

An Overview of the Graphical User Interface .....	4
Data checking.....	4
Installation.....	6
System Requirements.....	6
Installation Disk .....	6
Uninstalling the HBMGUI .....	6
Preprocessor.....	7
DROP-DOWN MENU BAR.....	7
Write data .....	7
Open project.....	7
Access .....	8
Run.....	8
Exit.....	8
Help .....	8
Copy and Paste Functionality.....	8
STARTING THE GUI.....	9
GENERAL AND TIME PANE .....	10
Job ID: .....	10
Job Name: .....	10
Analysis type: .....	10
<i>Initialise moisture</i> .....	11
<i>Transient state</i> .....	11
Step increment .....	11
Duration .....	11
GEOMETRY PANE .....	12
Number of Rows.....	12
Number of Columns .....	13
Key points: x-coordinate & y-coordinate .....	13
<i>Apply</i> .....	13
Key Points, Node Numbers, Element Numbers & Material Properties .....	13
Element Assignment Table .....	13

MATERIAL PROPERTIES PANE .....	14
Add Set.....	14
Clear set .....	15
BOUNDARY CONDITIONS PANE.....	16
Hydraulic Sub-pane.....	16
<i>Type</i> .....	17
Mechanical Sub-pane.....	17
<i>Nodal fixities</i> .....	18
Filling & Infiltration Sub-pane .....	18
<i>Filling</i> .....	19
<i>Infiltration</i> .....	20
GRAPHICS OUTPUT PANE .....	21
Organic content & other element properties .....	21
Discharge locations .....	22
Moisture Content, VFA, MB, Settlement. ....	22
Days .....	22
NUMERICAL PANE.....	24
Running HBM Engine .....	25
Interrupting a simulation.....	25
Postprocessor .....	26
GENERAL STRUCTURE .....	27
Mouse functions .....	28
DROP-DOWN MENU BAR.....	29
File.....	29
Access .....	29
Exit.....	29
Help .....	29
HYDRAULIC PANE .....	30
Deformed Mesh & Flow Sub-pane .....	30
<i>Image controls</i> .....	30
<i>Other information</i> .....	31
Moisture Sub-pane .....	32

Boundary Flows Sub-pane (Lixflux) .....	33
BIODEGRADATION PANE .....	34
VFA Sub-pane .....	34
Methanogenic Biomass Sub-pane .....	35
Solid Degradable Fraction Sub-pane .....	36
MECHANICAL PANE .....	37
Settlement Sub-pane.....	37
Phase composition Sub-pane .....	38
Bulk Properties Sub-pane .....	39
NUMERICAL PANE.....	40

## An Overview of the Graphical User Interface

The Graphical User Interface (GUI) is a Windows© based environment in which to prepare, run, and interrogate simulations of landfill behaviour made using the Hydro-Bio-Mechanical (HBM) model or engine. The GUI comprises two main parts: the Preprocessor and the Postprocessor.

### **Preprocessor**

The preprocessor enables the all input data files to be prepared and written.

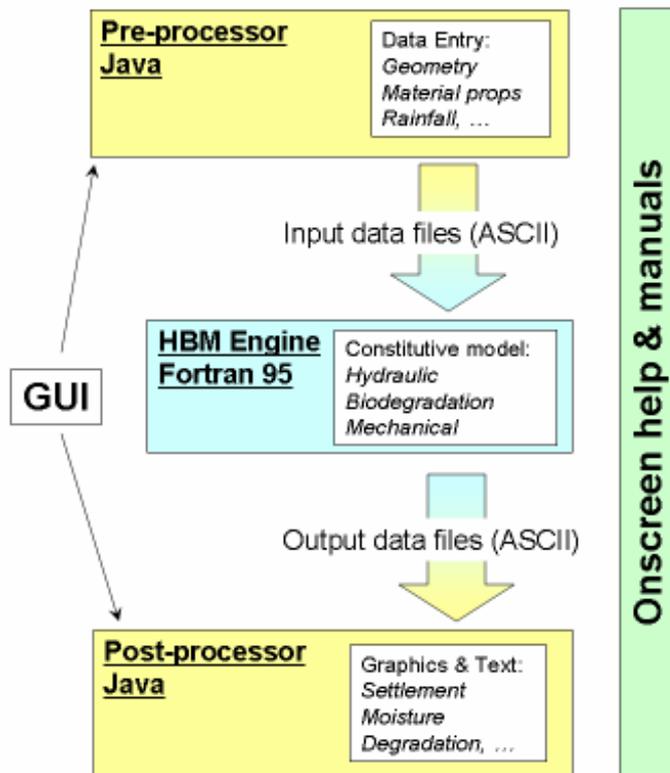
### **Postprocessor**

The postprocessor provides for the graphical interpretation of output data files.

The main engine is written in Fortran 95. It is the passing of data from the preprocessor, to the main engine and then to the postprocessor that dictates the nature of data file management. A schematic view of the data flows between the GUI and main engine is shown in Fig. 1.

### **Data checking**

The first objective in the development of the GUI has been to facilitate input data file preparation and output data interrogation. Neither data formatting nor verification checking is implemented in the GUI. **It is therefore important that users consider the use of any parameter values given in the Theory or Examples Manual.**



Data flow and management between HBM model & GUI

## Installation

### System Requirements

To install and run the GUI and HBM model successfully, your system must meet the following specifications:

- 140MB of hard drive space
- Windows 98, 2000, NT or XP operating system

### Installation Disk

The HBMGUI software is contained within an installation executable called 'HBMGUI with JRE.msi'.

To install the HBMGUI to your local hard drive, insert the installation CD in your computer. Double click the 'Install' file. You should see the following set-up screen. Follow the on-screen instructions.

A shortcut to HBMGUI.exe is placed on your desktop. It is recommended that you use this shortcut rather than running the GUI from its installation directory, as this will avoid any contact with (and possible alteration of) the file structure of the GUI program.

### Uninstalling the HBMGUI

To uninstall the HBMGUI, click on the 'Start' button of the Windows© desktop. Select 'Control Panel' from the menu, then click on 'Add or Remove Programs'. Once the list is populated, click on 'HBMGUI' and then click on 'Remove'.

## Preprocessor

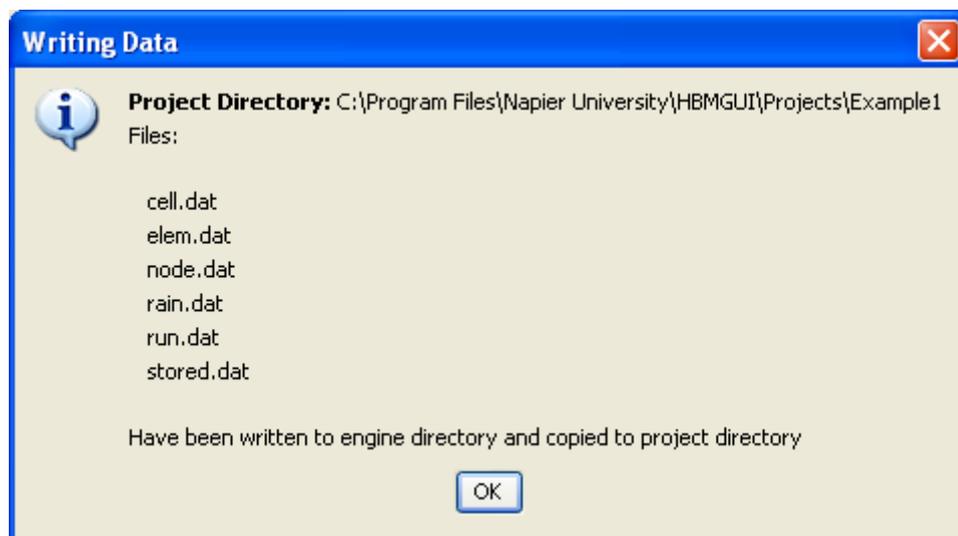
The preprocessor is structured to reflect the model-building process with six tabbed main panes and three tabbed sub-panes.

Commands for data transfer, software operation and help are located on the drop-down menu bar and accessible from any location in the preprocessor.

### DROP-DOWN MENU BAR

#### Write data

Writes all data currently in preprocessor storage to HBM input data files. Input data files are ASCII type with specified data format and sequence. A dialog box confirms the write operation.



#### Open project

Allows you to switch to a different project directory without exiting the pre-processor.

## Access

On entry to the preprocessor, access level is set to basic. In this mode all but two material property parameters are greyed out.

Advanced access is obtained by clicking on advanced. In this mode all material properties and other parameters are accessible.

## Run

There are two options here,

- Engine to run the HBM engine, or
- Postprocessor to start the postprocessor.

## Exit

Allows controlled exit from either preprocessor and postprocessor, depending on where you are.

## Help

Provides on-screen access to the three help documents, the Theory Manual, Graphical User Interface Manual and Examples Manual. Help is provided via web-style documents with context-active sub-menus and hyperlink contents.

## Copy and Paste Functionality

The tables in the pre-processor have similar functionality to spreadsheets in applications such as MS Excel®. By right-clicking on a table, a pop-up menu will appear with these options:

- Copy: Copies the contents of the selected cells
- Paste Paste the contents of the clipboard to the selected cells. This function applies to data copied in from other applications, such as MS Excel® or Notepad®.

## STARTING THE GUI

To start the GUI:

- ✦ Click on the '*HBMGUI*' desktop icon.

A splash screen appears,

- ✦ Click on '*ENTER HBMGUI*'.

A file chooser dialog box appears,

- ✦ Open either,
  - an existing project directory, or
  - a new project directory name by entering your own project directory name, or
  - leave project directory name blank, in which case it will be assigned the default name *NEW#* where # is the lowest available integer.

