c" would have been correct also because there are 2 user's options available in menu "FILTERING".

Step 4: Here, the user should look at the file "wdmfilu1.c" where there is an example of how to code a function for PHYSITEL. Note that there are two functions but only one file. If you want to spread your functions on two or more files, the file PHYSITEL.MAK would have to be modified.

Step 5: Run "NMAKE PHYSITEL.MAK".

TOPOGRAPHY, NETWORK AND SUB-BASIN FILE FORMAT

In order to describe the file format shared by those 6 file types, a representation of the header is given first, with the particularities for each type of file. The data part of each of those files is given individually.

HEADER PART FOR TOPOGRAPHY, NETWORK AND SUB-BASIN FILES

Line	Format	Description
#1	1 char	Type of file: '1': DEM '2': SLOPE '3': ASPECT '4': NETWORK '5': SUB_BASINS '6': DOWNSTREAM LINKS
#2	1 char	Geographic projection UTM: '1'
	variable	Characteristic_of_projection
	UTM:[1-2]char	UTM: zone[1-60]
#3	[1-n] char	Number of rows
	[1-n] char	Number of columns
#4	variable	Coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the upper left cell of the rectangular geographic region.
	UTM: 6 char	UTM: EASTING
	UTM: 7 char	UTM: NORTHING
	variable	Grid size in the **x** direction Grid size in the **y** direction
	UTM:[1-n]char	UTM: in meter
#5	[1-65] char	Comment on the file

Example of header for a DEM file (using UTM projection)

```
1
1    19
30   30
290000    502800    1000    1000
Dem for database of southern Quebec
```

Data part format for topography, network and sub-basin files

The format for the data part of these files is the same, but the interpretation of the values changes for each type. First a description of the format is given, then, for each type of file, the interpretation of those values is given.

The data part is a series of **two-byte integers** (type short in C language) starting at byte 512 (first byte is byte 0). The number of elements in the data part is the product of the **number of rows** times the **number of columns** which are read in the header. The values are entered from east to west and from north to south, so the first values refers to the upper left cell and the last value to the lower right cell.

DEM FILE

Each value corresponds to the altitude (m) of a cell.

SLOPE FILE

Each value corresponds to the slope (m/m * 1000) of a cell.

ASPECT FILE

Each aspect value is coded using the following convention:

0: FLAT;
1: EAST;
2: NORTHEAST;

3: NORTH;
4: NORTHWEST;
5: WEST;
6: SOUTHWEST;
7: SOUTH;
8: SOUTHEAST

NETWORK FILE

Each cell value is a number indicating the number of cells that this cell drains. This number is at least equal to one (1) because each cell drains at least itself and the maximum value is the number of grid cells within a watershed.

SUB-BASIN FILE

Each cell value is a number identifying to which sub-basin the cell belongs. When the area threshold is "1", each cell has a different value. Those numbers are arbitrary and signify that each cell with the same number belongs to the same sub-basin. They also give the order in which the sub-basins or cells will be evaluated in HYDROTEL. A value of "0" is reserved to cells that are outside the whole watershed, so outside any sub-basin.

DOWNSTREAM LINK

This file cannot be interpreted alone, you need the sub-basin file along with it to interpret it. Each cell value is a number identifying the sub-basin into which the sub-basin of that cell flows. For example, if the value read is "1", this would mean that the sub-basin to which this cell belong flows into sub-basin #1. Of course, all cells of a same sub-basin will have the same value. To see to which sub-basin the value "1" refers, one has to look at the sub-basin file and identify all cells with values equal to "1".

LAND-USE FILE FORMAT

The land-use file is an all ASCII file, header and data part, so it can be seen by most text editor. This file is the result of the integration of the land-use file of the RDB to the

resolution of the WDB. Since it is an all ASCII file, the header does not have to be 512 bytes.

HEADER PART FOR LAND-USE FILE

Line	Format	Description
#1	1 char	Type of file: '7'
#2	[1-n] char [1-n] char [1-2] char	Number of rows(NROW) Number of columns(NCOL) Number of classes(NCLAS) [1-16]
#3	[1-65] char	Comment on the file
#4	4 char 5 char [1-7] char . . [1-7] 5 char	String "EAST" String "NORTH" Theme 0 . . Theme NCLAS-1 String "TOTAL"

Example of header for land-use file

```
7
29   20   6
Land-use file for Clifton basin
EAST  NORTH  RESIN   FEUIL   EAU1  GRAVI   HERBE   TOTAL
```

