MIKE
Powered by DHI

MIKE FLOOD

1D-2D and 1D-3D Modelling

User Manual

PLEASE NOTE

COPYRIGHT

This document refers to proprietary computer software which is protected by copyright. All rights are reserved. Copying or other reproduction of this manual or the related programs is prohibited without prior written consent of DHI A/S (hereinafter referred to as “DHI”). For details please refer to your 'DHI Software Licence Agreement'.

LIMITED LIABILITY

The liability of DHI is limited as specified in your DHI Software Licence Agreement:

In no event shall DHI or its representatives (agents and suppliers) be liable for any damages whatsoever including, without limitation, special, indirect, incidental or consequential damages or damages for loss of business profits or savings, business interruption, loss of business information or other pecuniary loss arising in connection with the Agreement, e.g. out of Licensee's use of or the inability to use the Software, even if DHI has been advised of the possibility of such damages.

This limitation shall apply to claims of personal injury to the extent permitted by law. Some jurisdictions do not allow the exclusion or limitation of liability for consequential, special, indirect, incidental damages and, accordingly, some portions of these limitations may not apply.

Notwithstanding the above, DHI's total liability (whether in contract, tort, including negligence, or otherwise) under or in connection with the Agreement shall in aggregate during the term not exceed the lesser of EUR 10.000 or the fees paid by Licensee under the Agreement during the 12 months' period previous to the event giving rise to a claim.

Licensee acknowledge that the liability limitations and exclusions set out in the Agreement reflect the allocation of risk negotiated and agreed by the parties and that DHI would not enter into the Agreement without these limitations and exclusions on its liability. These limitations and exclusions will apply notwithstanding any failure of essential purpose of any limited remedy.

CONTENTS

1 Introduction . . . 11
1.1 General Approach to Modelling with MIKE FLOOD . . . 12
1.2 How to Use this Manual . . . 13

2 General Description of Model Linkages . . . 15
2.1 The Standard Link . . . 15
2.2 The Lateral Link . . . 16
2.3 The Structure Link . . . 17
2.4 The Urban Link . . . 18
2.5 The Zero Flow Link (X and Y) . . . 19
2.6 The River - Urban link . . . 20
2.7 The Side Structure Link . . . 21

3 The MIKE FLOOD Editor . . . 23
3.1 Tools . . . 24
3.1.1 Default values, River / 2D surface links . . . 25
3.1.2 Default values, Urban / 2D surface links . . . 26
3.1.3 Default values, River / Urban links . . . 27
3.1.4 Change existing values, River / 2D surface links . . . 28
3.1.5 Change existing values, Urban / 2D surface links . . . 29
3.1.6 Change existing values, River / Urban links . . . 30
3.1.7 Export river / 2D surface link lines to text file . . . 31
3.1.8 Select links . . . 32
3.2 The Linkage Files Page . . . 33
3.2.1 2D Surface Model . . . 34
3.2.2 River Model . . . 34
3.2.3 Urban Model . . . 35
3.3 The Link Definitions page . . . 35
3.3.1 Link types; feature overview . . . 36
3.3.2 Table of defined model links . . . 38
3.4 The Graphical Layout . . . 43
3.4.1 Select and activate linkages graphically . . . 46
3.4.2 Editing linkage lines graphically . . . 46
3.4.3 Information on the individual cells . . . 48
3.4.4 Add/Remove layers... . . . 48
3.4.5 Layer properties... . . . 50
3.4.6 Add/Remove images... . . . 56
3.4.7 Link river branches to MIKE 21 . . . 57
3.4.8 Link natural channels to MIKE 21 . . . 60

3.4.9 Block out river cells... 62
3.4.10 Link urban node to MIKE 21... 67
3.4.11 Link river branch to urban network... 67
3.4.12 Export links to selection File... 68
3.5 Details on Standard / Structure Links Options, 70
3.5.1 Mom fact 71
3.5.2 Ext fact 72
3.5.3 Add / replace momentum terms 72
3.5.4 Depth adjustment 73
3.5.5 Activation depth (minimum and maximum) 73
3.5.6 Exponential smoothing factor 73
3.6 Details on Lateral Links Options 75
3.6.1 Side of river 76
3.6.2 Method 76
3.6.3 Structure type 76
3.6.4 Source 77
3.6.5 Depth tolerance 78
3.6.6 Structure coefficients 79
3.6.7 External files for lateral links 79
3.6.8 Additional lateral Linkage feature; Linkage Level analysis 80
3.6.9 Lateral links in rectangular grids and flexible mesh 82
3.7 Details on Urban Link Options 83
3.7.1 Type 84
3.7.2 Inlet method 84
3.7.3 Max flow 85
3.7.4 Inlet area 85
3.7.5 Crest width 85
3.7.6 Discharge coefficient 86
3.7.7 Scaling factor 86
3.7.8 Exponent factor 86
3.7.9 Qdh factor 86
3.7.10 Freeboard 86
3.7.11 Capacity curve DQ Relation 86
3.8 Details on River - Urban Link Options 87
3.9 Details on Side Structure Link Options 88
3.10 AD Components 89
4 Simulation Results 91
4.1 Defining Result Files for a MIKE FLOOD Simulation 91
4.2 Seamless Integrated 1D and 2D River Flooding Results 91
5 Running MIKE FLOOD- recommended Steps 93
5.1 Define Model Layout 93
5.2 Setup and Run 1D Models 93
5.3 Setup and Run MIKE 21 Model 94
5.4 Setup MIKE FLOOD 94
5.5 Run MIKE FLOOD Simulation 94

6 Pre- and Post-processing . . . 95
6.1 Volume Balance Summary from Simulations . . . 96
7 Tips and Troubleshooting . . . 99
7.1 General Considerations . . . 99
7.1.1 River modelling with MIKE HYDRO River or MIKE 11 . . . 99
7.1.2 MIKE 21 rectangular grid . . . 100
7.1.3 MIKE 21 flexible mesh . . . 101
7.1.4 MIKE 3 flexible mesh . . . 102
7.1.5 MIKE+ . . . 102
7.2 Stability Issues . . . 102
7.2.1 General MIKE FLOOD issues . . . 102
7.2.2 MIKE 11 specific issues . . . 103
7.3 Standard Links . . . 104
7.4 Lateral Links . . . 104
7.5 Structure Links . . . 106
7.6 Zero Flow Links . . . 107
7.7 Urban links . . . 107
7.8 River Urban links . . . 108
8 Scientific Background . . . 109
8.1 Hydrodynamics - Standard Links . . . 109
8.1.1 Rectangular grid . . . 109
8.1.2 Flexible mesh . . . 110
8.2 Hydrodynamics - Lateral Links . . . 110
8.2.1 Rectangular Grid . . . 110
8.2.2 Automated cell selection . . . 113
8.2.3 Definition of lateral linkage lines . . . 114
8.3 Hydrodynamics - Structure Links . . . 115
8.3.1 Hydrodynamics - Exponential smoothing factor . . . 117
8.4 Hydrodynamics - Zero Flow Links . . . 117
8.5 Hydrodynamics - Urban links . . . 118
8.6 Urban River Links . . . 119
8.7 Advection-Dispersion . . . 119
8.8 Flow Distribution by Depth . . . 120
8.9 Inclusion of Friction Term in Weir Formulae 1 and 2 (Honma) . . . 121
9 Examples . . . 125
9.1 Standing Wave . . . 125
9.2 Lateral Link 1 . . . 127
9.3 Lateral Link 2 . . . 133
9.4 Flow Direction . . . 136
9.5 Flood plain Flow . . . 140
9.6 Floodplain Demonstration . . . 142
9.7 Urban examples . . . 147
9.7.1 Urban . . . 147
9.7.2 Waterville . . . 147

9.8 MIKE FLOOD 3way 148
9.8.1 River links between MIKE 11 and MIKE 21 150
9.8.2 Urban links between MIKE+ and MIKE 21 150
9.8.3 River/Urban links between MIKE+ (Urban) and MIKE HYDRO . . . 151

MIKE FLOOD

User Guide

1 Introduction

MIKE FLOOD is a product that integrates the one-dimensional models MIKE+ (Urban), MIKE HYDRO River, MIKE 11 and the two-dimensional model MIKE 21 or three-dimensional model MIKE 3 into a single, dynamically coupled modelling system.

Using a coupled approach enables the best features of both the one -dimensional and the two- or three-dimensional models to be utilised, whilst at the same time avoiding many of the limitations of resolution and accuracy encountered when using MIKE HYDRO River, MIKE 11, MIKE+ (MIKE1D engine), MIKE 21 or MIKE 3 separately.

Special features of MIKE FLOOD include:

- Lateral links, enabling simulation of over bank flow from river channel to flood plain
- Comprehensive hydraulic structures package
- Implicit structure links
- Manhole links whereby the interaction of the sewer/storm water system may interact with the overland flow
- River/urban links securing direct linking between the collection system and the river network
- GIS integration
- Links possible along any alignment in MIKE 21 (not just horizontally or vertically)
- A graphical user interface, allowing for easy data input and output as well as data preparation and analysis.
- A thorough on-line help system, user guide and technical reference documentation
- Support and continuing commitment from DHI

There are many advantages to using MIKE FLOOD and many model applications can be improved through its use, including:

- Flood plain applications
- Storm surge studies
- Urban drainage
- Dam break
- Hydraulic design of structures
- Broad scale estuarine applications

1.1 General Approach to Modelling with MIKE FLOOD

Consider the modelling systems that are integrated: MIKE HYDRO River, MIKE 11, MIKE+ (Urban) and MIKE 21 or MIKE 3. By combining - or linking - the systems the modeller can choose the best features of each and make the best model with these features.

For instance, consider the following abilities and limitations of MIKE HYDRO River and MIKE 11:

- Has comprehensive and proven structure routines
- Can model very long or complicated river systems with little computational effort
- Can model one dimensional channel flow accurately
- Can be easily linked to rainfall and runoff programs
- Can simulate high velocity/super critical flow conditions
- Is one dimensional, so two dimensional effects such as cross-channel momentum is not possible
- Overland flow is difficult to model if flow paths are uncertain
- Requires more conceptualisation of flow conditions and more approximations
- Cannot easily simulate a coastal situation

Consider then MIKE+ (Urban):

- Has sophisticated descriptions for pipe flow and structures
- Can model highly complex pipe networks
- Can be easily linked to rainfall and runoff programs
- May be used to model open sections
- Is one dimensional, so a true two dimensional description of the overland flow is not possible
- Difficult to describe the complex interaction between overland flow and pipe flow

Finally consider MIKE 21 and MIKE 3:

- Two dimensional means more accuracy and better resolution
- Overland flow can be simulated without a priori knowledge of flow paths
- Flooding and drying may be efficiently handled using robust algorithms
- Can simulate high velocity / supercritical flow conditions
- Can simulate a coastal situation in either two- or three-dimensions
- Requires more computational effort

Additionally MIKE 21 rectangular grid has the following abilities and limitations:

- Fixed grid means less flexibility
- Difficulty modelling narrow channels and flow paths, particularly if grid is diagonal to flow direction
- MIKE 21 boundaries must be aligned with the grid (horizontal or vertical)

Finally the abilities and limitations of MIKE 21 and MIKE 3 flexible mesh are the following:

- Adaptive time step so that the time step of the 2D part adjusts to the dynamics
- Boundaries may have any alignment
- The river outline may be integrated in the mesh
- A fine mesh may be needed for resolving rivers and streams in mesh

Consider which of these features are most desirable for your application. How can you integrate MIKE HYDRO River, MIKE 11, MIKE+ (Urban) and MIKE 21 or MIKE 3 to best utilise the most desirable features, while minimising the bad features? MIKE FLOOD enables this integration to be performed easily, but it is still the modeller who decides how best to design the integrated model. This manual will help you to make the decisions on how best to create a MIKE FLOOD simulation.