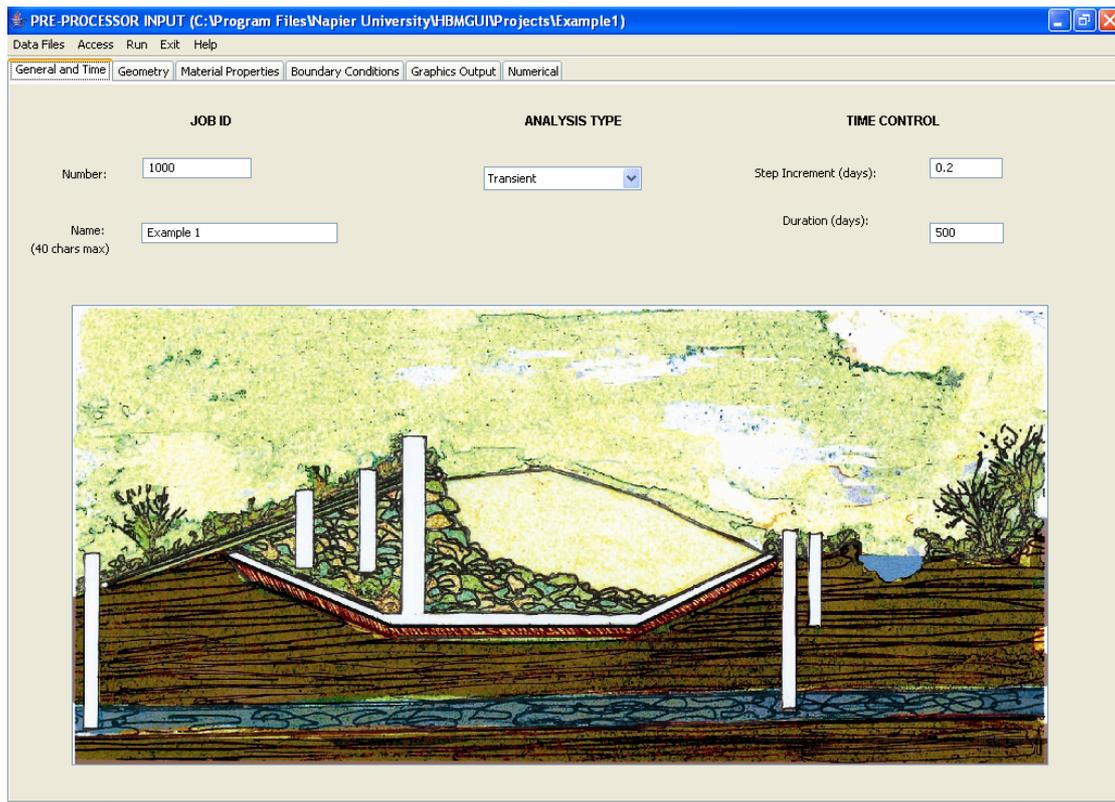
A dialog box appears, confirming the project directory and that the initial data has been opened,

- ✦ Click '*OK*'.

Entry to the preprocessor is at the *General & Time* pane. If an existing project is selected then all relevant input fields should be filled. If a new project directory is selected then input fields will be blank.

## GENERAL AND TIME PANE

For reference information, analysis type, time step increment and duration data.



### Job ID:

A job number reference, which has no significance in the analysis.

### Job Name:

A job text string reference, which has no significance in the analysis.

### Analysis type:

Either Initialise Moisture or Transient Analysis

### ***Initialise moisture***

Controls the HBM engine to determine steady state hydraulic pressure head data for the defined hydraulic boundary conditions.

An initial moisture analysis is a steady state solution of the hydraulic model. Biodegradation and mechanical input data are not used. However, default biodegradation and mechanical material properties data must be present in order that data input can be correctly handled.

### ***Transient state***

Sets the HBM engine to a transient analysis. Relevant hydraulic, biodegradation and mechanical input data are required.

### **Step increment**

The magnitude of the time step by which the analysis advances

### **Duration**

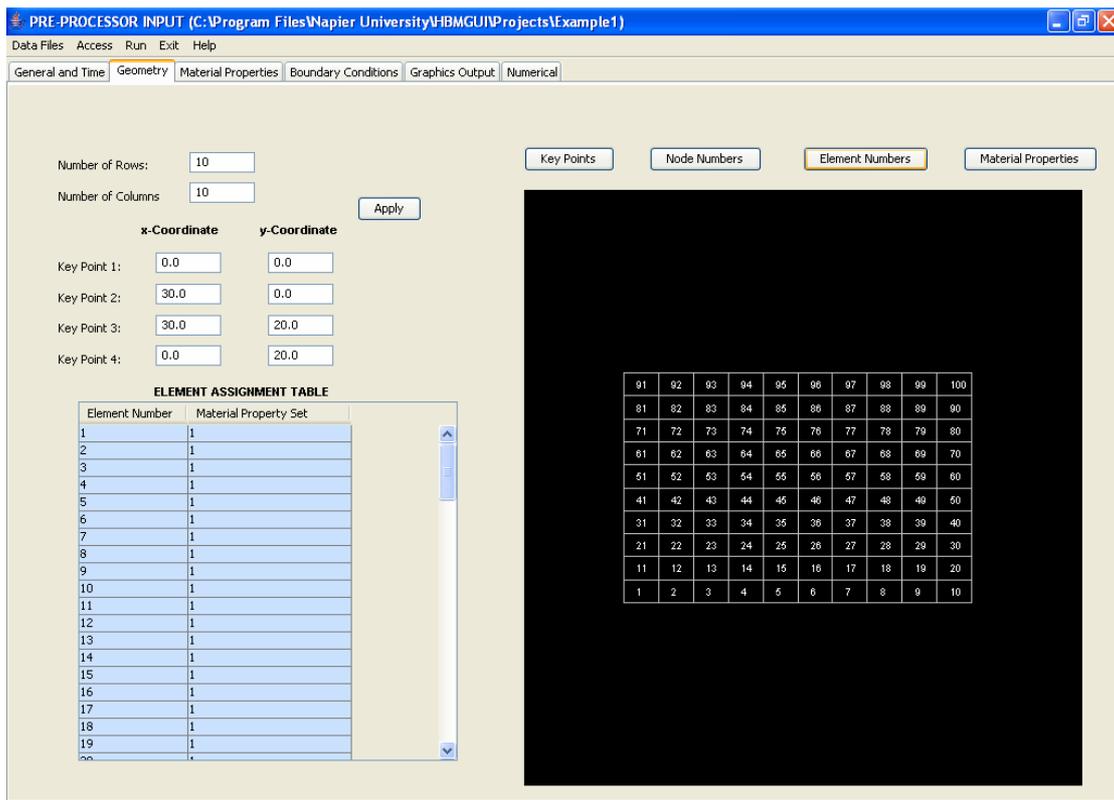
The period over which the simulation is performed

## GEOMETRY PANE

For mesh building and assignment of material property sets.

The preprocessor contains a simple mesh generation facility capable of creating quadrilateral meshes of up to approximately 200 uniformly distributed elements. Mesh domains are defined by the number of element rows, number of element columns and the coordinates of the four corners of the domain (keypoints).

More refined meshes, as might be created using commercial mesh generators, can be readily handled by the HBM engine providing data input requirements are clearly understood and correctly configured.



### Number of Rows

Sets the number of rows in the mesh.

### **Number of Columns**

Sets the number of columns in the mesh.

### **Key points: x-coordinate & y-coordinate**

Sets the coordinates of the four corner keypoints of the domain mesh.

### ***Apply***

Click on the apply button to update the mesh data. The mesh is displayed in the graphics pane on the right.

### **Key Points, Node Numbers, Element Numbers & Material Properties**

Sets the mesh annotation in the viewing pane.

### **Element Assignment Table**

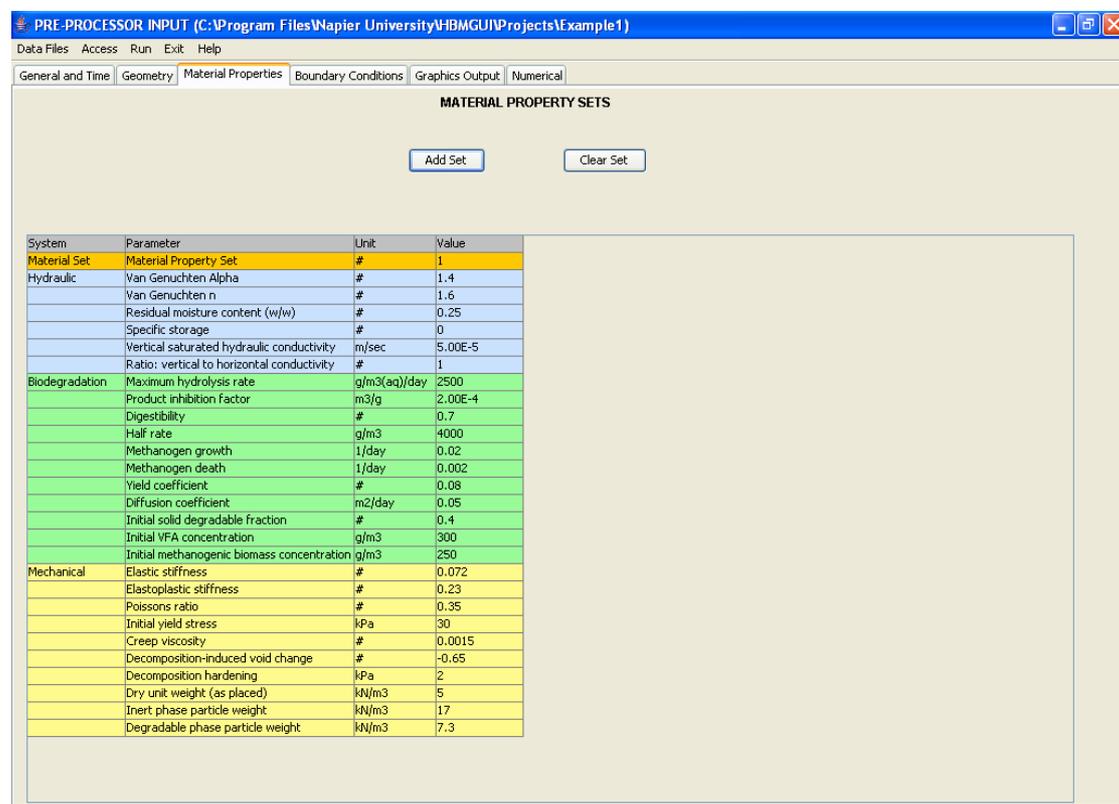
Dimensioned and activated once mesh domain is defined. The table is automatically populated with element numbers in left column and default material property set (default = 1) in right column. Table is then used to assign material property set numbers as required. Material property sets are defined in the Material Properties pane.