Data part format for land-use files

Each line of the data part corresponds to one cell of the grid, so there must be NCOL x NROW lines in the data part. For each line the following information is present:

Format	Description
6 char	EASTING coordinates of the lower left corner of the cell
7 char	NORTHING coordinates of the lower left corner of the cell
[1-n] char . . [1-n] char	Number of pixels belonging to class 0 . . Number of pixels belonging to class NCLAS-1
[1-n] char	Total number of pixels for that cell

Example of data part for land-use file

```
300000   5028100    70   10    5    2    3   100
301000   5028100   100    0    0    0    0   100
302000   5028100    65    0   10   12   13   100
  :        :        :    :    :    :    :    :
```

The example can be interpreted as follows: for the cell having UTM coordinates EASTING:300000 and NORTHING:5028000, 70 pixels out of 100 belong to class "0" or from the header class RESIN, 10 pixels out of 100 belong to class "1" or "FEUIL", etc...

HIGH VALUE & LOW VALUE FILE FORMAT

High value and low value files are all ASCII files which can be visualized with most text editor. This also means that the header does not have a fixed size of 512 bytes. These files are produced when the task "REMOVAL OF LOCAL EXTREME VALUES" is run. As you probably have notice, those files are used after being output, so they are provided

only on an informational base. These files have the same format, only the type and the comment change.

HEADER FORMAT FOR HIGH VALUE & LOW VALUE FILES

Line	Format	Description
#1	3 char	Type of file: '101': HIGH_VALUE '102': LOW_VALUE
#2	[1-65]char	Comment identifying the file.
#3	variable	Comment identifying the columns of the data part.

Example of header for a high value file

```
101
List of high values
max#      row      col       alt
```

Example of header for low value file

```
102
List of low values
min#      row      col       alt
```

Data part format for high value and low value files

For each local maximum (high value) or local minimum (low value) there is a line writtin with the following format.

Format	Description
[1-n] char	Identification number of the extreme value
[1-n] char	Row index where the value was observed, index starts at '0'
[1-n] char	Column index where the value was observed, index starts at '0'
[1-n] char	Elevation (m) observed before correction

Example of data part for high value & low value files			
1	5	2	382
2	10	21	513
:	:	:	:

LOCAL PIT & OUTLET FILE FORMAT

Local pit and outlet files have a 512-byte header followed by the data part. A local pit file is produced when the task available through menu "LOCALISATION OF LOCAL PITS" is run. It is used as input file in menu "FLAT AREA OUTLETS". This file contains a list of the cells where the aspect is "flat" (code 0 in the aspect file). An outlet file is produced as a result of running the task available through menu "FLAT AREA OUTLETS".

HEADER FORMAT FOR LOCAL PIT & OUTLET FILES

Line	Format	Description
#1	3 char	Type of file: '103': local pit '105': outlet
#2	[1-65]char	Comment identifying the file.

Example of header for a local pit file
103 Local pits for Clifton basin

Example of header for an outlet file
105 Outlet file for Clifton basin

Data part format for local pit & outlet files

The data part is a series of triplets of 2-byte integers (type short), one triplet for each local pit found. The first two bytes(0 and 1) represent the row index of the cell, byte 2 and 3 represent the column index of the cell and finally the last two represent the elevation of that cell. Indices start at zero (0).

DATABASE FILE FORMAT

Here, the term DATABASE does not refer to the REGIONAL (RDB) or the WATERSHED DATABASE (WDB). A DATABASE FILE is a temporary FILE regrouping predefined informations (elevation, slope, aspect, ...) on a geographic region. This file is created in order to reduce the number of input file names that the user has to enter in the menu. It is composed of a 512-byte header and a data part which may vary in size.

HEADER PART FOR DATABASE FILES

Line	Format	Description
#1	3 char	Type of file: '104'
#2	1 char	Geographic projection UTM: '1'
	variable	Characteristic_of_projection
	UTM:[1-2]char	UTM: zone[1-60]
#3	[1-n] char	Number of rows
	[1-n] char	Number of columns
#4	variable	Coordinates, expressed in the projection specified in the **projection** field, of the lower left corner of the upper left cell of the rectangular geographic region.
	UTM: 6 char	UTM: EASTING
	UTM: 7 char	UTM: NORTHING
	variable	Grid size in the **x** direction Grid size in the **y** direction
	UTM:[1-n]char	UTM: (m)
#5	[1-65] char	Comment on the file

Example of header for a database file (using UTM projection)

```
104
1    19
26   26
290000    502800    1000    1000
Dem for database of southern Quebec
```

Data part format for database file

The data part is a series of two-byte integers (type short) starting at byte 512. Each cell of the grid has 5 integers values associated with it. Following is a representation of how those 5 integer are organized and how they can be interpreted.