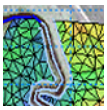
1.2 How to Use this Manual

MIKE FLOOD offers a range of flexibility. Through MIKE FLOOD the modeller can couple a pipe network, a river/stream network and an overland flow solver into one model. This flexibility is reflected in the range of modelling packages integrated in MIKE FLOOD namely MIKE+ (Urban), MIKE HYDRO River, MIKE 11 and MIKE 21 (in either a rectangular grid or a flexible mesh version) or MIKE 3 (flexible mesh only).

A MIKE FLOOD model may run with only one component or it may consist of up to three components covering overland, river network and collection system. This flexibility is also reflected in the manual such that certain sections are of importance only if that specific component has been included (e.g. MIKE+ (Urban)).

Throughout the manual the following icons will be used to indicate which sections are relevant for which components

Icon for MIKE 21 rectangular grid model component

 Icon for MIKE 21 flexible mesh model component, regardless whether MIKE 21 FM is setup with a flexible mesh or a rectangular grid domain (also applicable for MIKE 3)

Icon for MIKE HYDRO River / MIKE 11 component

Icon for MIKE+ (Urban) component

Links may be defined between any of the three model components MIKE 21, MIKE HYDRO River, MIKE 11 and MIKE+ (Urban). Further MIKE 21 may either be a rectangular grid version or a flexible mesh version.

NOTE: All the individual components required for the coupled modelling need to be licensed.

NOTE: As a rule of thumb, comments made for MIKE 11 in this manual also apply to MIKE HYDRO River.

NOTE: Comments made for MIKE 21 Flexible Mesh in this manual also apply to MIKE 3 Flexible Mesh. Additionally, comments made for 2D links (flexible mesh only) in this manual also generally apply to 3D links. Where appropriate in the MIKE FLOOD UI, ‘MIKE 21’ items have been renamed ‘Surface model’ and ‘2D surface links’ have been renamed ‘Surface links’.

2 General Description of Model Linkages

Coupling of the different models are made through different linkage options. Seven different types of links are presently available in MIKE FLOOD:

1. Standard Link
2. Lateral Link
3. Structure Link (for the MIKE 21 rectangular grid model only)
4. Side Structures Link
5. Zero Flow links (XFlow=0 and YFlow=0) (for the MIKE 21 rectangular grid model only)
6. Urban Link
7. River-Urban Link

Link types 1 to 5 above concern the coupling of MIKE 11 and MIKE 21, Link type 6 is designed for linking MIKE+ (Urban) with one or more cells/elements in MIKE 21 and finally, Link type 7 is reserved for linking the river network (MIKE 11) with the collection system (MIKE+ (Urban)).

A description of each of these link types follows below.

2.1 The Standard Link

This is the standard linkage in MIKE FLOOD, where one or more MIKE 21 cells/elements are linked to the end of a MIKE 11 river branch.

This type of link is useful for connecting a detailed MIKE 21 grid/mesh into a broader MIKE 11 network, or to connect an internal structure (with an extent of more than a grid cell) or feature inside a MIKE 21 grid/mesh.

Potential applications are as shown below:

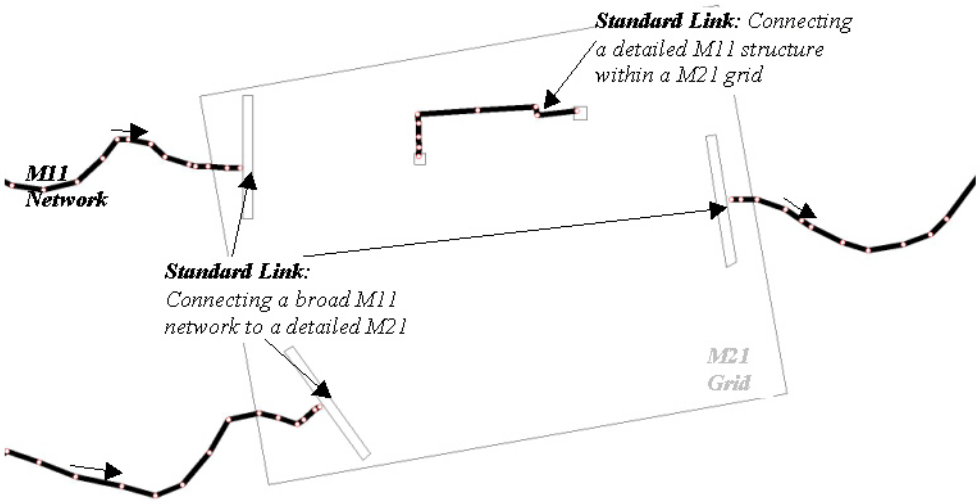


Figure 2.1 Application of Standard Links

The Standard link is explicit - see the scientific documentation for a full description.

2.2 The Lateral Link

A lateral link allows a string of MIKE 21 cells/elements to be laterally linked to a given reach in MIKE 11, either a section of a branch or an entire branch.

Flow through the lateral link is calculated using a structure equation. This type of link is particularly useful for simulating overflow from a river channel onto a flood plain.

An example is shown:

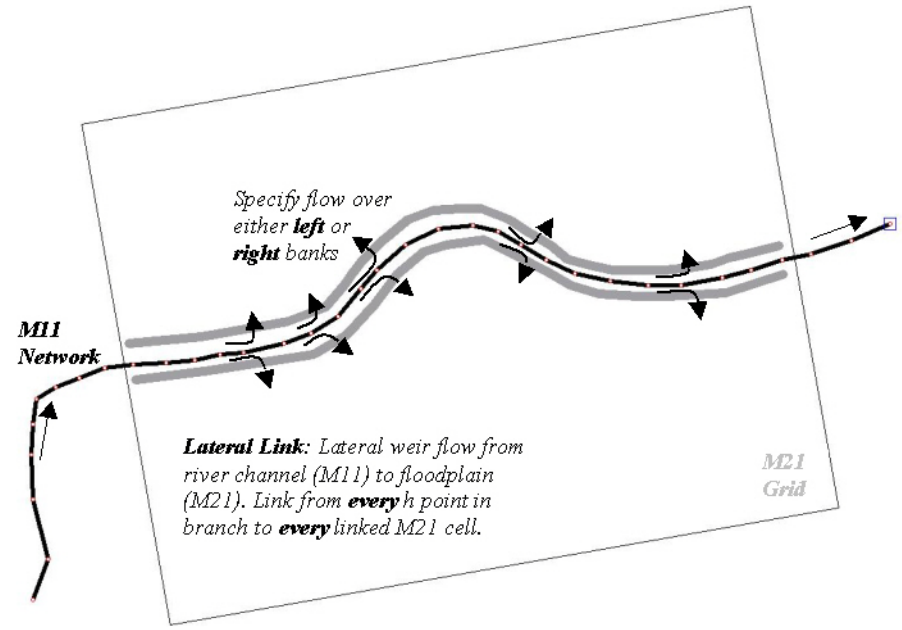


Figure 2.2 Application of Lateral Links

2.3 The Structure Link

The structure link takes the flow terms from a structure in MIKE 11 and inserts them directly into the momentum equations of MIKE 21 (rectangular MIKE 21 version only). This is fully implicit, so should not affect time step considerations in MIKE 21.

The structure link is useful for simulating structures within a MIKE 21 model. The link consists of a 3 point MIKE 11 branch (upstream cross-section, structure, downstream cross-section), the flow terms of which are applied to a MIKE 21 cell or group of cells. An example is shown:

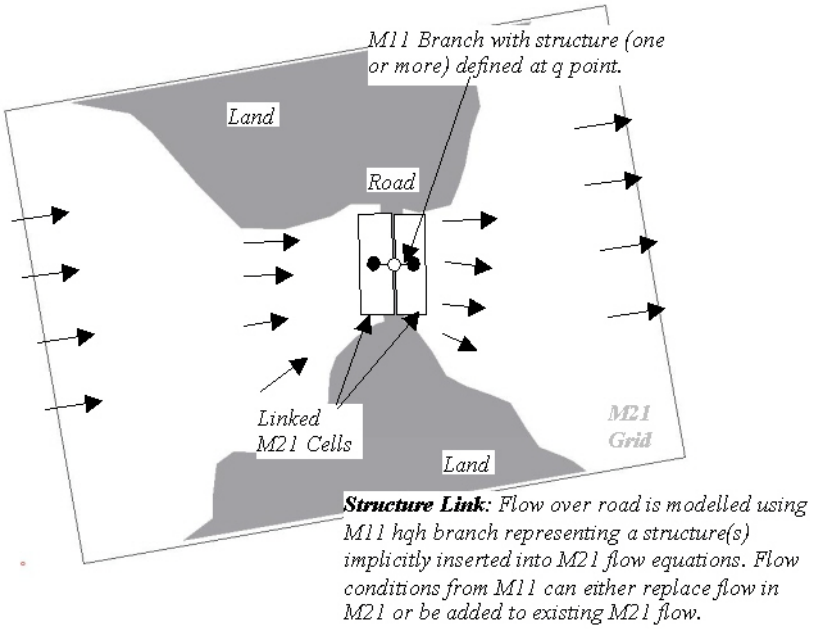


Figure 2.3 Application of Structure Links. Only to be used for a rectangular grid

2.4 The Urban Link

The urban link is designed to describe the interaction of water when a manhole is overtopped or when overland flow enters a sewer/storm water network.

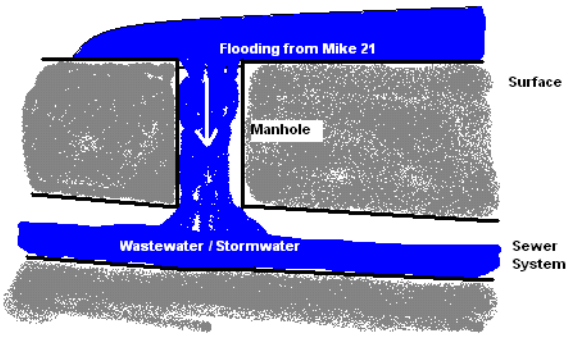


Figure 2.4 Flooding from MIKE 21 into a non-surcharged sewer system

The urban link may also be used for linking a sewer outlet with the overland topography. This may be used to describe the dynamic interaction between a sewer system and a collection basin described using the topography as opposed to describing the basin using an area elevation curve.

Finally the link is also applicable to situations where the sewer system is discharging into the surrounding area through a pump or over a weir. In these cases the pump or the weir must be defined as having no downstream node.

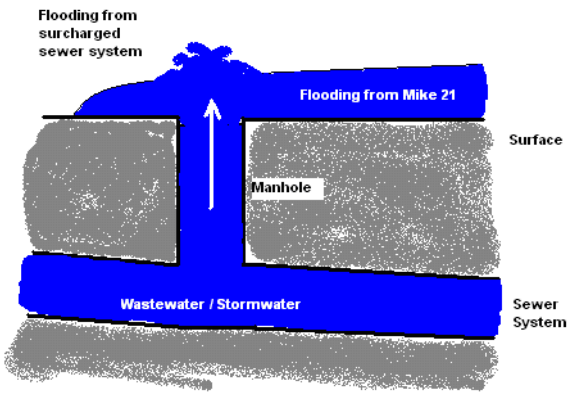


Figure 2.5 Flooding from a surcharged sewer system into MIKE 21

The link is designed such that one or more cells/elements in MIKE 21 may be linked to a manhole, basin, outlet, pump or weir in MIKE+ (Urban).

2.5 The Zero Flow Link (X and Y)

A MIKE 21 cell specified as a zero flow link in the x direction will have zero flow passing across the right side of the cell. Similarly, a zero flow link in the y direction will have zero flow passing across the top of the cell.