## MATERIAL PROPERTIES PANE

The material property table is an editable table in which material properties and initial conditions are defined.

The table is divided into three main sections, each corresponding to the three main system models – hydraulic, biodegradation and mechanical.

On entry to a new project the material property table is empty of sets.



### Add Set

On clicking on Add Set, a dialog box appears. Select from three material property set options:

- Biodegradable
- Inert
- Blank

A material property set appears with the lowest available set number (in the topmost row). Material property values are provided for specimen biodegradable and inert materials. It is advisable however to consider the *Solid Degradable Fraction* and *Dry Unit Weight*. These are the only properties that are editable under *Basic Users* option. Changes to other material property values can be made under the *Advanced* option. The default values of material property sets are given in Appendix 1 of the Examples Manual. Further information on the nature of the material property parameters is given in the Theory Manual.

**Clear set**

Click to remove material property set. A dialog box appears with radio buttons for each of the currently defined material property sets. Select the set you wish to delete.

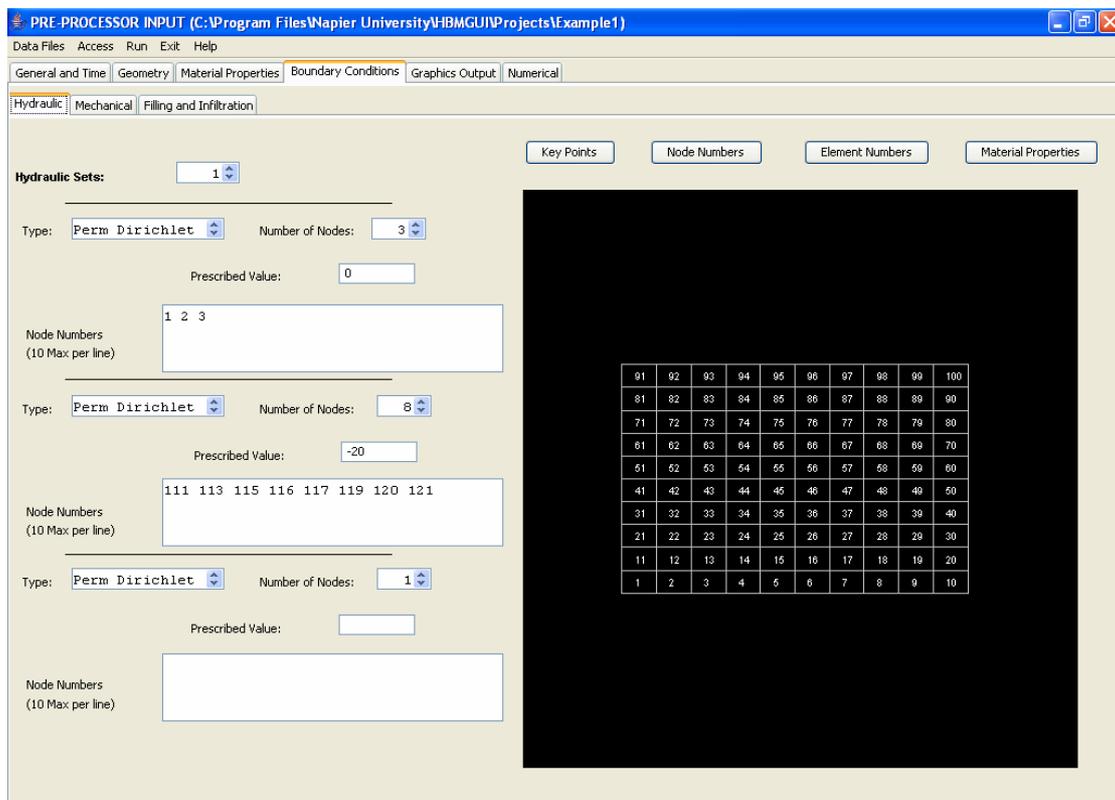
## BOUNDARY CONDITIONS PANE

Comprises three sub-panes for Hydraulic, Mechanical, and Filling & Infiltration boundary conditions. Mesh viewing pane is present; mesh annotation switches for node numbers and element numbers are active.

### Hydraulic Sub-pane

Controls the hydraulic regime. Accommodates up to three sets of hydraulic boundary conditions. Each set comprises four parts:

- boundary condition type (either permanent Dirichlet, temporary Dirichlet or Neumann)
- number of nodes to which the conditions apply,
- prescribed value of the boundary condition and
- node numbers.



**Type***Permanent Dirichlet [units = metres]*

Sets a prescribed pressure head value at a specified node. Value may be either positive (saturated, below the phreatic surface) or negative (unsaturated, above the phreatic surface), and is usually permanently active, i.e. throughout the duration of a simulation. However, this is not the case if the element is question treated as a sump; in this case, the zero pressure head is activated by the HBM engine but only when local nodal pressure heads are non-negative.

*Temporary Dirichlet*

Not currently used

*Neumann condition*

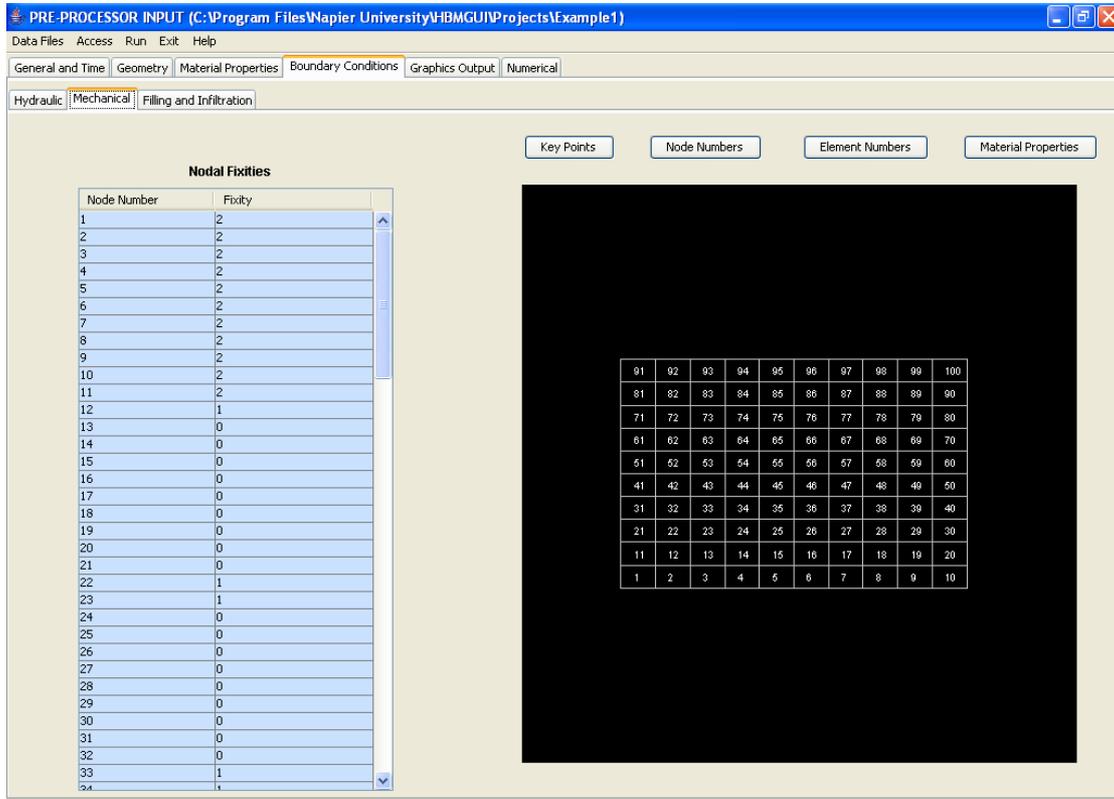
Neumann conditions specify a flux. The operation of this boundary condition is signalled here but the volume flux is defined on specified days in the infiltration table. The prescribed value field is not acted upon in the case of the Neumann condition. That said do not leave this field blank or a run-time error will occur.

*Dirichlet pairs*

Not currently used

**Mechanical Sub-pane**

Controls mesh fixities by assigning codes to individual nodes.