Format	Description
2 bytes(short)	Indicator 0: cell outside the basin else: cell inside the basin Note: This is used only when determining basin network and mask of basin.
2 bytes(short)	Number of cells drained by a particular cell (see description of network file)
2 bytes(short)	Aspect of the cell (same interpretation as in aspect file)
2 bytes(short)	Slope of the cell (same interpretation as in slope file)
2 bytes(short)	Altitude of the cell (m)

FLAT AREA FILE FORMAT

A flat area file is an all ASCII file which can be visualized with most text editors. Since it is an all ASCII file, the header does not have to be of a fixed lenght. Description of the header and data part follows.

HEADER PART FOR FLAT AREA FILES

Line	Format	Description
#1	3 char	Type of file: '106'
#2	variable	Comment to help interpretation

Example of header for outlet
106 depr# pit# l_de c_de a_de l_NW c_NW l_SE c_SE

Data part format for flat area file

The data part is separated in a certain number of lines. Each line gives the characteristics of a depression and can be interpreted as follows:

Format	Description
[1-n] char	Depression number (depr#)
[1-n] char	Pit number (pit#): corresponds to the order of the pit in a local pit file. e.g.: '1' means that this depression will have the first pit present in local pit file as outlet.
[1-n] char	Line number of depression outlet(l_de)
[1-n] char	Column number of depression outlet(c_de)
[1-n] char	Altitude of depression outlet(a_de)
[1-n] char	Line index of upper left corner of depression area(l_NW)
[1-n] char	Column index of upper left corner of depression area(c_NW)
[1-n] char	Line index of lower right corner of depression area(l_SE)
[1-n] char	Column index of upper left corner of depression area(c_SE)

Note: all line and column indices start at 1.

Example of data part for an outlet file

1	1	3	17	317	3	17	3	17
2	2	19	26	472	19	26	19	26
3	3	24	18	509	23	17	24	18
4	5	23	24	518	23	24	24	24
:	:	:	:	:	:	:	:	:

DEPRESSION FILE FORMAT

A depression file is an all ASCII file which can be visualize with most text editors. Since its an all ASCII file, the header does not have to be of a fixed lenght. Description of the header and data part follows.

HEADER PART FOR DEPRESSION FILES

Line	Format	Description
#1	3 char	Type of file: '107'
#2	variable	Comment to help interpretation

Example of header for outlet

```
107
depr#   l_de   c_de   a_de   l_NW   c_NW   l_SE   c_SE
```

Data part format for a depression file

The data part is separated in a certain number of lines. Each line gives the characteristics of a depression and can be interpreted as follows:

Format	Description
[1-n] char	Depression number (depr#)
[1-n] char	Line number of depression outlet(l_de)
[1-n] char	Column number of depression outlet(c_de)
[1-n] char	Altitude of depression outlet(a_de)
[1-n] char	Line index of upper left corner of depression area(l_NW)
[1-n] char	Column index of upper left corner of depression area(c_NW)
[1-n] char	Line index of lower right corner of depression area(l_SE)
[1-n] char	Column index of upper left corner of depression area(c_SE)

Note: all line and column indices start at 1.

Example of data part for a depression file

1	3	17	317	1	17	13	26
2	19	26	472	13	21	22	26
3	24	18	509	17	14	25	21
4	23	24	518	21	21	26	26
:	:	:	:	:	:	:	:

APPENDIX B

DATA FILES

APPENDIX B

DATA FILES

The data files are structured in two parts, header and data. The header contains information related to the file and the simulation. The data section contains individual values for each time step on each cell of the grid or on each reach of the river. The file is in standard Ascii format, and can be read or modified with a text editor. The file is read in free format, so the only restriction is to separate each field by a blank character (space, tab or return).

Each field has a format specifier. Valid formats are: "char", "string", "line", "short", "long" and "float". The "char" format is the format to specify only one character in the data field. The "string" format refers to groups of characters, excluding blank characters. The "line" format refers to groups of strings, including blank characters, beginning after a "carriage return" and up to the next one. A "short" format is used to describe an integer coded over two bytes, giving a range of -32768 to 32767. "Long" format describe an integer coded over four bytes, giving a range of -2147483648 to 2147483647. Finally a "float" format is used to specify a real value coded over four bytes, giving a range of 1.17549e-38 to 3.40282e+38.