The zero flow links were developed to complement the lateral flow links. To ensure that flood plain flow in MIKE 21 does not travel directly across a river to the opposite side of the flood plain without passing through MIKE 11, zero flow links are inserted to block MIKE 21 flows. An alternative to using the zero flow links is to apply land cells which, depending upon grid resolution, may not be appropriate.

Another useful application of zero flow links is to represent narrow blockages on a flood plain, such as roads and levees. Rather than using a string of land cells, a string of zero flow cells can be used.

Note this link is only available when linking MIKE 21 rectangular grid to MIKE 11.

2.6 The River - Urban link

The river urban link has been designed for modelling the dynamic interaction of the river network and the collection system. Areas of application are

- Collection system discharging to a river through an outlet
- Pumps discharging to a canal
- A collection system spilling into a stream over a weir

The river - urban link has been designed so that it may be used with a full three component model but is also applicable when the model only consists of MIKE+ (Urban) and MIKE HYDRO.

Figure 2.6 illustrates the situation with a sewer outlet discharging into a river. For this case the user needs to supply the river link location through a branch name and a chainage. The link will be placed at the nearest river cross section in the river. For the sewer the user must specify the outlet ID and ensure that a standard water level boundary condition is applied (no Q/H relation allowed).

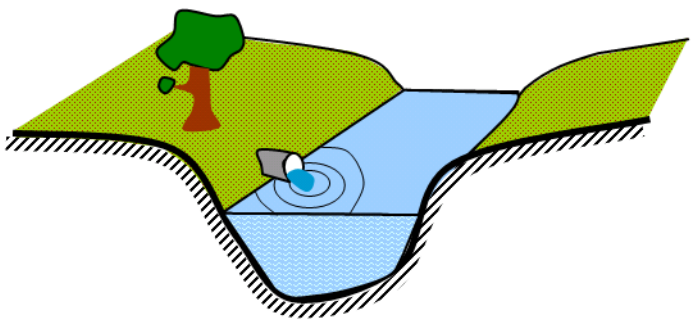


Figure 2.6 A sewer outlet discharging into a river. The water level in the river will have an impact on the flow through the outlet. Note that an adverse head difference at the outlet will drive flow into the sewer system

Figure 2.7 illustrates the situation where a sewer system is connected to a river through a weir in the sewer system. Note that the weir must be specified as having no “to node” i.e. out of the sewer system. In this case the user supplies the river location and the ID of the weir. The situation with a pump is

similar. The user in this case supplies the ID of the pump to be linked. Both the pump and the weir links are uni-directional i.e. flow is only allowed from the sewer system to the river and not vice versa.

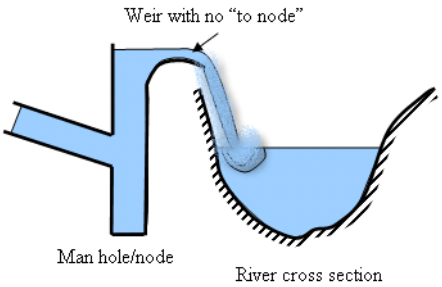


Figure 2.7 A cross sectional illustration of a sewer discharging into a river through a weir. Note that the flow is uni-directional. Thus the water can only travel from the sewer system to the river and not vice versa

2.7 The Side Structure Link

The Side Structure Link is designed to model interaction between the river model and the overland flow model through Side Structures as defined in MIKE 11.

Side structures can be defined in MIKE 11 for almost all structure types available and then are typically applied in MIKE 11 to define local lateral abstraction (or source) of water from the main river course in applications where either fixed hydraulic structures are present to convey water from the main river course to a neighbour area or channel-system or where e.g. a local breach of embankment occurred during a historical event.

Typical applications of Side Structure link are:

- Fixed hydraulic structure embedded locally in the river embankments such as drainage pipes (eventually with a directional valve control), local low-crested spill-structures etc.
- Local Controllable structures such as pumps and gates for flood control and irrigation.
- Embankment breaches where breaches can be described using a dam-break structure using either a time controlled or soil erosion breach definition.

The principle in the Side Structure Linkage is illustrated in Figure 2.8.

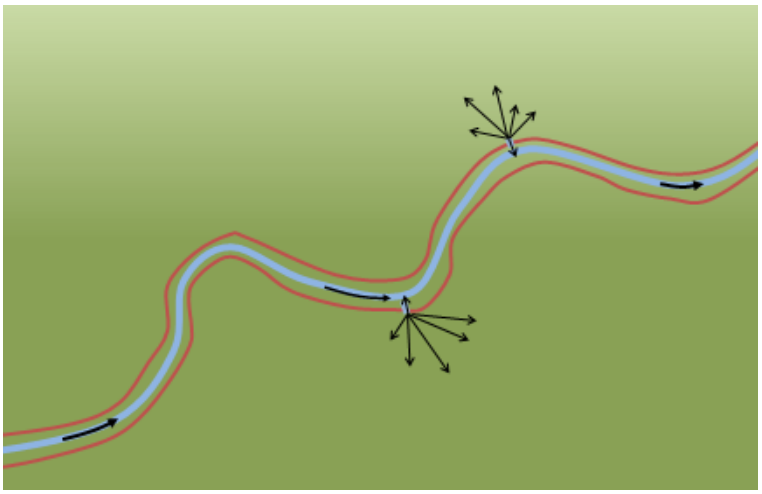


Figure 2.8 Illustration of Side Structure linkage with water spilling from the river to the flood plains through side structures located at specific locations within the River model

The Side Structure Link is explicit and implemented in the computational engine equivalent to the Standard Link option (for further details, see scientific documentation).

For details on the actual user-specification of Side Structures as well as the numerical approach for implementing Side Structures, please consult the MIKE 11 Documentation (Users guide and Reference Manual).

3 The MIKE FLOOD Editor

The MIKE FLOOD editor consists of a number of sub-pages with Graphical and Tabular editing possibilities combined with a navigational tree-view. The opening page of MIKE FLOOD editor is presented below.

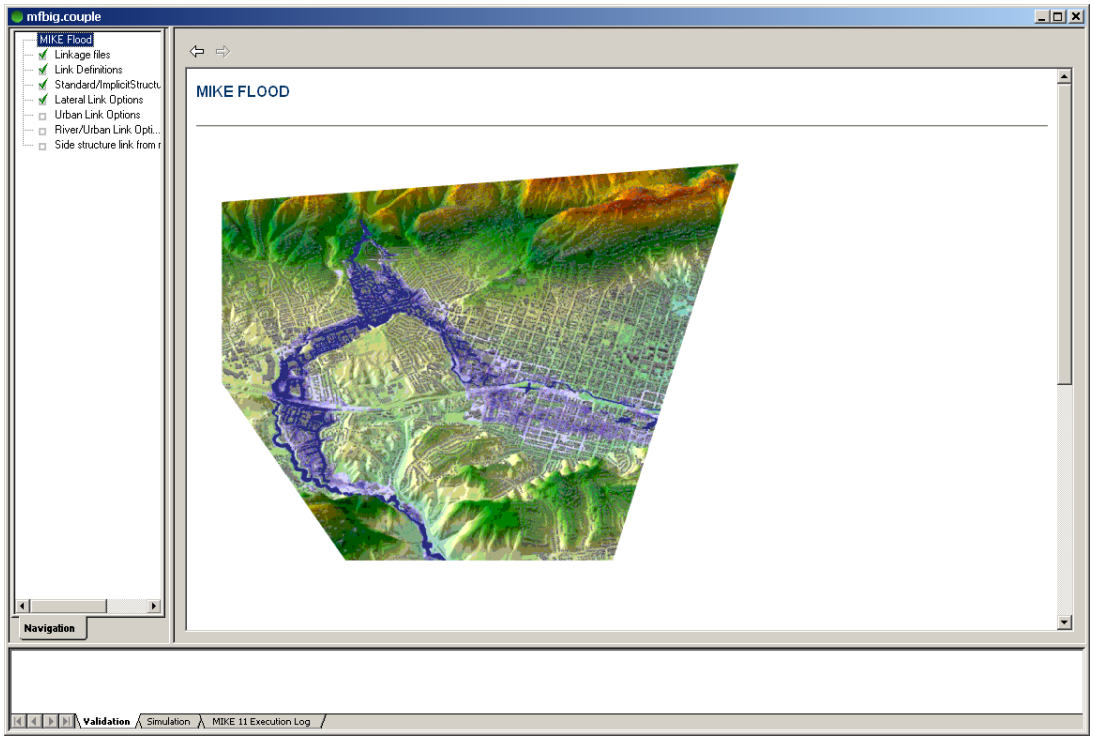


Figure 3.1 MIKE FLOOD Editor; Opening Page

Any combination of links can be used in a MIKE FLOOD simulation. All the information relating to the MIKE FLOOD links is contained in one file: the coupling file (file extension.COUPLE).

The MIKE 11, MIKE 21 and MIKE+ (Urban) simulation files do not contain any information relating specifically to the linkages between models, except for:

- A dummy water level boundary condition must be applied at each standard or implicit link point in MIKE 11.

The coupling file interface is arranged with a number of sub-menus which are easily accessed by clicking on any of the lines in the tree-view on the left side of the MIKE FLOOD Editor (see Figure 3.1).

The sub-pages available are:

- Linkage files

- Link Definitions
- Standard / Structure Link Options
- Lateral Link Options
- Urban Link Options
- River Urban Link Options
- Side Structure Link Options
- AD Components

Each of the sub-menus is described in Sections 3.2 to 3.10.

In addition to the above listed linkage definition sub-menus, an option for changing the default values for new links or changing parameter values for existing links of specific types can be found through the main menu bar of the editor. The Change Link Parameters option is described in the following section.

3.1 Tools

The Main menu bar of the Couple editor contains the ‘Tools’ drop-down menu which contains four entries as presented in Figure 3.3:

- ‘Default Values’
  When using the automatic linkage tool within MIKE FLOOD a number of default values are assigned to the created links. Editing of link parameters can be made subsequently, but the ‘Default Values’ tool is an option for changing the link parameter values assigned per default.

- ‘Apply to Existing’
  The Apply to Existing tool makes it possible to change link parameters globally for one or multiple link types in one operation.
  In an established MIKE FLOOD setup it is often required to change the value of one or more link parameters globally. For a small setup with few links this is relatively simple, but for a setup with a large number of links this change becomes rather time consuming and the Apply to Existing tool is developed to ease the global editing of multiple links.

- 'Invert M11 negative branch sections'
  This switch allows the user to invert the direction (left to right side) of cross sections for branches defined with negative flow direction.

- ‘Export river / 2D surface link lines to text file’
  This tool creates a text file containing the links locations. This text file can then be used in the Mesh Generator, to build a flexible mesh fitted to the links.

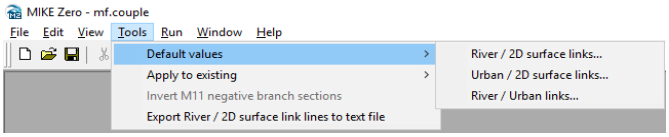


Figure 3.2 Tools drop-down menu; 'Default values' tool

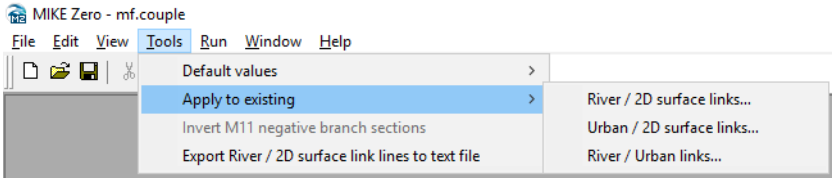


Figure 3.3 Tools drop-down menu; 'Apply to existing' tool

Please note that changing default value settings are only effective within the specific Couple-file being active as these values are saved in the file. Opening - or creating - another couple file may therefore require the user to change default values again for values to take effect in this file.

Details of the tools available within the 'Tools' drop-down menu are provided in the following chapters.