### Nodal fixities

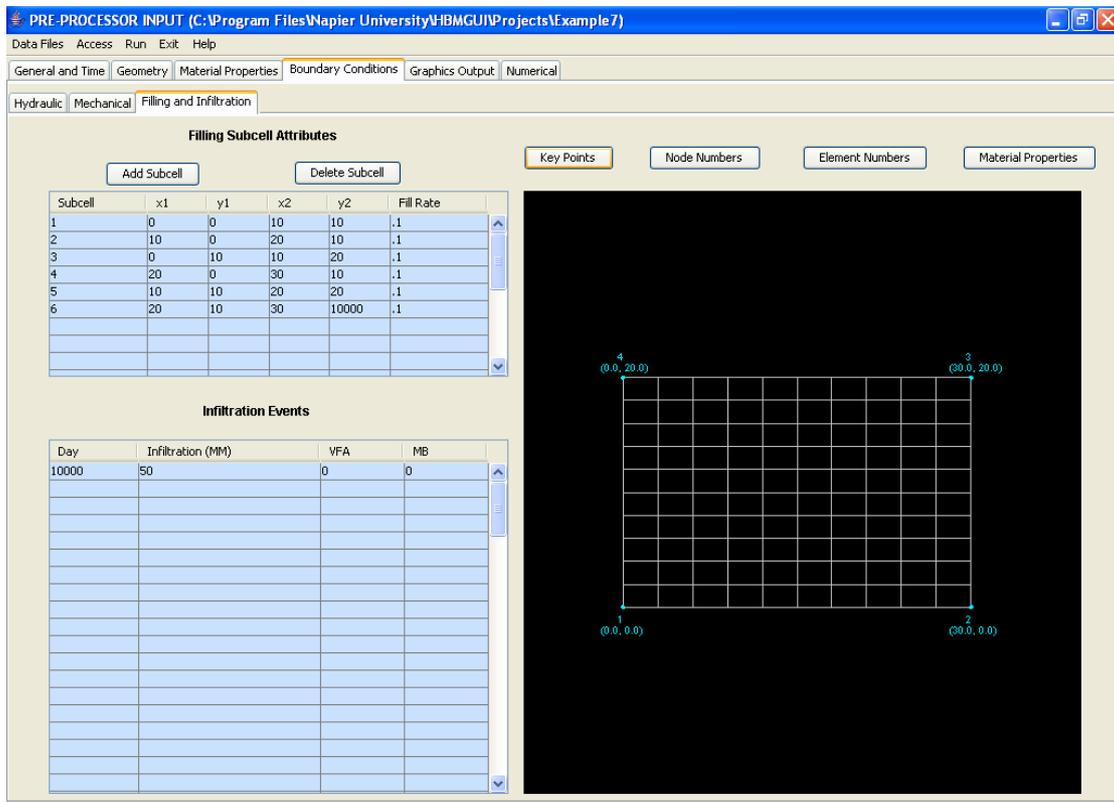
The table is dimensioned and activated after the problem geometry is defined. It is automatically populated with node numbers in left column and a default value of 0 (0 = no fixity) in right column. Table may be edited (using copy and paste functions) to assign fixities.

Nodal fixity codes are:

- 0 = no fixity
- 1 = x fixity
- 2 = x & y fixity

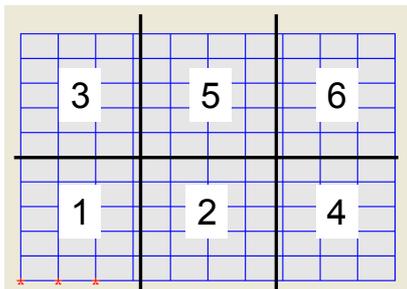
### Filling & Infiltration Sub-pane

Controls simulation of infilling and rainfall/recirculation.



### Filling

Problem domain is divided into a number of sub-cells, the sequence of which, as listed in the *Filling Sub-cell* table defines the domain filling pattern.



Click on *Add Sub-cell* to create the required number of sub-cells. Even if infilling is not simulated it is necessary to define a dummy cell in order to avoid end of file errors in the HBM engine.

Each sub-cell is identified by its bottom left and upper right corner coordinates.

The fill rate [in m/day] determines rate at which fill level rises within any sub-cell.

The fill rate can be thought of as a notional level that rises from the base of a sub-cell (defined by bottom left y coordinate value) to the upper surface (upper right y coordinate value). As the notional fill level rises, its position is compared to the centroidal elevation of each undisclosed element located between the left sub-cell boundary (bottom left x coordinate value less a small tolerance) and the right sub-cell boundary (upper right x coordinate value plus a small tolerance). When the fill level passes the centroidal elevation of an undisclosed element, the element is disclosed. When the fill level reaches the elevation of the current sub-cell's upper surface the reference for the notional level shifts to the base of the next cell in the list.

Undisclosed elements are present but temporarily assigned the set number 9. The properties of set number 9 - a very low hydraulic conductivity ( $10^{-15}$  m/s), zero hydrolysis rate, zero methanogen growth and decay rates and low diffusion coefficient - means they do not have any effective participation in the hydraulic, biodegradation and mechanical behaviour of the problem domain. Disclosure means that the original user defined material properties are restored.

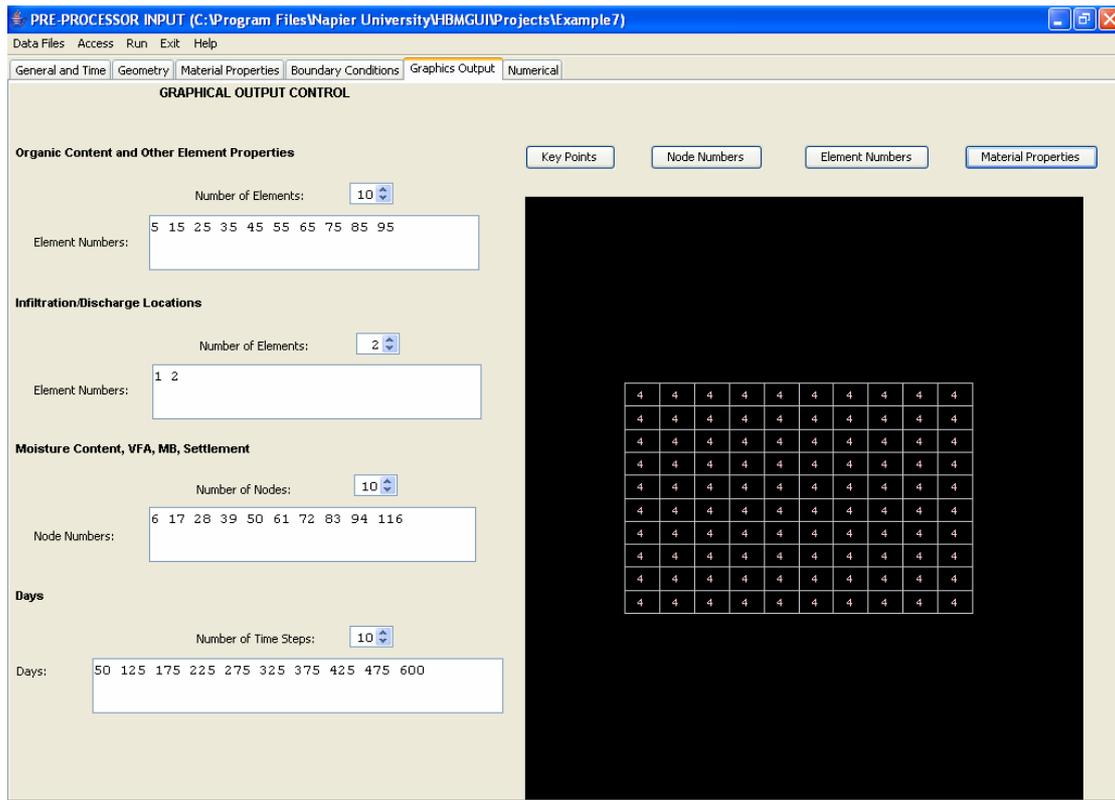
### ***Infiltration***

Defines incident climatic conditions/recirculation/raw water addition as a daily infiltration rate.

*Infiltration Events* are defined within the table by the day of occurrence, the daily rate [mm/day], and liquid characteristics given as VFA and methanogenic biomass contents [g/m<sup>3</sup>]. There are about ninety rows, hence ninety infiltration events can be specified.

## GRAPHICS OUTPUT PANE

Defines locations and times at which to extract output data for use in the postprocessor. Output data is of four main types.



### Organic content & other element properties

Defines elements for which the HBM model outputs time series data on organic content [kg/m<sup>3</sup>], and profile data on unit weights and saturated hydraulic conductivity.

*Number of elements:*

Number (max = 10) of elements to be entered here.

*Element numbers:*

Elements for which data is required. To be entered on single line. Box will scroll if required.

## **Discharge locations**

Defines elements at which the hydraulic model monitors discharge flow vectors.

It is not necessary to define upper surface nodes for the purposes of infiltration monitoring. The existence of Neumann conditions automatically activates element flux monitoring. During filling, Neumann conditions are automatically assigned to the upper nodes of newly disclosed elements; these conditions are removed by the placement of an overlying element.

Flux rates and cumulative quantities are assembled and presented as time series by *Lixflux*.

*Number of elements:*

Number (max = 10) of elements to be entered here.

*Element numbers:*

Elements for which data is required. To be entered on single line. Box will scroll if required.

## **Moisture Content, VFA, MB, Settlement.**

Defines nodes for which the HBM model outputs profile data on moisture contents (residual, actual and saturate) and time series data on VFA, MB and Settlement.

*Number of nodes:*

Number (max = 10) of nodes to be entered here.

*Node numbers:*

Nodes for which data is required. To be entered on single line. Box will scroll if required.

## **Days**

Defines the days at which the *Deformed Mesh & Flow Vectors* diagrams and *Moisture* profiles are taken.

*Number of days:*

Number (max = 12) of days to be entered here.