A filename is made up of four parts: the drive designator, the directory, the name and the extension. The name given to the file is arbitrary but HYDROTEL uses a convention: the name part of the filename corresponds to the name of the watershed and the extension to the type of data contained in the file. If you stick to the convention you will never have to enter a filename for data file.

TOPOGRAPHIC DATA

Topographic data files contain the time invariant variables describing the watershed. The data are related to two main data structures: a grid over the watershed and the reaches composing the drainage network of the watershed. We also use an

intermediate data structure to describe the reach ends. So we use three different types of files: one for the data on the grid, one for the data on the reaches and one for the data on the reach ends. **Homogeneous hydrological units (HHU's) are simply considered as aggregates of grid cells. To specify a characteristic of a HHU you must give a value to each of the grid cells.**

Grid data are spread over 7 files (*.MSK, *.ZON, *.ORI, *.REL, *.ALT and *.PTE) and two formats. The MSK extension is for the basin mask, each cell of the grid with a zero value is outside the basin. For cells within the basin, the value represents the order in which each cell is evaluated. The ZON extension is for the definition of the HHU mask, each cell of a HHU must have the same value and the value gives the order of evaluation of each HHU. The ALT extension is for an altitude data file. That file must contain mean altitudes for each cell of the grid; the altitude for a HHU is the mean of the mean altitude for the cells belonging to this HHU. The ORI extension is for an aspect data file. That file contains the aspect of each cell to eight points of the compass, identified 1 to 8 counterclockwise from East (East = 1). Aspect data files are not relevant for HHU's, we use REL data files containing for each cell of a HHU the id of the downstream HHU. The PTE extension is for slope data on each cell, the slope of a HHU is the mean of the slopes on the cells.

If the number of HHU's, as summed up by the program, is equal to the cells, this means that the simulation is made on cells.

File structure for *.ALT, *.MSK, *.ORI, *.PTE, *.REL and *.ZON:

Line	Format	Description
#1	short	File type (always 1);
#2	short short	Number of lines of the grid; Number of columns of the grid;
#3	long long short	Coordinate (x) of the upper left corner (UTM); Coordinate (y) of the upper left corner (UTM); Grid resolution (m);
#4	line	Comment describing the file;
for every cell of the grid:		
#5...	float	Value.

The cells are read beginning with the upper left cell to the lower right cell, line by line and from left to right.

The data related to the hydrographic network is split in two types of data, one on reaches and one on reach ends. The topology of the hydrographic network is determined by reach ends data. Each reach is specified by its ends, and two connected reaches have one common node. The hydrological behavior is determined by reach data and node data. Files with the extension NDS contains nodes or reach end data. Files with the extension TRO contain reach related data.

LAND-USE DATA

Land-use data are related to the grid data structure. The first file (*.CLA) describes the land-use of each grid cell. The other files characterize each land-use class. Some

characteristics of land-uses can vary over one year. The files Albedo.YY, hau_veg.YY, Pro_rac.YY and Ind_fol.YY contain discrete values taken on specific dates by the variable identified by the filename. The value for a particular day is interpolated linearly from the two nearest day available.

File structure for *.CLA:

Line	Format	Description
#1	short	File type (always 1);
#2	short short short	Number of lines of the grid; Number of columns of the grid; Number of classes;
#3	line	Land-use class identifier. Each column must be identified by a name. That name will be used in HYDROTEL to refer to the class in that column. You can use as many classes as you want. Classes can be combined in HYDROTEL;
for every cell of the grid:		
#4...	long	Easting coordinate of the lower left corner of the cell (UTM);
	long	Northing coordinate of the lower left corner of the cell (UTM);
for every classes:		
	short	Number of pixels belonging to that class;
	short	Total number of pixels for that cell.

The cells are read beginning with the upper left cell and ending with the lower right cell, line by line and from left to right, one cell per line.

Suggested codes and class identification*:

- "champ" bare fields;
- "herbe" crops and pasture 1;
- "paill" crops and pasture 2;
- "gravi" extracting areas;
- "resin" forested areas 1 (coniferous);
- "feuil" forested areas 2 (deciduous);
- "route" highways and other impervious areas;
- "eau1" surface waters 1;
- "eau2" surface waters 2;
- "urb" urban areas;
- "frich" waste lands and bushes;
- "mar" wet lands and marshes.

* Remember that classes may be aggregated by HYDROTEL into groups changing from sub-model to sub-model depending on their ability to differentiate between land-use classes. Also, any class code can be given to a land-use class.