3.1.1 Default values, River / 2D surface links

Changing default values for parameters in all types of River / 2D surface links can be made through this dialog.

Parameters are grouped depending on which link-type they relate to. The parameters 'Exponential Smoothing' and 'Depth Adjustment' on the bottom of the page are used in multiple link-types and hence presented separately (see Figure 3.4).

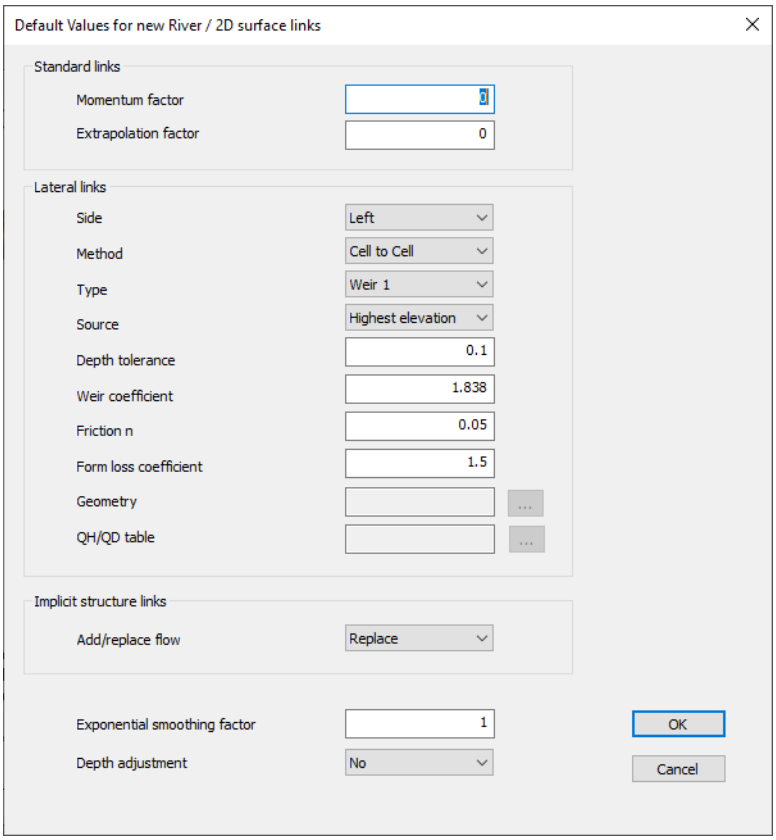


Figure 3.4 Dialog for changing Default Values for River / 2D surface Links

For details on the individual parameters, see the respective sections; ‘Details on Standard / Structure Links Options,’, ‘Details on Lateral Links Options’ and ‘Details on Side Structure Link Options’.

To change default values for the couple-file, adjust the required parameters and press OK. Press Cancel to close the Default Values dialog without changing parameters.

3.1.2 Default values, Urban / 2D surface links

Default values for Urban / 2D surface links can be changed in this dialog (see Figure 3.5).

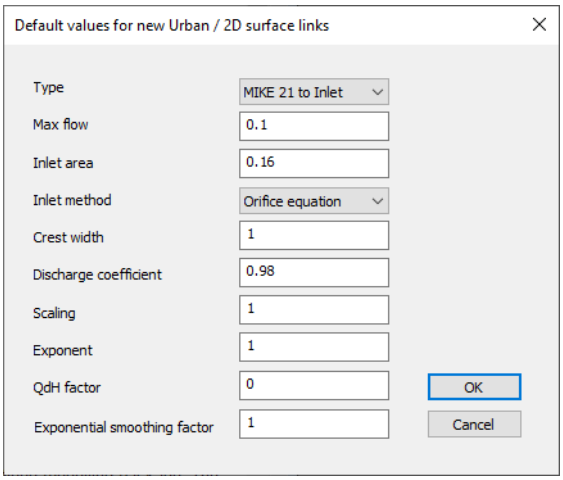


Figure 3.5 Dialog for changing Default Values for Urban / 2D surface Links

For details on the individual parameters, see the section; 'Details on Urban Link Options'.

To change default values for the couple-file, adjust the required parameters and press OK. Press Cancel to close the Default Values dialog without changing parameters.

3.1.3 Default values, River / Urban links

The Default values for the River / Urban links can be made in this dialog (see Figure 3.6).

Further details on the link type variables can be found in the section; 'Details on River - Urban Link Options'.

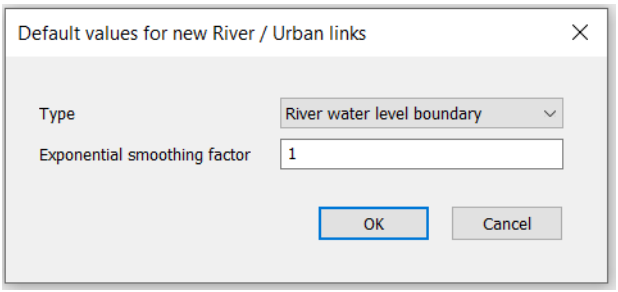


Figure 3.6 Dialog for changing Default Values for River / Urban Links

To change default values for the couple-file, adjust the required parameters and press OK. Press Cancel to close the Default Values dialog without changing parameters.

3.1.4 Change existing values, River / 2D surface links

Global changes to River / 2D surface link types can be made through this dialog, where the user decides which link-type is to be changed and which parameters should be included in the global change (see Figure 3.7).

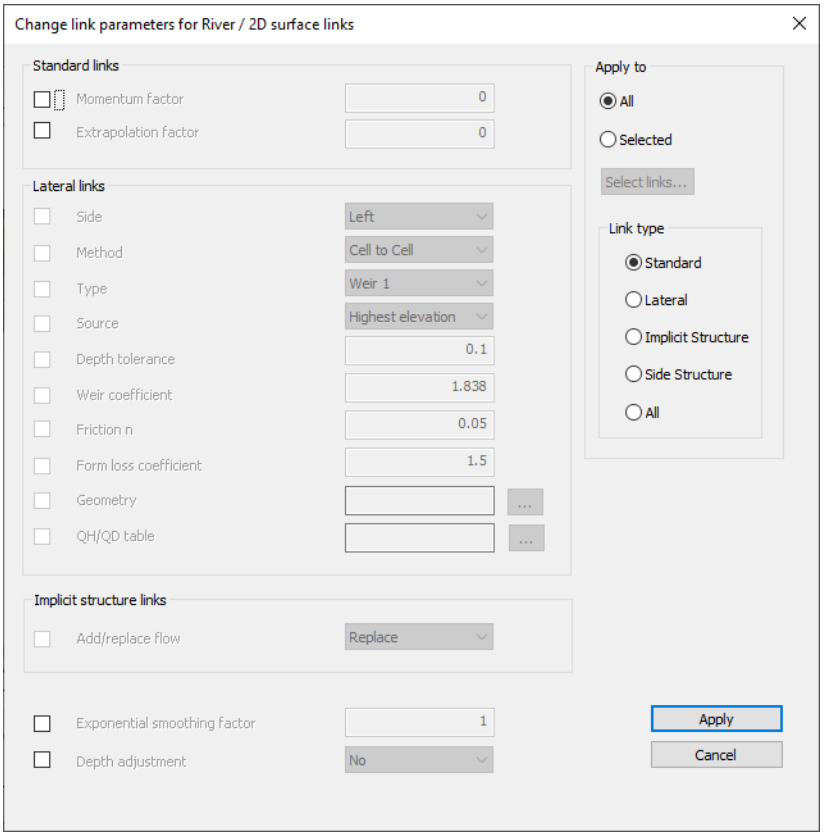


Figure 3.7 Dialog for changing existing River / 2D surface link parameters

Use the list of radio buttons in the ‘Link Types’ group-box to select which link types that are to be included in the global change. If you select a specific link type, parameters will be changed for this particular type only. Alternatively, you can select “All” in order to change the parameters of multiple link types in the same operation.

Tick-boxes for parameters in the dialog are related to a specific link type and they become active depending on the selection in the ‘Link Type’ radio button group. Activate one or multiple tick-boxes to activate the specific edit field for the parameters, which should be globally adjusted, and change the parameter values as requested.

Press the ‘Apply’ button to change values of the activated link parameters.

Please note that the Apply operation cannot be reverted automatically. Press Cancel to close dialog without changing parameter values.

If it is required to change parameter values for only a subset of existing links this is also possible through this dialog. Activate the 'Selected' option in the 'Apply To' group box and the Select links... button becomes active. Press the button to open the 'Select Links' dialog (see Figure 3.11) and select the specific Links which should be changed by selecting / crossing the tick-box in the Select column at the respective links. Further details in section 3.1.8.

For details on the individual parameters, see the respective sections; 'Details on Standard / Structure Links Options,', 'Details on Lateral Links Options' and 'Details on Side Structure Link Options'.

3.1.5 Change existing values, Urban / 2D surface links

Global changes to existing Urban / 2D surface links can be made through this dialog (presented in Figure 3.8).

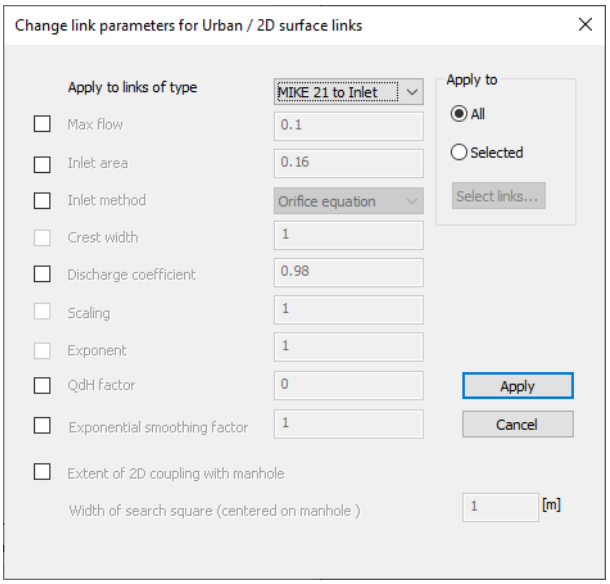


Figure 3.8 Dialog for changing existing Urban / 2D surface link parameters

Activate one or multiple tick-boxes to activate the specific edit field for the parameters, which should be globally adjusted and change the parameter values as requested. Tick-boxes will become active depending on the Link Type selection in the 'Apply to Links of Type' combo-box as well as the method selection in the 'Inlet Method' combo-box.

If it is required to change parameter values for only a subset of existing links this is also possible through this dialog. Activate the 'Selected' option in the 'Apply To' group box and the Select links... button becomes active. Press the button to open the 'Select Links' dialog (see Figure 3.11) and select the specific Links which should be changed by selecting / crossing the tick-box in the Select column at the respective links. Further details in section 3.1.8.

Press 'Apply' button to change values of the activated link parameters.

Please note that the Apply operation cannot be reverted automatically. Press 'Cancel' to close the dialog without changing any parameter values.

The last option on this dialog; 'Extent of 2D coupling with manhole' allows automatic addition of 2D cells or mesh elements in the MIKE 21 model for the couplings. Per default only one cell or element are defined at the location of the urban model element in a coupling, but multiple 2D elements in an Urban coupling are often required e.g. to secure improved model stability. 'Width of search square' defines the threshold extent of a square within which the additional 2D elements are identified and included in the Urban couplings.

For details on all other individual parameters in this dialog, see the section; 'Details on Urban Link Options'.

3.1.6 Change existing values, River / Urban links

Only one parameter is changeable in River / Urban links; namely the exponential smoothing factor. This can be done for all links of the specific link-type in one operation through this dialog (see Figure 3.9).