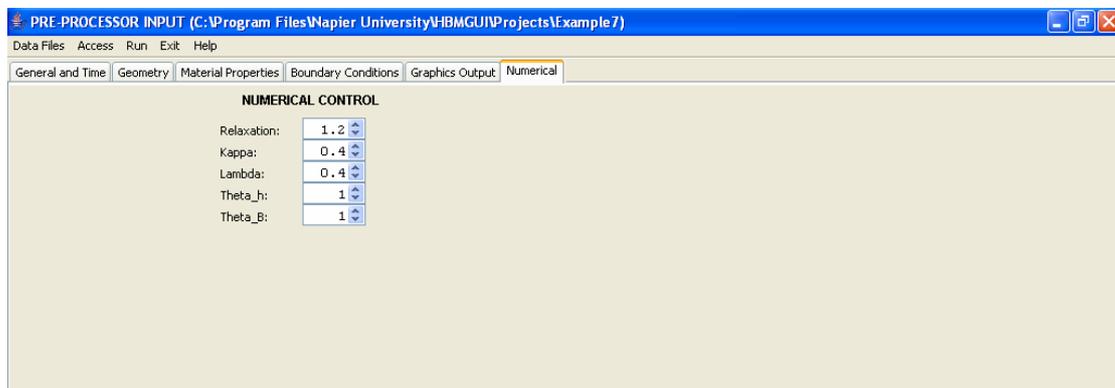
*Days:*

Days for which data is required. To be entered on single line. Box will scroll if required.

## NUMERICAL PANE

Sets the iterative solver control parameters:

- Over-relaxation parameter,  $\omega$
- Time step predictor,  $\kappa$
- Time step corrector,  $\lambda$
- Time stepping recursion parameter,  $\theta_h$
- Time stepping recursion parameter,  $\theta_b$



Default values of these parameters, drawn from many sensitivity analyses, are provided. Control of some solutions may be improved by changes in these parameters but this should not be attempted without some knowledge of their form and influence.

Parameter	Value
$\Omega$	1.2
$\kappa$	0.4
$\lambda$	0.4
$\theta_h$	1
$\theta_b$	1

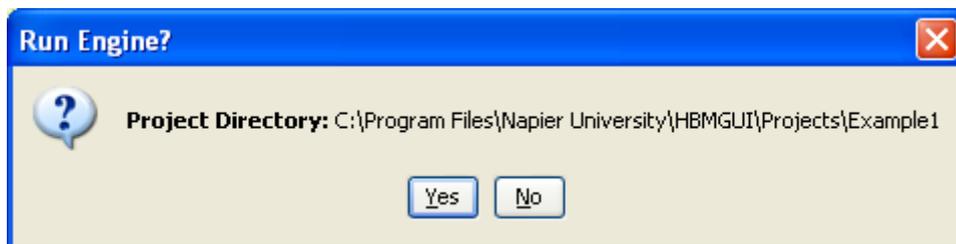
## Running HBM Engine

**At this stage any model must be saved and HBM input data files created by clicking on WRITE DATA**

From the drop-down menu,

- ✦ Click on *Run* then
- ✦ Click on *Run Engine*.

A confirmation dialog box appears.



After confirmation, a DOS window appears. Run-time information, reflecting the activity of the solution process, is sent to the DOS window. A run-time error will result in an error message to the screen or the runtime information hanging.

On completion of a simulation the DOS window closes and control is returned to the GUI.

### Interrupting a simulation

A simulation can be interrupted using DOS commands:

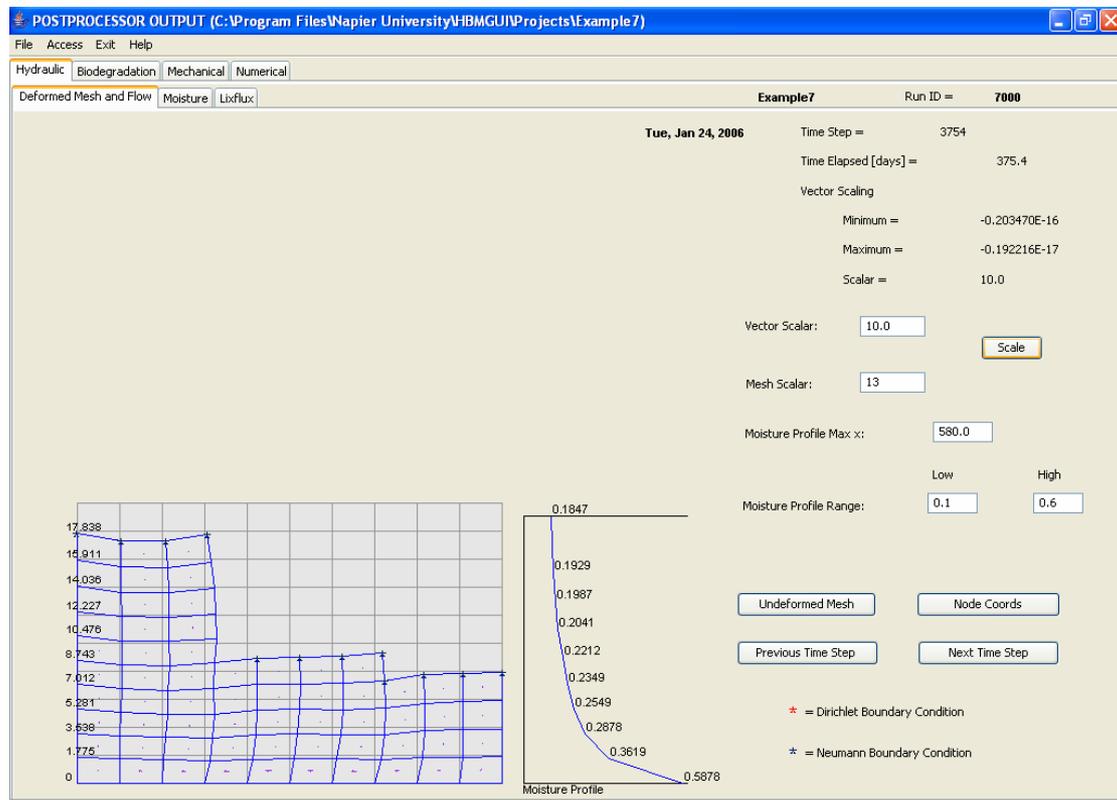
- <Ctrl + C> = cancel
- <Ctrl + S> = stop
- |<Ctrl + Q> = continue

## Postprocessor

From the drop-down menu,

- ✦ Click on *Run* then
- ✦ *Postprocessor*

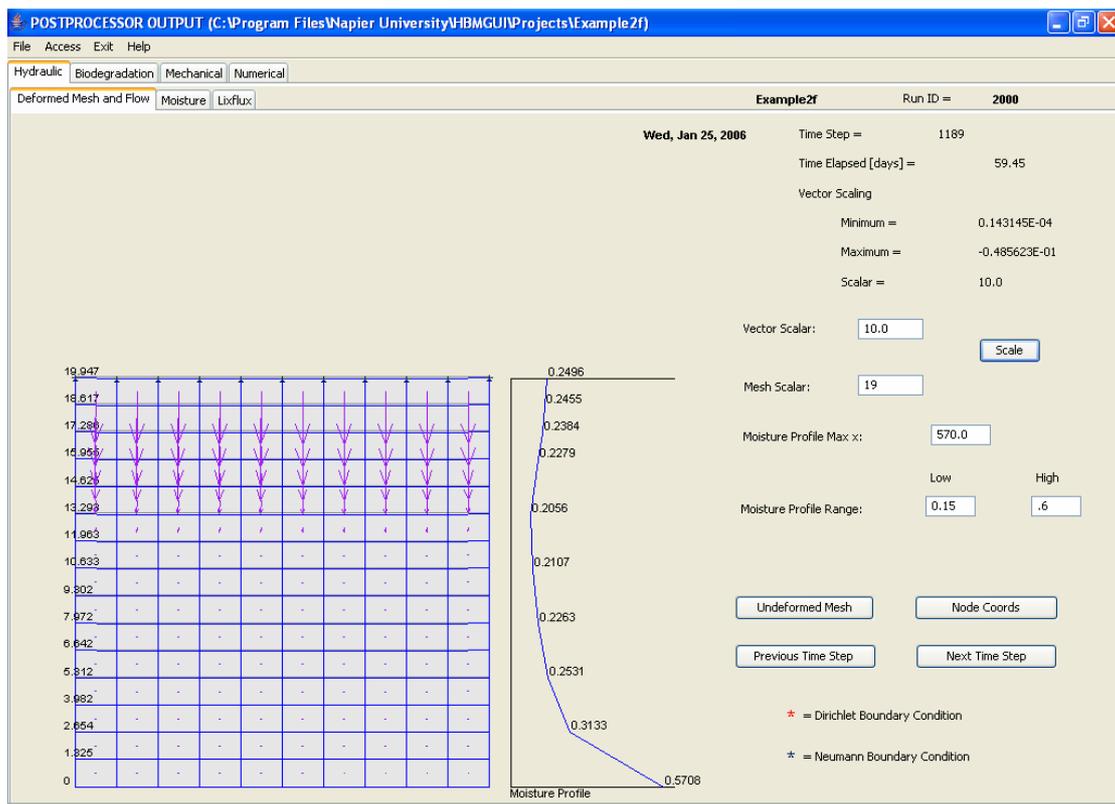
Entry to the postprocessor is at the *Deformed Mesh & Flow* sub-pane of the *Hydraulics* main pane.



## GENERAL STRUCTURE

There are four main panes corresponding to the three systems - hydraulic, biodegradation and mechanical - plus one for diagnosis of the numerical performance of the simulation.