So, it is only necessary to have a number of classes sufficient to fill the minimum requirements of the model.

APPENDIX C

USER'S DEFINED FUNCTIONS (HOW TO INSERT)

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USER'S DEFINED FUNCTIONS (HOW TO INSERT)

Before reading what follows it is suggested that you get familiar with PHYSITEL, its menus and the file formats described in appendix A. The goal of this section is to explain how to insert user's defined functions into PHYSITEL. If you have some experience on PHYSITEL, you have probably noticed that throughout the menuing system there are options which begin with the words "user's defined". These options provide a mean for the user to add easily new capabilities to PHYSITEL. In the next sections, a simple step by step method explaining how to insert new functions is given, followed by an example.

FIVE-STEPS METHOD TO INSERT USER'S DEFINED FUNCTION

Here are the logical steps that one should follow to insert his own function:

1. find menu where to insert function;
2. go into file PHYSITEL.ENM to get code for that menu;
3. build file name using the code of step 2;
4. insert function in file corresponding to the name built in step 3;
5. rebuild PHYSITEL.

Step 1 - Find menu where to insert function

This first step consist on running PHYSITEL and identifying the menu where he would like to add a new check task if there is a user's defined option and note the title of that menu. For example: if one wants to insert a new function to the tasks already available in the menu "EXISTING REGIONAL DATABASE" it is possible because there is a user's defined option. Then the user remembers the title (EXISTING REGIONAL DATABASE) and go to step 2.

Step 2 - Go into file PHYSITEL.ENM to get code for that menu

Once you have the title of the menu where to insert your function, you have to find the related code associated with it. Use any text editor and load file PHYSITEL.ENM. Locate the menu of interest. Note that some menus are very much alike so be sure to get the right one. The code you are looking for is the string appearing on the line above the title of the menu. Note that the series of numbers does not belong to the code. For example, the code associated with the menu EXISTING REGIONAL DATABASE is "ruse".

Step 3 - Build file name using the code of step 2

To build the name of the file where you are going to add the code of your function, you add to the code the letter 'u' as in user, a number (1 or 2) to identify which user's defined function and the extension ".c" because the file is a C source file. The number you add is '1' if it is the first or only user's option in the menu and '2' if it is the second. With our example we have: "ruse + u + 1 + .c = ruseu1.c". One way to check that result is to verify if that file exists. If it does, go to step 4, if not, go back to step 2.

Step 4 - Insert function in file corresponding to the name built in step 3

You are now ready to program your own application. Use any text editor and load the file with the name you have built in step 3. In that file you will find the skeleton of your function. Depending on the context and the type of function, parameters (file name, dimension of matrix, etc.) might be passed to the function. Before calling the user function, PHYSITEL closes the menuing system and it is now to the user's function to take control. When finished with that function, return control to PHYSITEL, which resume.

IMPORTANT: it is the responsibility of the user (programmer) to:

- manage interaction with the user(get filename and others);
- open and close files;
- read and write header and content of files;
- handle upcoming errors.

Step 5 - Rebuild PHYSITEL

The last step consists in compiling the file(s) you have modify and link it (them) with the rest of PHYSITEL. If you followed step 1 to 4 and did not create other source files, this step is made easy with the use of a "MAKE description file" called PHYSITEL.MAK which comes with PHYSITEL 2.0. To use that file, you need the following tools: MICROSOFT C compiler version 6.0 along with a linker and the MICROSOFT program maintenance utility NMAKE. The NMAKE utility with the compiler, the linker and the description file will compile your file and link it with the rest of PHYSITEL. To do that, simply type "NMAKE PHYSITEL.MAK". If you are using version 5.0 or 5.1 with the program maintenance utility MAKE, minor changes have to be made to the file PHYSITEL.MAK. If you are familiar with the use of MAKE files, those changes should cause no problem. If not, contact us.

EXAMPLE OF INSERTION OF A USER'S DEFINED FUNCTION

Goal: implement another type of DEM filtering function. "FILTERING".

Step 1: Name of the menu is "FILTERING".

Step 2: Code for that menu is "wdmfil".

Step 3: File name is "wdmfil + u + 1 + .c = wdmfilu1.c". The name "wdmfilu2.c" would have been correct also because there are 2 user's options available in menu "FILTERING".

Step 4: Here, the user should look at the file "wdmfilu1.c" where there is an example of how to code a function for PHYSITEL. Note that there are two functions but only one file. If you want to spread your functions on two or more files, the file PHYSITEL.MAK would have to be modified.

Step 5: Run "NMAKE PHYSITEL.MAK".