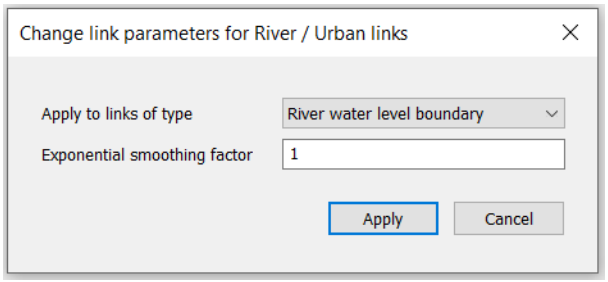


Figure 3.9 Dialog for changing existing River / Urban link parameters

Select the required link-type in the combo-box selection list and adjust the parameter value.

Press 'Apply' button to change values of the activated link parameters.

Please note that the Apply operation cannot be reverted automatically. Press Cancel to close dialog without changing parameter values.

Further details on the link type variables can be found in the section; ‘Details on River - Urban Link Options’.

3.1.7 Export river / 2D surface link lines to text file

The tool 'Export River / 2D surface link lines to text file' offers an option to export polylines, describing the linkage lines between the river and 2D surface models, in a text file format. The tool is designed for coupled models using a flexible mesh as input domain for the 2D surface model. The exported file can be imported in the Mesh Generator to adjust the mesh to the linkage lines and eventually exclude the river extent from a 2D flexible mesh.

The output file is a text file with file extension *.xyz, containing one polyline definition per selected link. The file contains three columns with X and Y coordinates, followed by the connectivity. Connectivity information is used to distinguish the various links which may be contained in the file. A fourth column contains an identification text at the start and end of links. Units are always expressed in meters.

Output

Use the '…' button to specify the file name and location for the text file to be created.

Apply to

Options selected here control which links should be exported. Two main options are available:

- All links: All links in the MIKE FLOOD file will be exported.
- Selected links: Only on the selected links will be exported. Press the ‘Select links...’ button to open the 'Select Links' dialog (see Figure 3.11) and select the links which should be exported by checking them in the Select column. Further details in section 3.1.8 (page 32). The 'Select Links' dialog shows only the links with the type selected under 'Link type'.

Use the list of radio buttons in the 'Link type' group-box to select which link types that are to be exported.

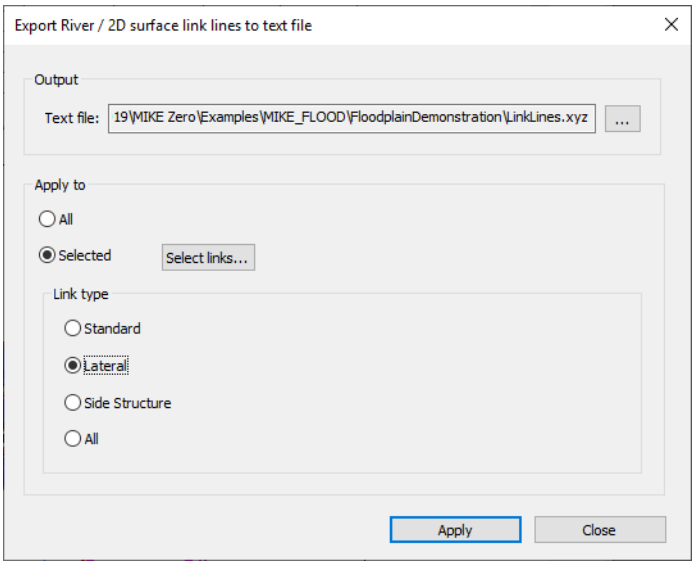


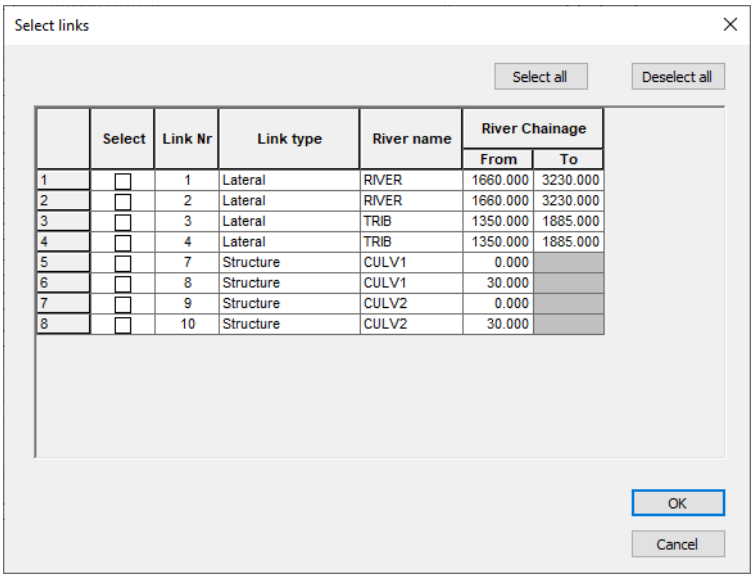
Figure 3.10 Dialog for exporting River / 2D surface link lines to text file

Press the Apply button to export the text file with selected settings.

3.1.8 Select links

Apply changes to existing links can be made as a global operation where all links in the setup are changed in one operation. However, it is desirable also to be able to change values for a sub-set of defined links to differentiate parameters of different links, and the selection of links to be changed in this process is made using the Select Links dialog (Figure 3.11).

Open the Select Links page from one of the Change Existing Parameter value pages by pressing the Select links... button in these pages. A list of all links of the specified link types in the model setup is presented in the table, and the specific links which shall be processed during the following change of link parameter values is simply selected by activating the respective tick-boxes in the 'Select' column.



	Select	Link Nr	Link type	River name	River Chainage	
					From	To
1	☐	1	Lateral	RIVER	1660.000	3230.000
2	☐	2	Lateral	RIVER	1660.000	3230.000
3	☐	3	Lateral	TRIB	1350.000	1885.000
4	☐	4	Lateral	TRIB	1350.000	1885.000
5	☐	7	Structure	CULV1	0.000	
6	☐	8	Structure	CULV1	30.000	
7	☐	9	Structure	CULV2	0.000	
8	☐	10	Structure	CULV2	30.000	

Figure 3.11 Link Selection dialog for selection of specific links to be included in Global change of parameter values for existing links. Figure illustrates a number of MIKE 21 / MIKE 11 links where 'All' link types has been selected in the Change Parameter Value page

Press OK to activate the selection and return to the Change Existing Value page from which you entered the Select Links option. Click Cancel to return without activating any selections.

3.2 The Linkage Files Page

The Linkage Files definition page contains information about the respective 1D and 2D model setup files used for couplings in the MIKE FLOOD setup.

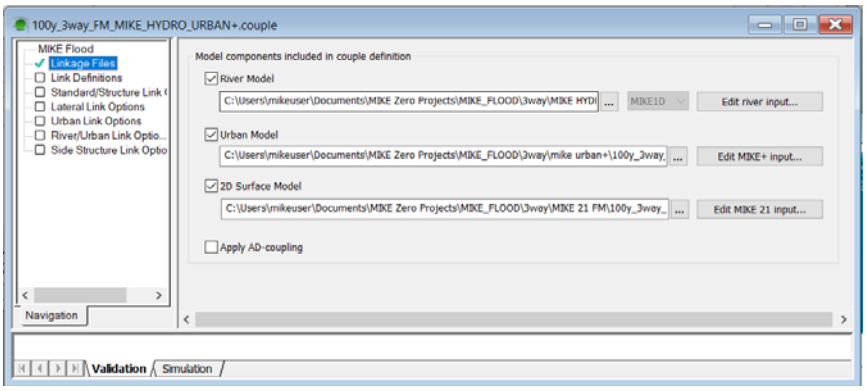


Figure 3.12 Linkage Files definition page of the MIKE FLOOD Editor

3.2.1 2D Surface Model

It is optional whether to include a MIKE 21 set up or not in MIKE FLOOD. If a 2D model is required in the coupling, a MIKE 21 set up must be selected through activation of the '2D Surface model' tick box above the file name browse for the MIKE 21 file using the browse button '...'.

A complete MIKE 21 setup should be established and tested prior to setting up MIKE FLOOD. The MIKE 21 setup is defined in the usual way using the respective editor. The path and file name of the resulting MIKE 21 File Name (*.m21 or *.m21fm or *.m21fst) is provided in this menu. Note that the MIKE 21 engine is selected through the selection of the file type.

Figure 3.13 MIKE 21 path name along with browse and edit buttons

The '...' button allows for browsing of the MIKE 21 parameter file. Furthermore, the "Edit MIKE 21 input..." button open the existing MIKE 21 parameter file for further editing.

3.2.2 River Model

It is optional if a river model is to be used with MIKE FLOOD. It is possible to use a river model defined in MIKE HYDRO River or in MIKE 11. If a river model is to be included, activate the 'River Model' tick box.

If a river model is to be used with MIKE FLOOD the complete MIKE HYDRO River or MIKE 11 setup should be established and tested prior to running a coupled model simulation. As with MIKE 21, this is done in the usual way using the appropriate editors. The path and file name of the MIKE HYDRO set-up (*.mhydro) or MIKE 11 set-up (*.sim11) is presented in this menu.

Figure 3.14 MIKE HYDRO River or MIKE 11 simulation file path name along related buttons. Note the tick box on the left which may be used to select or de-select whether a river set-up is to be included.

The '...' button allows for browsing of the required parameter file. Furthermore, the "Edit river input" button opens the selected river model for further editing.

Additionally, if the selected river model is a MIKE 11 set-up, a drop-down list allows selecting whether the river model simulation is to be conducted using

the ‘MIKE 1D’ or ‘MIKE 11 Classic’ simulation engine.
When the river model is a MIKE HYDRO River model, only the MIKE 1D engine is available.

3.2.3 Urban Model

It is optional whether an urban model is to be used with MIKE FLOOD. To activate the Urban coupling, activate the ‘Urban Model’ tick box. If an urban set-up is to be used with MIKE FLOOD the complete urban set-up should be established and tested.

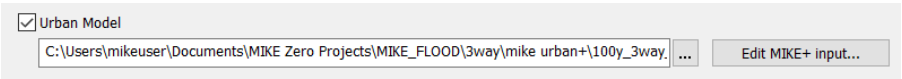


Figure 3.15 MIKE+ (Urban) file path. If a MIKE+ (Urban) database has been selected the ‘Edit MIKE+’ button will be active and the user may access the MIKE+ (Urban) set-up directly

A button allows for browsing the parameter file. Furthermore, the “Edit MIKE+” button allows for opening the existing MIKE+ (Urban) set-up for further editing.

If a MIKE+ (Urban) set-up is used in conjunction with MIKE FLOOD the set-up must be preprocessed before launching MIKE FLOOD. The preprocessing tool is located in the main menu bar under the run menu. Note that if MIKE+ (Urban) is not installed this menu item will be de-activated.

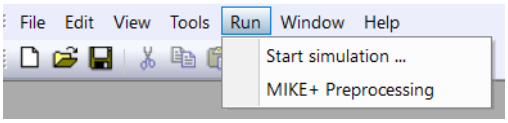


Figure 3.16 The pre-processing menu. Note that in case the menu item is deactivated if MIKE+ (Urban) has not been installed

3.3 The Link Definitions page

The Definition page contains tabular view for general linkage definitions such as link types and link connection details with branch segments, pipes and MIKE 21 link coordinates. A key component on this page is the graphical view from which most of the linkage operations are performed.

The Link Definitions page is presented in Figure 3.17.