Various graphical output routines are contained on sub-panes. Nodes and elements to which output data refer are those nodes and elements specified in the graphics output control pane of the preprocessor. In any one run, only data for specified nodes and elements are available to the postprocessor. Other nodal and element data can be obtained by running the simulation for different nodal and element data.



## Mouse functions

A number of graphical manipulation routines are accessible in the graph panes of the postprocessor: By right-clicking on the graph a context menu appears with the following options:

- *Properties...*
  - Title* - options to format the chart title.
  - Plot* – options to re-label axes, re-set ranges.
  - Other* – to repaint background/chart surrounds.
- *Save As...* to save the chart as a .PNG image.
- *Print...* to set print preferences and print the chart.
- *Zoom-in/Zoom-out* ► to rescale the plots with the zoom based on rescaling both, the vertical or the horizontal axes.
- *Auto-range* ► resets the chart to display the plots with optimum range-scaling and zoom.

It is also possible to click and drag on any part of a graphics display pane to zoom in on that area.

## **DROP-DOWN MENU BAR**

### **File**

- *Save Screen Image*: allows the graphics pane (without tabs) to be saved as jpeg file.
- *Print Screen Image*: Prints the graphics pane.

### **Access**

Defaults to *Basic*.

Advanced setting allows access sub-panes that are currently under development.

### **Exit**

Allows controlled exit from postprocessor. Return is to the point of departure in the preprocessor.

### **Help**

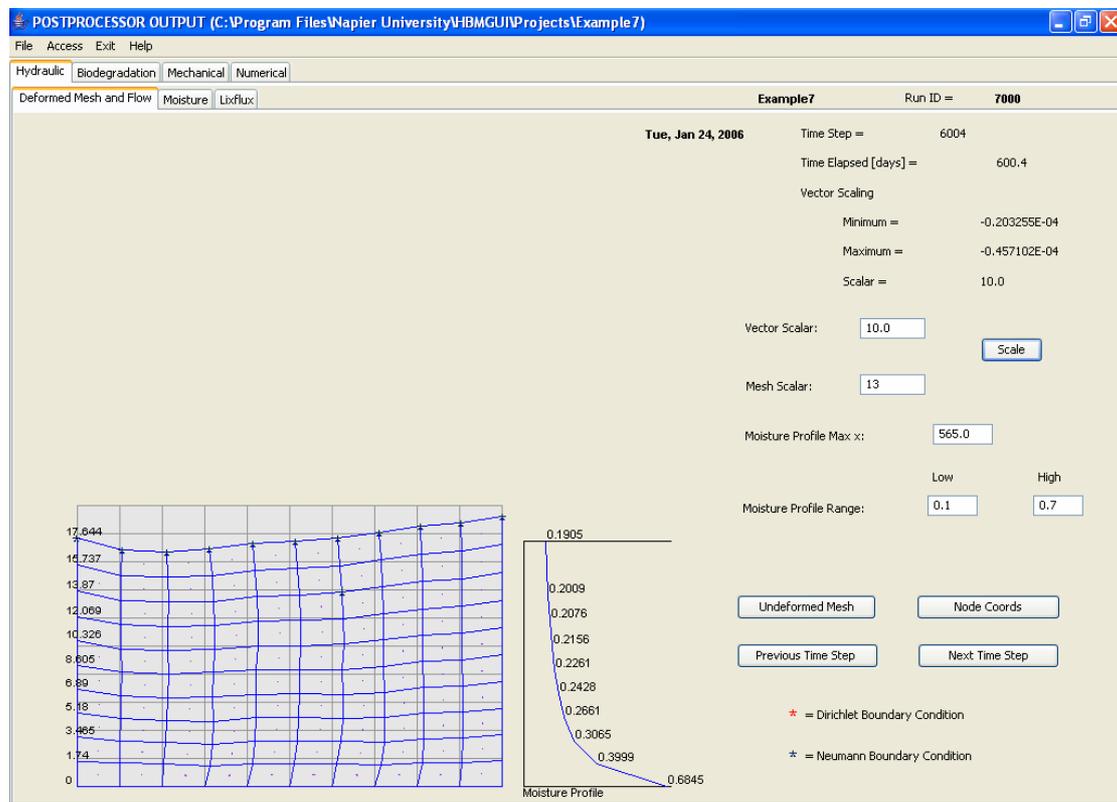
Provides on-screen access to the three help documents: the Theory Manual, Graphical User Interface Manual and Examples Manual. Help is provided via web-style documents with context-active sub-menus and hyperlink contents.

## HYDRAULIC PANE

Comprises three sub-panes: Deformed Mesh & Flow, Moisture and Lixflux.

### Deformed Mesh & Flow Sub-pane

Shows finite element mesh with flow vectors alongside moisture profile for the nodes specified in *Graphics Output Control*.



### Image controls

Image can be adjusted using the following controls:

- *Vector scalar* – to rescale flow vectors. Default is 10.0
- *Mesh scalar* – to rescale problem domain. Default is based on width of mesh.

- 
- *Moisture profile max x* – fixes the right edge of the moisture profile plot in the sub-pane. Default is 460.
  - *Moisture Profile Range, Low & High* – to rescale the horizontal axis of the moisture profile plot. Defaults are 0.0 and 1.0
  - *Undeformed mesh* button – toggle on and off
  - *Node coordinates* – toggle on and off the left edge nodal elevation coordinates
  - *Next Time Step* – advances to next time-step image in sub-pane
  - *Previous Time Step* – restores previous time-step image in sub-pane

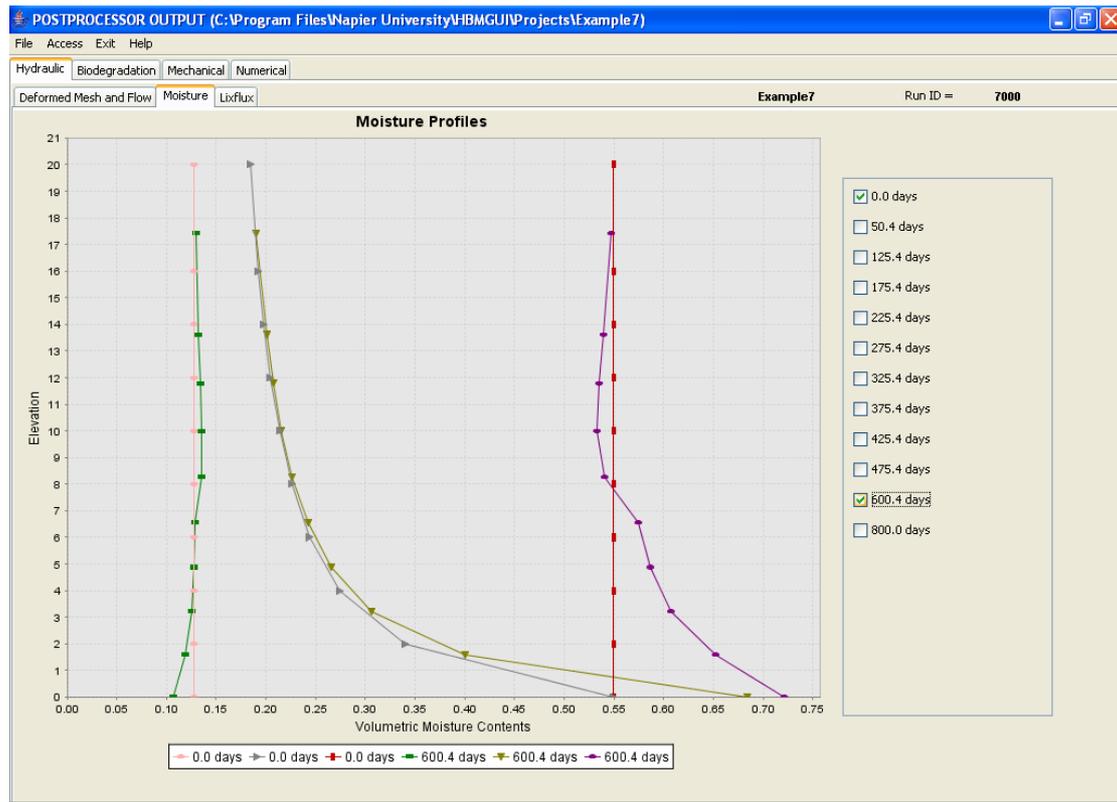
### ***Other information***

Apart from date and job ID information, the Deformed Mesh and Flow pane reports:

- *Current time step*
- *Time elapsed [days]*
- *Vector flow rates, maximum & minimum* – data here shows the maximum and minimum flow rates obtained from the vector moduli [in m/day].
- *Dirichlet & Neumann boundary conditions* – mesh annotation for nodes at which conditions are active.

## Moisture Sub-pane

Shows three volumetric moisture content profiles – residual, actual & saturated for any combination of days, selected by tick boxes to the right of the viewing pane.