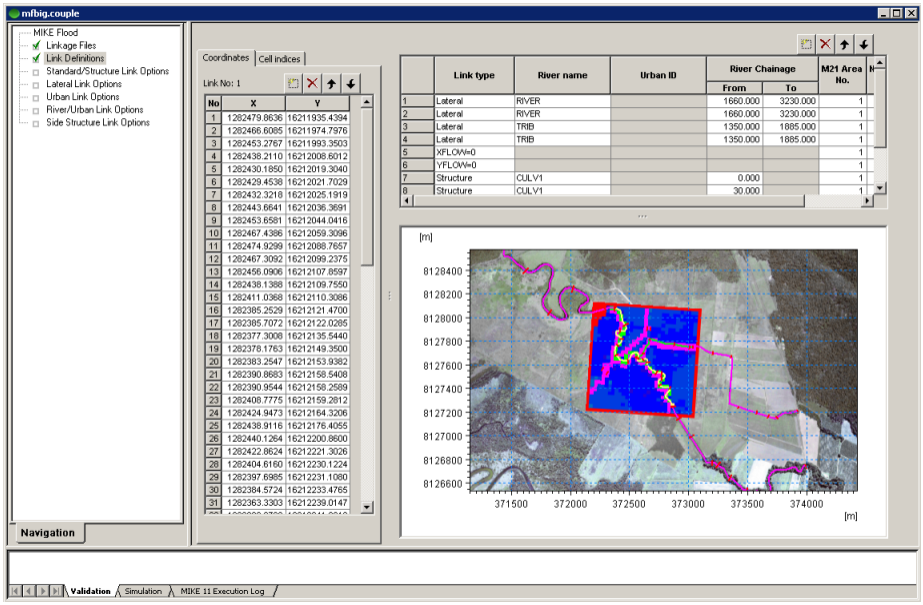


Figure 3.17 Link Definition page of the MIKE FLOOD Editor. The set-up shown utilizes a rectangular grid

Please note that standard graphical editor functions like Panning using <Shift> + Left mouse button, Zooming using <Shift> + Mouse Scroll wheel, Right mouse click access to editing tools through a pop-up dialog as well as editing options through standard toolbars are available in the graphical view of the Link Definitions page. Resizing of the different editor components in this dialog is also possible through adjustment of the divider lines separating the tabular sections from the graphical view.

Additionally, linkages can be sorted alphabetically in the overview table by double-clicking on the column header fields. Sorting are possible for the Linkage type, River name and Urban ID columns in this table.

Details on the content of the Link Definitions page is described in the following sections.

3.3.1 Link types; feature overview

The links may be of the following different types:

- Standard (river) links,
  the link is the connection between the end of a MIKE 11 branch and a series of MIKE 21 cells or element faces (the latter if MIKE 21 FM is used).

- Lateral (river) links,
  the link is the connection between one MIKE 11 river reach (within one branch) and a series of MIKE 21 cells/elements.
- Structure links,
  the link is the connection between the end of a MIKE 11 branch and a series of MIKE 21 cells (same as a standard link). However, two links are required for each structure link - one for each end of the structure. These link pairs should link adjacent cells in the grid.
- Zero flow links (XFLOW=0 and YFLOW=0),
  the link is a list of cells in MIKE 21. There is no corresponding reference to the MIKE 11 simulation.
- Urban Link,
  the link is the connection between one or more cells in MIKE 21 and a manhole, a basin, a weir, an outlet or a pump in MIKE+ (Urban).
- River Urban link,
  used for connecting the collection system directly with the river system.
- Side Structure link,
  the link is the connection between a side structure location in MIKE 11 and a single or group of MIKE 21 cells or element faces.
- Lateral (urban) link,
  the link is the connection between one MIKE+ river or natural channel reach and a series of MIKE 21 FM elements.
- Standard (urban) link,
  the link is the connection between the end of a MIKE+ river and a series of MIKE 21 FM's element faces.

Table 3.1 below presents the applicability of the above listed link-types as a function of the different coupling model-types available.

Table 3.1 An overview of the various links of their applicability

Model: ---------- Link type:	MIKE 11, MIKE HYDRO River	MIKE+ (MIKE1D)	MIKE 21 Rectangular	MIKE 21 FM
Standard (river)	Yes	No	Yes	Yes
Lateral (river)	Yes	No	Yes	Yes
Structure	Yes	No	Yes	No
Zero Flow	Yes	Yes	Yes	No
Urban	No	Yes	Yes	Yes

Table 3.1 An overview of the various links of their applicability

Model: ---------- Link type:	MIKE 11, MIKE HYDRO River	MIKE+ (MIKE1D)	MIKE 21 Rectangular	MIKE 21 FM
River-Urban	Yes	Yes	No	No
Side Structures	Yes	No	Yes	Yes
Lateral (urban)	No	Yes	No	Yes
Standard (urban)	No	Yes	No	Yes

Note that the number of links is not the total number of MIKE 21 cells/elements connected to the 1D models calculation points. To demonstrate this, the setup shown in Figure 2.1 has five links, although each link contains several MIKE 21 cells/elements. There are two links shown in Figure 2.2, one for the left bank lateral flow and another for the right bank lateral flow. Figure 2.3 has two links, one upstream of the road and the other downstream of the road.

The list of links may be re-ordered, augmented or reduced using the standard MIKE Zero Table editing toolbar:

The toolbar buttons have the following functionalities:

Add a new link. The link will be added to the list.

Remove an existing link.

Move an existing link up the list.

Move an existing link down the list.

Please note that the 'insert' and 'delete' keys on the keyboard cannot be used for inserting and deleting links in the overview.

3.3.2 Table of defined model links

The table above the Graphical view contains information on all links defined in the actual couple-file.

Links definition comprise type of link, type of coupling, River and Urban models locations as well as information on MIKE 21 model areas.

A description of the table columns is given below.

Link type

The link type defines the type of link:

- Standard (River) (E) - the E indicates that the link is explicit
- Lateral (River)
- Structure (I)- The I indicates that the link is implicit
- XFLOW=0
- YFLOW=0
- Urban
- River Urban
- Side Structure
- Lateral (Urban)
- Standard (Urban) (E)

The link type is set from the selection combo box in the Link Type column.

River name, Urban ID and M11 chainage columns

- If using a standard (River) or structure link, River name is the MIKE 11/MIKE HYDRO branch with the link and ‘From’ chainage is the chainage of the MIKE 11/MIKE HYDRO boundary point. Note that this is not necessarily the upstream chainage in the branch (it may well be the downstream chainage). The label "From" refers to lateral link specifications only. The same boundary location should exist in the MIKE 11 boundary file (*.bnd11) or MIKE HYDRO setup and be defined as a water level boundary in the initial MIKE 11/MIKE HYDRO set-up. This boundary condition specification is only to maintain consistency between MIKE FLOOD and MIKE 11/MIKE HYDRO- it will be overridden by information from the link during simulation. Furthermore, if performing an AD simulation then an open concentration boundary should be specified (not the Time Series dependent option). If using a standard (Urban) link, River name is the coupled river ID from MIKE+ (Urban) and 'From' chainage is the chainage of the river's end being coupled (upstream or downstream end).

- If using a lateral link (river), River name is the name of the MIKE 11 or MIKE HYDRO River branch. If using a lateral link (urban), River name is the name of the natural channel. 'From' chainage and 'To' chainage define the upper and lower extents of the lateral link, so all 1D calculation points between the specified chainages will be linked to MIKE 21. Note however that when using the MIKE 1D engine and MIKE 21 FM, these upper and lower extents are defined with the first and the last chainage values from the table of coordinates in the left table instead. Unlike the standard links, no further adjustments need to be made to the MIKE 11 boundary definitions. Please note that the lateral link must span a reach in the river which includes at least one grid point (typically a cross section).
- For zero flow links, no MIKE 11 information is required.
- For urban links an urban ID is required. This urban ID depends on the type of urban link. That is if the link is to an inlet or an outlet the node ID must be supplied. For a link to a pump the urban ID constitutes the pump ID and a for a link to a weir the weir ID is needed. The chainage column is not applicable.

	Link type	River name	Urban ID	River Chainage		M21 Area No.	No of M21 Cells
				From	To		
1	Standard	Thames		10023.00		1	4
2	Structure	Hudson		120.000		1	1
3	Urban		mancover1			1	3
4	River/Urban	Cherry Creek	outlet4	220.000			
5	Structure	Hudson		0.000		1	1

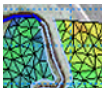
Figure 3.18 The overview of links. Four of the possible six link types are represented (lateral and side structure links are missing). Note that for a lateral link two chainages are required whereas for structure and standard links only one chainage is required. The XFlow=0 and YFlow=0 are not truly links and thus do not require any MIKE 11 data since their purpose is purely to block flow in the two-dimensional grid. Finally the Urban link requires a node ID of the manhole, outlet, weir or pump

MIKE 21 area number

This option is available for applications with nested MIKE 21 rectangular grids. The default value (for un-nested grids) is 1.Thus the M21 Area No. must correspond to the identifier in the MIKE 21 parameter file.

MIKE 21 coordinates

On the left in the overview a 'Coordinates' tab is located. This tab holds a list of (x,y) coordinates indicating the location of the linkage line. The linkage line is used differently depending on whether the MIKE 21 set-up is Cartesian or a flexible mesh based.



1. If the flexible mesh version of MIKE 21 is utilized to model the overland flow, the tab contains a third column listing chainage values along the

river. The chainage column controls how the linkage points are mapped onto the river. At run time the linkage line is mapped onto the nearest list of flexible mesh element faces.

Coordinates

Link No: 5

No	X	Y	Chainage
1	372877.	8127256.	1660.0000
2	372861.	8127295.	1698.9686
3	372846.	8127312.	1718.5050
4	372830.	8127327.	1739.6419
5	372822.	8127337.	1757.0046
6	372821.	8127339.	1767.4058
7	372823.	8127343.	1778.6277
8	372834.	8127355.	1797.4118
9	372843.	8127363.	1809.5960
10	372856.	8127379.	1825.3130
11	372862.	8127409.	1843.0635
12	372853.	8127419.	1846.6800

Figure 3.19 The list of coordinates as shown in the case of flexible mesh overland model

2. If the Cartesian version of MIKE 21 is used for overland flow the linkage line must be transformed into the equivalent linked cells in the MIKE 21 model. This transformation is done initially when creating a link but may be activated explicitly by clicking the “Update cell indices” located on the Cell indices tab. Please note that this operation will overwrite the existing linked cells in the active link and thus should only be done if the desire is to reflect edits in the coordinates.

Coordinates | Cell indices

Link No: 1

No	X	Y
1	372877.2022	8127256.9154
2	372861.3695	8127295.3093
3	372846.8381	8127312.9383
4	372830.7955	8127327.1578
5	372822.0782	8127337.3056
6	372821.1898	8127339.6508
7	372823.8203	8127343.3221
8	372834.3975	8127355.2260
9	372843.8614	8127363.5436
10	372856.6004	8127379.6907
11	372862.1243	8127409.5784
12	372853.8268	8127419.5224

Figure 3.20 The coordinates tab when utilizing a rectangular grid based overland model. Note the additional tab ‘Cell Indices

’MIKE 21 cell indices

The cell indices tab holds a list of (j,k) indices defining the MIKE 21 linked cells. That is, the grid specific cell coordinates ranging from zero to the num-

ber of cells in the horizontal and vertical directions respectively. The cells are organised in an ordered list. The linked cells can be horizontal, vertical, or have any other alignment.

Remember that when using a lateral link the cells should be ordered in a sequence corresponding to increasing chainage in the linked river.

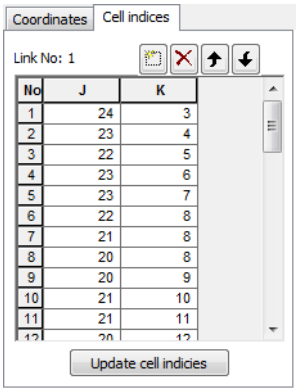


Figure 3.21 The list of cells used for a specific link (link number 1). Illustrated example presents (j,k) coordinates from a MIKE 21 Rectangular coupling. The four buttons at the top are used in the same way as the ones described for the link overview section.The update cell indices will reconstruct the list based on the current coordinates in the active link i.e. the values in the Coordinates tab

Further note that MIKE FLOOD requires lateral linked cells in the same link to be adjacent. Thus a sequence (J_1,K_1) ,(J_2,K_2) must be different and satisfy two of the following equations:

$$\begin{aligned} K_2 &= K_1 - 1 \\ K_2 &= K_1 + 1 \\ K_2 &= K_1 \\ J_2 &= J_1 + 1 \\ J_2 &= J_1 - 1 \\ J_2 &= J_1 \end{aligned} \tag{3.1}$$

The valid cells are illustrated in the figure below.

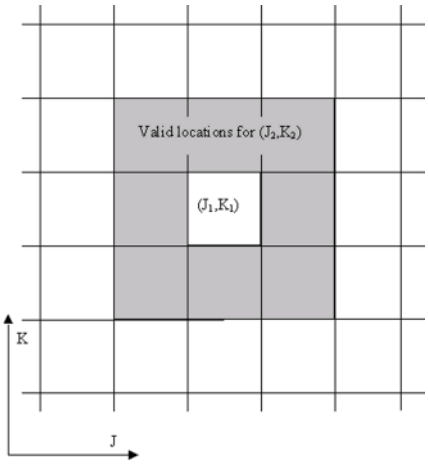


Figure 3.22 Valid locations for a cell (J_2,K_2) being adjacent to cell (J_1,K_1)

3.4 The Graphical Layout

MIKE FLOOD includes a graphical view that displays the bathymetry, the modelled MIKE 11 branches, the MIKE+ (Urban) pipe network along with additional image files (see Figure 3.23, Figure 3.24 and Figure 3.25).

The graphical view gives a clear overview of the location of the links in MIKE FLOOD. Further the graphical view has a number of tools for automatically selecting the linkage points/cells in MIKE 21 and also edit the coordinates of the individual links.

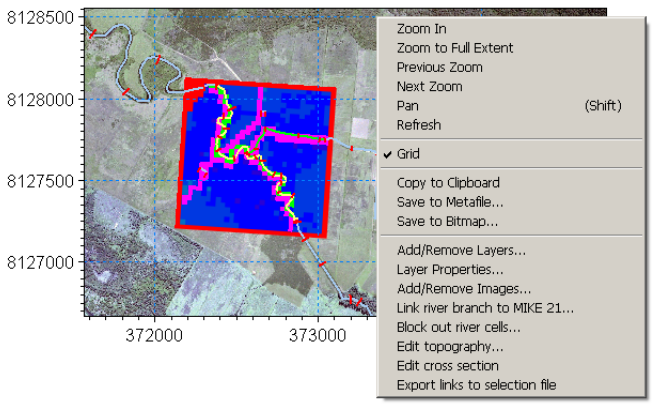


Figure 3.23 The graphical layout of MIKE FLOOD. Note the drop down list that may be accessed by right clicking. The figure illustrates the use of a rectangular grid version of MIKE 21

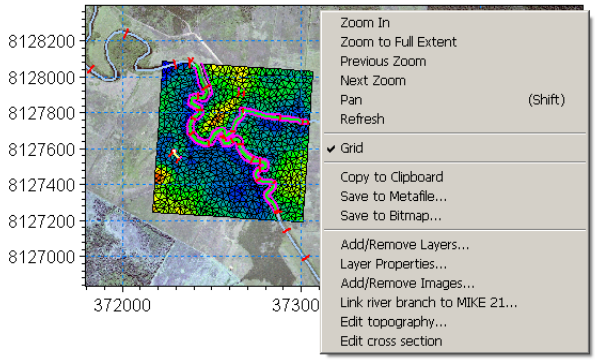


Figure 3.24 The graphical layout of MIKE FLOOD. The figure illustrates the use of a flexible mesh version of MIKE 21. The 'Block out river cells' and Export links to selection file do not apply to a flexible mesh

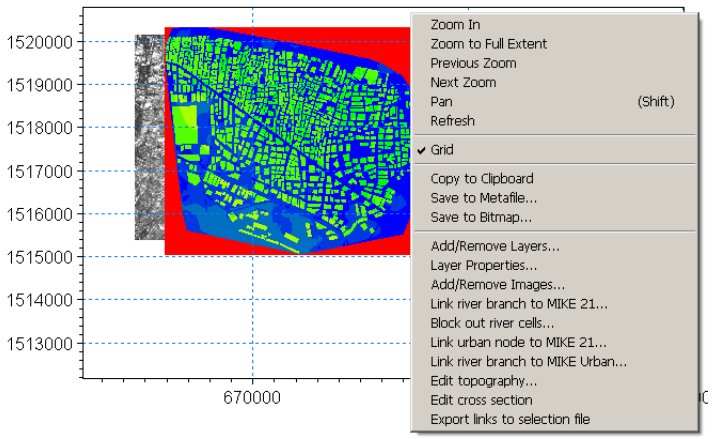


Figure 3.25 The graphical layout of MIKE FLOOD. The figure illustrates the use of an Urban model coupled to the Rectangular version of MIKE 21 as well as a River Model

Right clicking on the graphical view of MIKE FLOOD displays a number of options through the context-sensitive pop-up dialog.

The following options are available through the graphical view (some of them described in details in following sections):

- Standard Zoom features:
  It is possible to zoom in and out in the graphical view. To return to the full view right click and choose Zoom extents. Note that the extent of the graphical view is governed by the last selected file either MIKE 21, MIKE+ (Urban) or MIKE 11. Thus to ensure that all set-ups can be viewed at the same time it may be necessary to adjust the working area of the MIKE 11 and the MIKE+ (Urban) set-ups.

- Pan:
  Panning the graphical view is possible in two ways; either right click and select the listed pan option or alternatively, press and hold the <Shift> key in conjunction with the left mouse button.

- Refresh:
  Refresh the content of the Graphical View to present eventual changes in coupling files, etc.

- Grid:
  Activate / de-activate the vertical and horizontal grid coordinate lines in the graphical view.

- Copy to Clipboard or save to Graphical files:
  The content of the active graphical view can be copied to the clipboard or saved in a bitmap or a metafile format using this feature.

- Add/Remove Layers...:
  Selection of layers (bathymetry files and MIKE 11 network file) to be included in the graphical view.

- Layer Properties...
  The display properties of the graphical view for adjusting colours, symbols, lines, grid and cross section settings etc. are accessed through this sub-menu.

- Add/Remove Images...
  Adding or removing background images can be managed through this sub-menu.

- Link River branch to MIKE 21...
  MIKE11 Branches may be automatically linked to the MIKE 21 set-up.

- Link natural channels to MIKE 21...
  Natural channels from MIKE+ (Urban) may be automatically linked to the MIKE 21 FM set-up.

- Block out River Cells...
  Cells lying in the main MIKE 11 river bed between the left and the right levee may be blocked out. This may be done to ensure that mass is not double counted.
  Note this feature is only available for the rectangular grid version of MIKE FLOOD.

- Link Urban node to MIKE 21...
  Nodes in the urban MIKE+ (Urban) set-up may be linked to the MIKE 21 grid cells/elements through this sub-menu.
  Note: Only visible when Urban coupling is active.

- Link River branch to urban network..
  Opens sub-menu for linking MIKE HYDRO river branches to MIKE+.

- Edit Topography...
  Opens the topography file of the MIKE 21 model in the respective editor (dfs2 grid-file for Rectangular version and Mesh file for Flexible Mesh version).

- Edit Cross sections...
  Opens the MIKE 11 Cross section Editor at the cross section closest to the cursor.

- Export Link to selection file...
  Utility for creating a selection file (dfs2) containing selection values in all the MIKE 21 grid-cells included in specified links.
  Note, this feature is only available for the rectangular grid version of MIKE FLOOD.

3.4.1 Select and activate linkages graphically

It is possible from the graphical view to select and activate any linkage in the setup in order to quickly assess and edit specific linkage definitions.

When the graphical view is active (click the mouse within the graphical view to activate) a ‘Couple model link editor’ toolbar is visible as illustrated in Figure 3.26 below. From this toolbar it is possible to activate a ‘Select Mode’ option as highlighted with a red circle below.

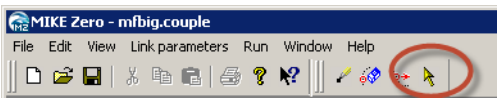


Figure 3.26 Select and activate linkage option in Couple model link editor toolbar

With the Select Mode active it is possible to point to any linkages in the graphical view and a fly-by label for the link will be presented as well as once you click on a linkage in the grabphical view, all tables will be activated and the specific link selected will be highlighed in and made active in the linkage tables on this page.

3.4.2 Editing linkage lines graphically

The MIKE FLOOD interface makes it possible to edit the coordinates of the linkage lines graphically. Three graphically editing tools are available. in the toolsbar of the graphical interface.

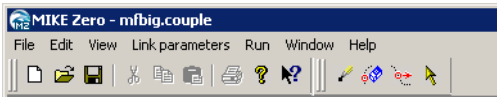


Figure 3.27 The graphical editing tools for modifying linkage lines

If the tools are not visible do the following

1. Ensure that he MIKE FLOOD editor is the active window
2. Ensure that 'Link definitions' has been selected in the tree view on the left.
3. If the tools are not visible then click View - Toolbar in the main menu bar of MIKE Zero
4. In the menu that appears please activate the 'Couple Model Link Editor' toolbar and click ok.
5. The toolbar should now be visible.

There are three tools available for editing linkage lines. Below follows the layout along with a description of the functionality:

- Insert intermediate points in a linkage line.
- Delete points in a linkage line.
- Move points in a linkage line.

Note that points cannot be augmented to a linkage line directly. To augment points to an existing line move the appropriate end point of the line to the new end location and subsequently insert additional points in the line. When inserting points in a linkage line chainages will be interpolated for the inserted points. Further note that the graphical operations described above only modify the list of coordinates for the links. Thus when editing linkage lines please consider whether the changes must also be reflected in some of the other parameters describing the link e.g. the 'to' and 'from' values for chainages in lateral links.

The graphical editing tools are not designed for adding new links. To this end use the automatic linkage tools as found when right clicking on the graphical map.

3.4.3 Information on the individual cells

To obtain information on the individual MIKE 21 cells simply click on a cell in the graphical view. The (j,k) coordinates for MIKE 21 Rectangular grid and geographical coordinates for a MIKE 21 FM coupling will be displayed in the lower information bar of MIKE Zero (see Figure 3.28).

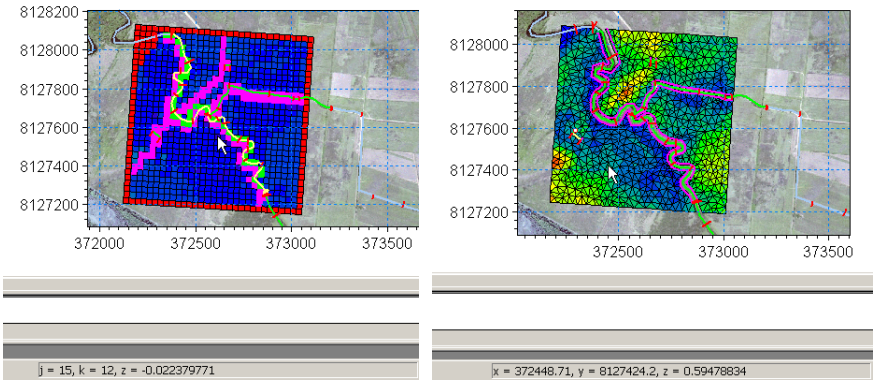


Figure 3.28 Clicking a particular cell displays the information in the lower MIKE Zero bar. Left: MIKE 21 Rectangular model (j,k) coordinates. Right: MIKE 21 Flexible Mesh model coordinates

3.4.4 Add/Remove layers...

The Add/Remove layers feature controls the coupling files components to be presented in the Graphical View.