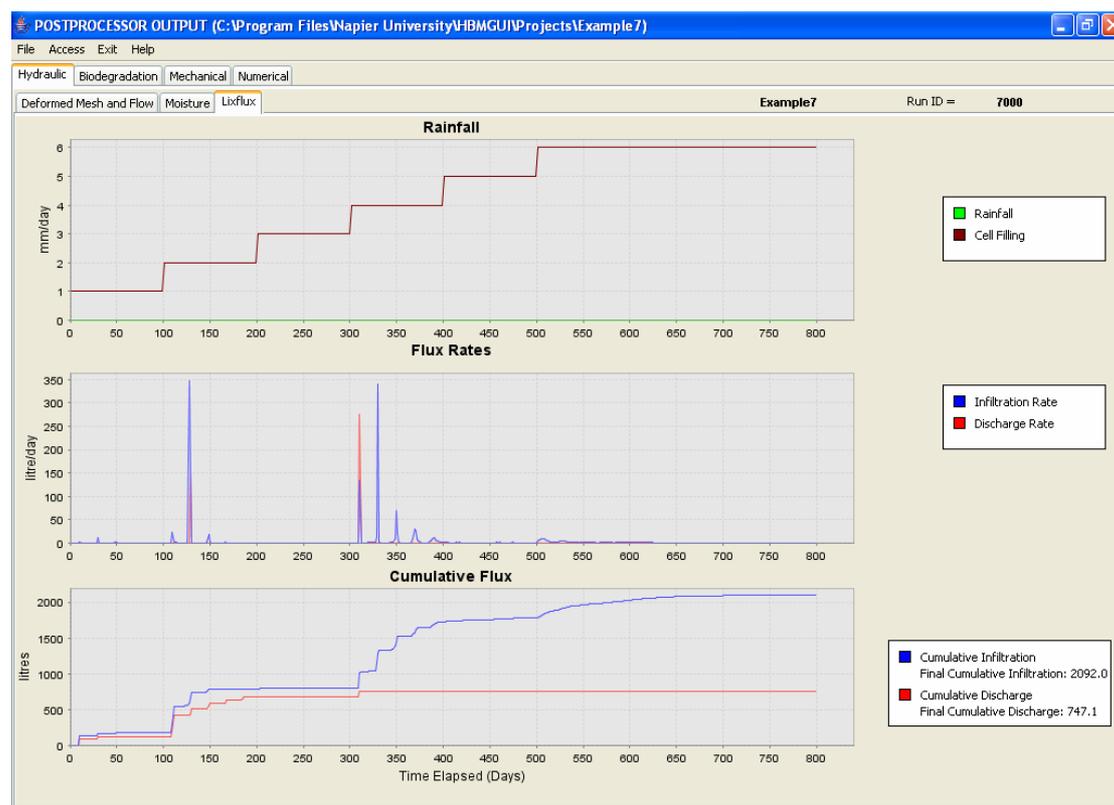


## Boundary Flows Sub-pane (Lixflux)

Contains three distinct time series plot panes:

- Rainfall & cell filling
- Flux rates – both infiltration and discharge
- Cumulative flux – both infiltration and discharge. Final cumulative infiltration and discharge values are reported in the plot legend.

Discharge fluxes are calculated from vector flow components in the specified element(s). Infiltration fluxes are calculated from vector flow components in infiltration elements. In the case of a fixed mesh, infiltration elements are defined by the user. When filling is simulated, the HBM model automatically defines and monitors infiltration elements.

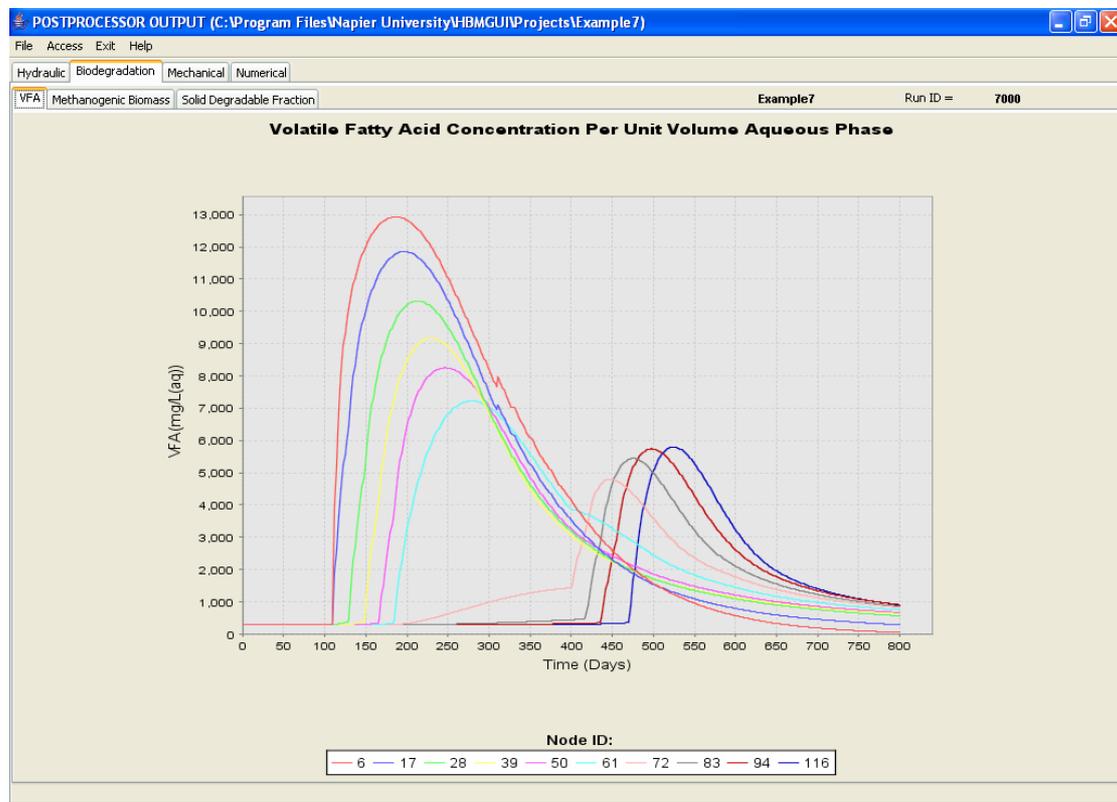


## BIODEGRADATION PANE

Comprises three sub-panes: VFA, Methanogenic Biomass and Solid Degradable Fraction.

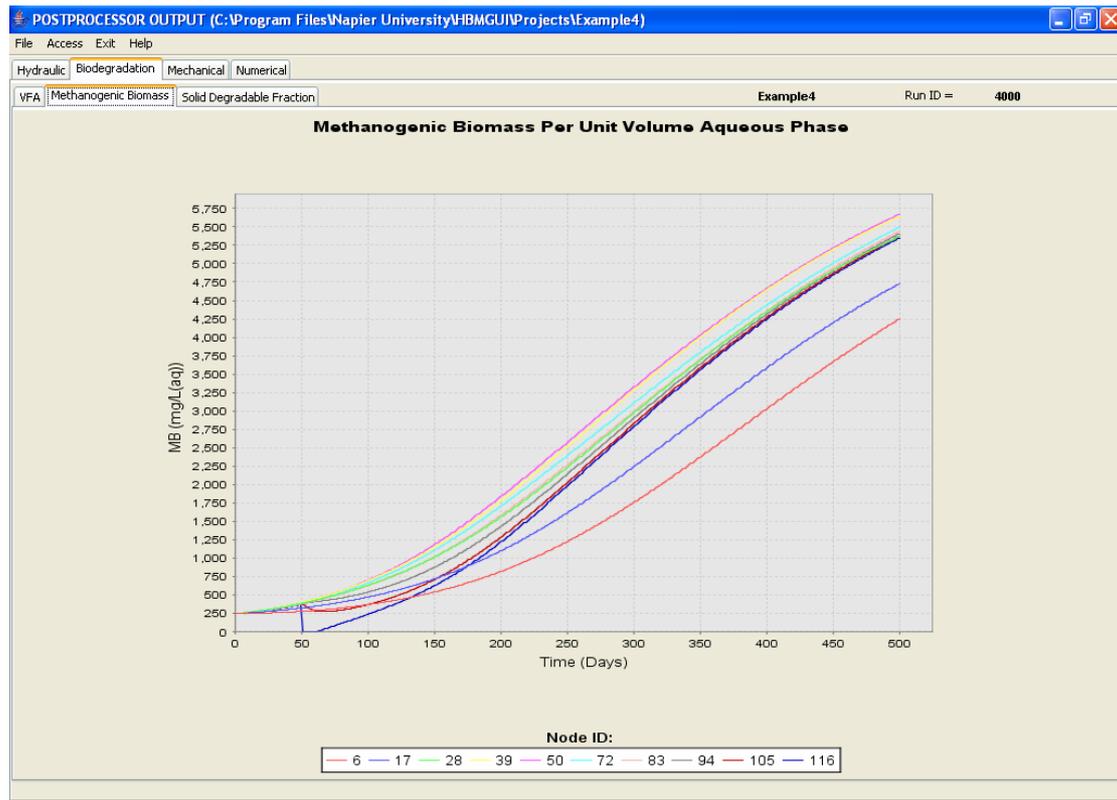
### VFA Sub-pane

Shows time series of volatile fatty acid as a mass concentration per unit volume aqueous phase for each of the nodes specified in *Graphics Output Control* .



## Methanogenic Biomass Sub-pane

Shows time series of methanogenic biomass as a mass concentration per unit volume aqueous phase for each of the nodes specified in *Graphics Output Control* .



## Solid Degradable Fraction Sub-pane

Shows time series of solid degradable fraction as a mass concentration per unit total volume for each of the elements specified in *Graphics Output Control* .



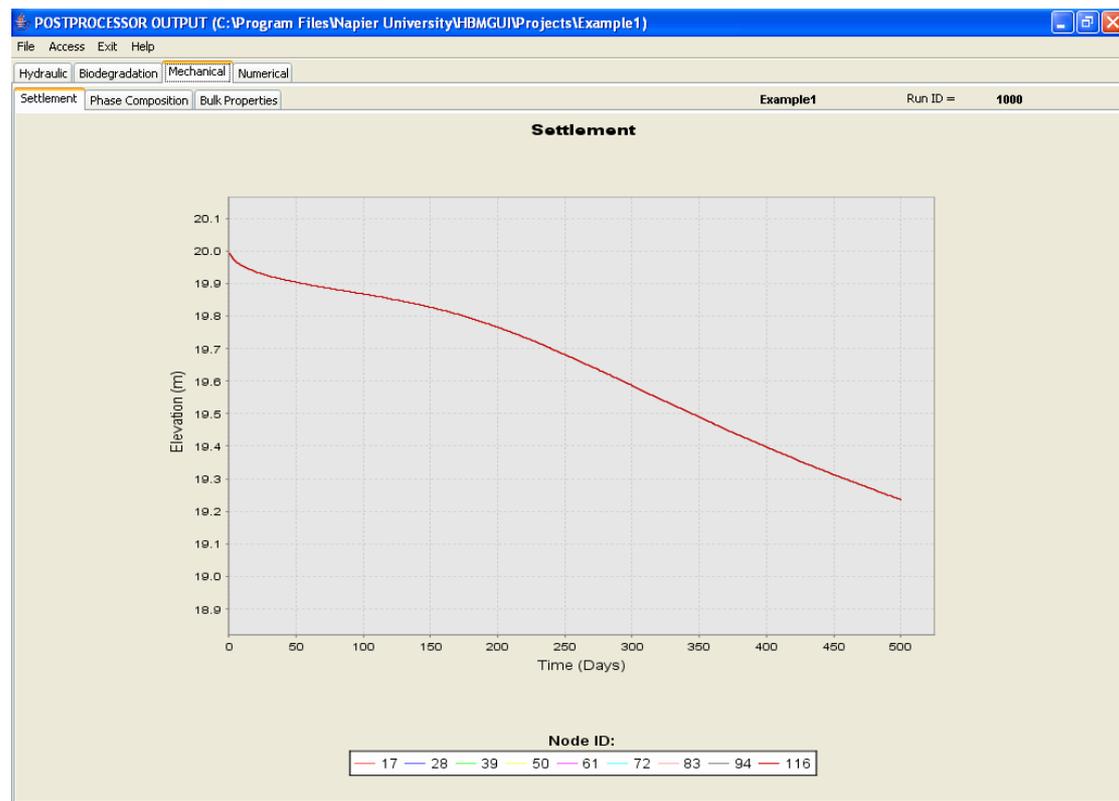
The vertical scale of this graphics pane has been zoomed in from its default scaling using the click and drag facility on the right mouse button.

## MECHANICAL PANE

Comprises three sub-panes: Settlement, Phase Composition and Bulk Properties.

### Settlement Sub-pane

Shows time series of settlement as vertical elevation for each of the nodes specified in *Graphics Output Control*. Note that the initial nodal elevations correspond to undeformed mesh locations; if infilling is occurring then initial displacement is for the node in the hidden state. The time of disclosure of an element can be estimated by reference to the biodegradation and deformed mesh plots.

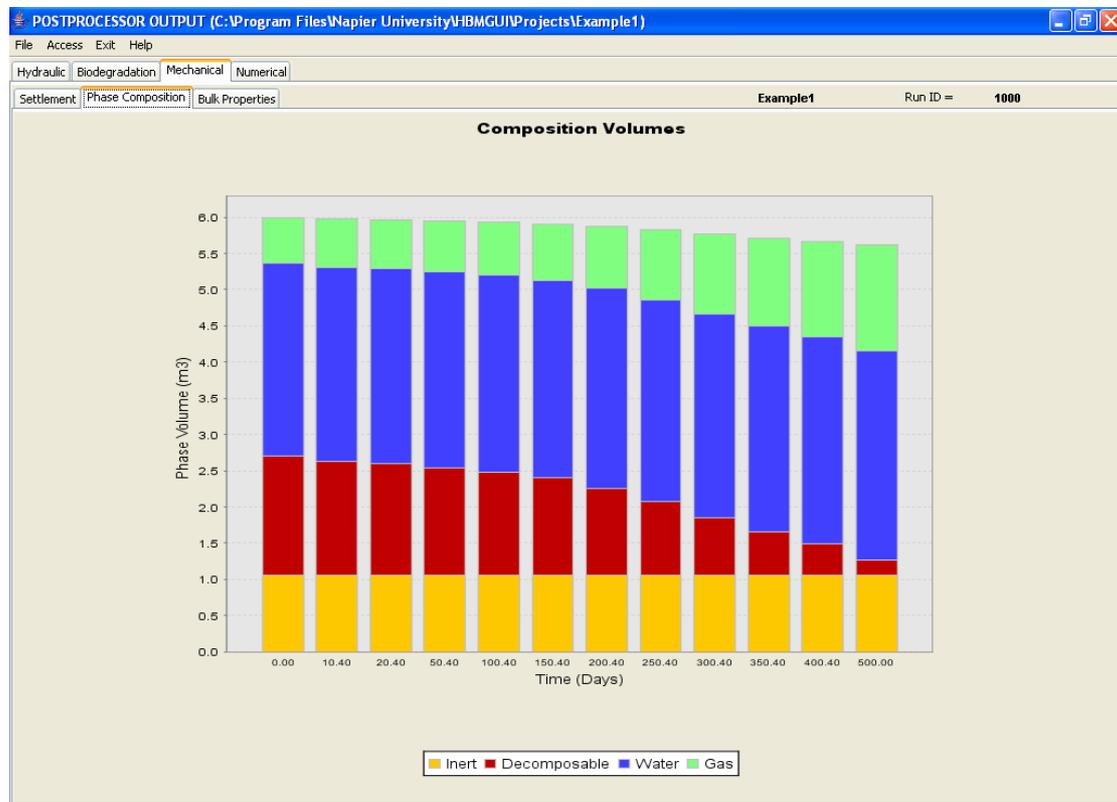


The vertical scale of this graphics pane has been zoomed in from its default scaling, using the click and drag facility on the right mouse button, to highlight the settlement behaviour of a surface node (116).

## Phase composition Sub-pane

Shows an aggregated four phase composition comprising (a) solid inert, (b) solid degradable, (c) moisture and (d) gas phases for element 1 on each of the days specified in *Graphics Output Control*. There is no option within the GUI to monitor other elements.

Note that individual phase volumes for any specified day can be revealed by hovering the mouse cursor over the respective phase element.

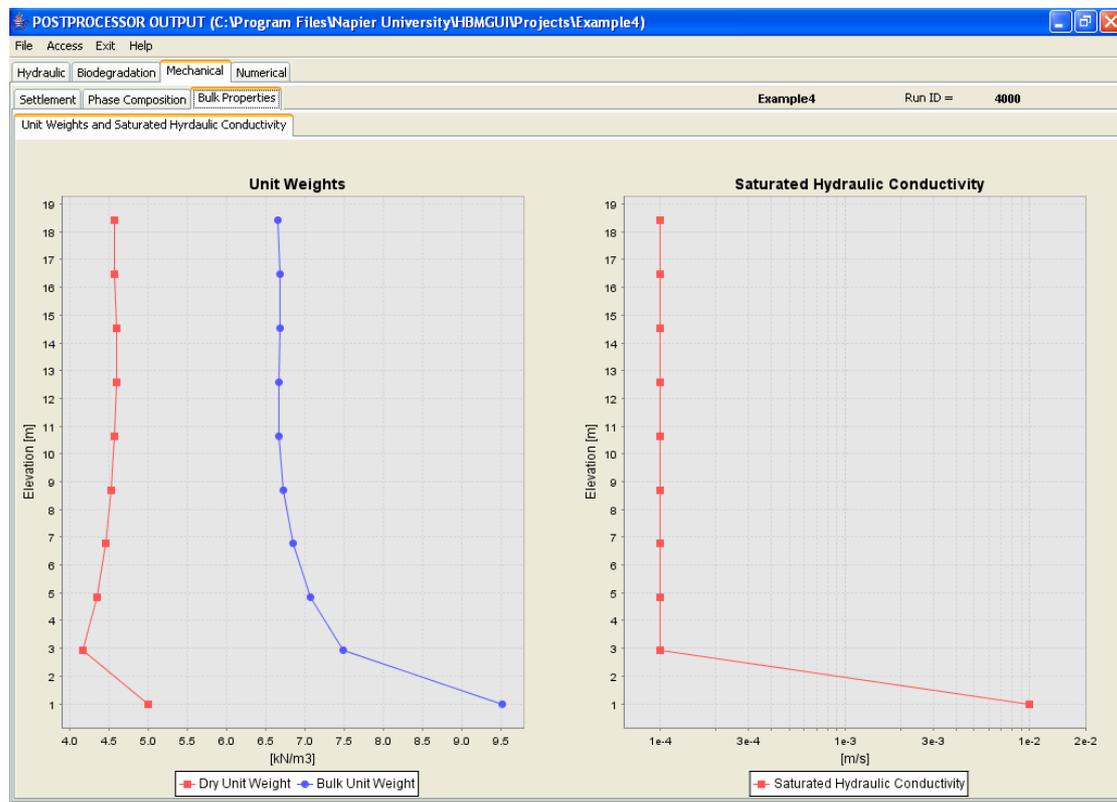


## Bulk Properties Sub-pane

Contains two separate profile plot panes:

- unit weights (dry and bulk) and
- saturated hydraulic conductivity.

Both sets of data are shown as element-averaged quantities and plotted at their respective element centroids.



## NUMERICAL PANE

A single pane containing three distinct plot panes:

- Updates – for hydraulic and biodegradation models. This data reports the number of updates required by the solution process to resolve the inherent non-linearity of the governing equations within a time step.
- Nodes out of tolerance at final update – for hydraulic, VFA and methanogenic biomass systems. This data shows the number of nodes that exceed allowable tolerances after the final (fourth) update, after which the solution is released to the next time step.
- Iterations – these are iterations in the Gauss-Seidel solver, that is iterations within a calculation procedure and not an update to resolve the non-linearity of the equations.