The graphical view per default displays all bathymetry files found in the MIKE 21 file along with the branches found in the MIKE 11 network file and the pipes located within the MIKE+ (Urban) model. Additional bathymetry files, MIKE 11 network files and pipe networks may be displayed if needed through this menu.

The sub-menu has two tab-pages. The first (Figure 3.29) controls the model files to be displayed and the second controls the display order of all files including images and colour legends

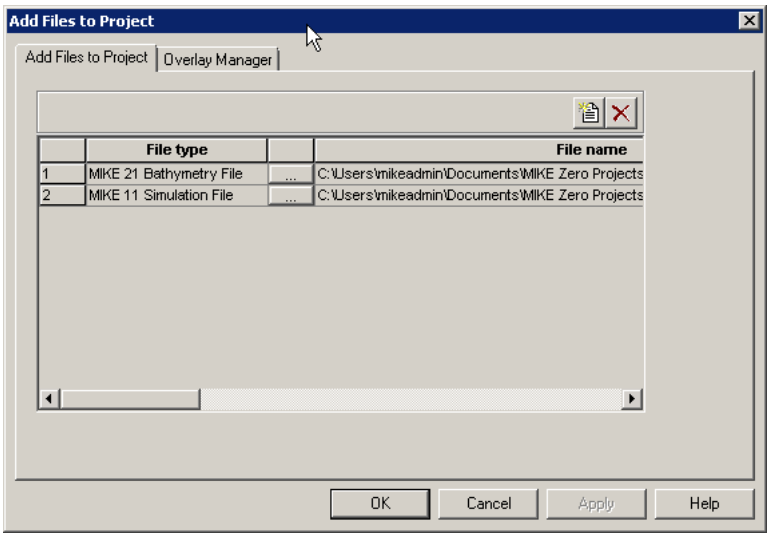


Figure 3.29 Files included in the set-up. The files from the coupled set-ups are included by default. Additional bathymetry files, mesh files and MIKE 11 or MIKE+ files may be added

Add or remove lines in the Files-table by use of the two table editing icons on the dialog. Use to Create a new line and to Delete an existing line.

To add a new file to be presented in the Graphical view follow the steps listed as below:

- Create a new line using the Create Line Icon
- Select the type of file to include by selection from the drop down selection combo-box present in the 'File Type' column
- Use the find file button; ... to select the required model file.

The second tab-page (Figure 3.30) is the general 'Overlay Manager' where the order of layer files and images can be defined. The Overlay manager for Layer files presents the selected and active image files on the Graphical view in an ordered listing with the image defined in the first line as the first layer and the Image in the last line as the top-most image.

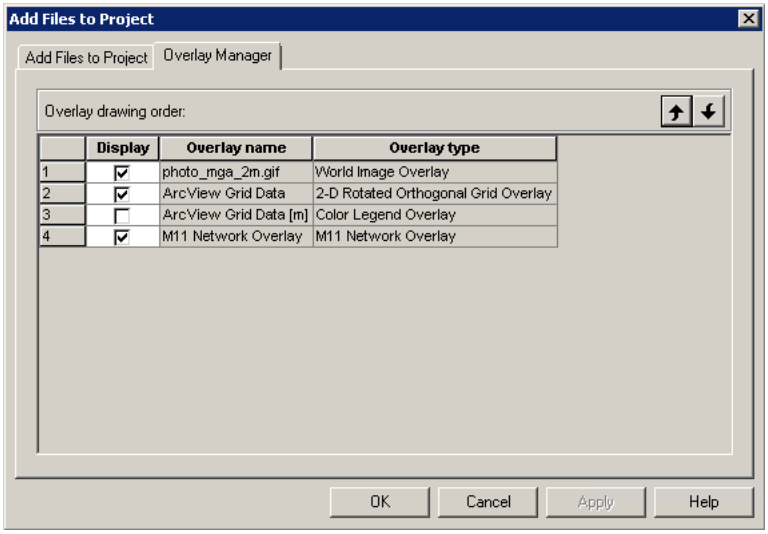


Figure 3.30 The overlay manager controlling which graphical themes to be displayed as well as the order of the themes. The latter may be changed through the use of the two arrow buttons in the upper right hand corner

To change the order of items in the table list, highlight a line by clicking in the row number column and then use the icons to move the line up in the list or to move the line down in the list.

3.4.5 Layer properties...

The Layer Properties dialog enables the user to configure the appearance of the Graphical view by activating/de-activating settings for the individual files as well as adjusting colours, lines, symbols etc. for items within the coupled files and linkage definitions.

The appearance of the Layer properties dialog depends on the type of MIKE 21 file used in the coupling as different features can be presented if a Rectangular grid or a Flexible Mesh is applied.

The four buttons at the bottom of the dialog have the following functionalities:

- OK
  Close the Properties dialog and activates eventual layer properties changes.
- Cancel
  Close the Properties dialog without activating latest changes (that is, changes made in dialog from last activation of ‘Apply’).
- Apply
  Applies the changes defined without closing the dialog.

- Help
  Opens the Help page.

Figure 3.31 presents the Layer Properties for the MIKE 21 Rectangular grid, where options specific for the Rectangular grid can be defined.

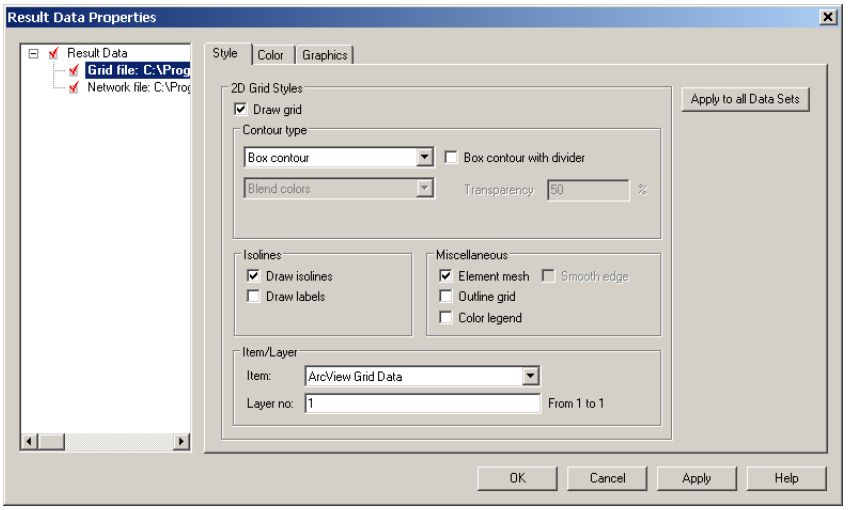


Figure 3.31 Layer Properties dialog for MIKE 21 rectangular grid file

Options are:

- Draw grid
  Activate / de-activate the drawing of the 2D Grid

- Contour Type
  Defines the contours presentation. Options are: Box contour with or without transparency, Shaded contour or no control.

- Isolines
  Draw isolines in the view. If 'Draw Isolines' is active it can be chosen whether or not labels should be presented on the isolines as well using the 'Draw Labels' tick-box.

- Miscellaneous
  Options for drawing of 2D Grid, activate colour palette/legend and smoothing edges if Shaded Contour is selected.

- Item/Layer:
  Select the layer to present if multiple layers/items are present in the Grid file.

- The 'Apply to All Data Sets' button
  Use this button to apply the definitions in this page to all data sets present in the 2D grid file (if more than one layer)

The Colour definition page (Figure 3.32) is used to define the colour palette (legend) for the 2D bathymetry values.

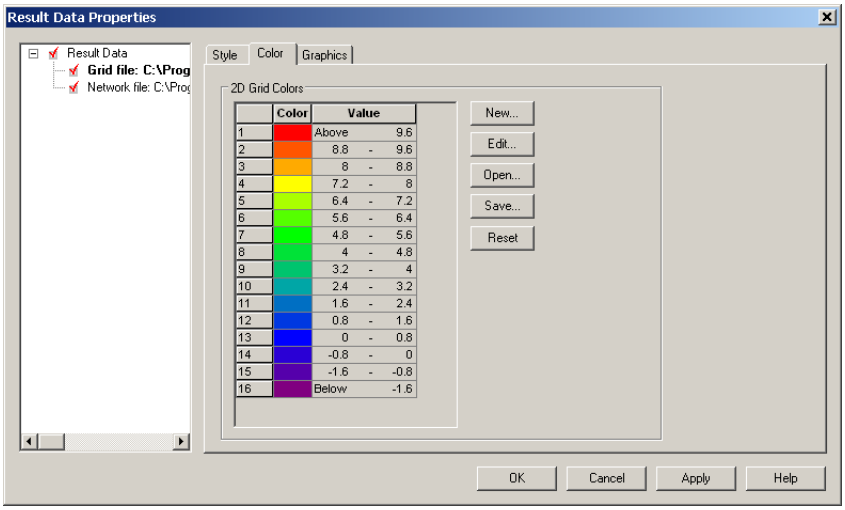


Figure 3.32 Layer Properties Colour definitions page for the 2D Grid colour palette

The buttons in the page have the following functionality:

- 'New...':
  Opens the Palette Wizard for creation of a new colour palette with user-defined selection of palette-type, colour-mode and number of colours in palette.
- 'Edit...':
  Opens the Edit Palette dialog for editing colours or values of the existing colour palette.
- 'Open...'
  Opens an existing colour palette file (*.pfs).
- 'Save...'
  Save the active colour palette to a palette file (*.dfs)
- 'Reset'
  Presently not activated.

The Graphics definition page (see Figure 3.33) includes options for user-defined settings of colours, symbols and text-displays in the graphical view for the cells in the MIKE 21 included in a link.

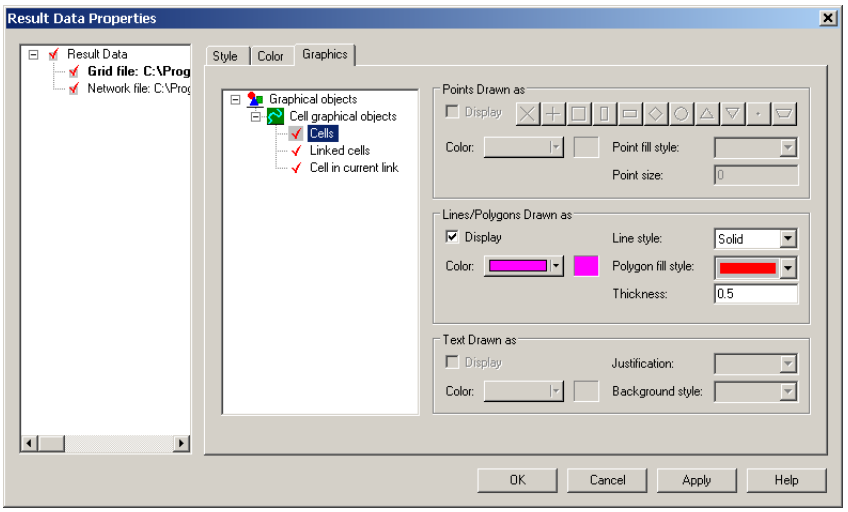


Figure 3.33 Layer Properties dialog; Graphics definition for MIKE 21 Rectangular grid coupling

Definitions can be made for:

- 'Cells'
  Settings for 'cells' applies to all cells which have been linked in the MIKE 21 model.
- 'Linked Cells'
  Settings for cells in the selected/active link in the Graphical view (active link in the links overview table).
- 'Cell in Current Link'
  Colour definition for the single selected cell in the actual MIKE 21 link (active cell selected in the MIKE 21 coordinates table for the selected link)

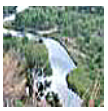


Figure 3.34 presents the Layer Properties for the MIKE 11 Network file and branch linkages.

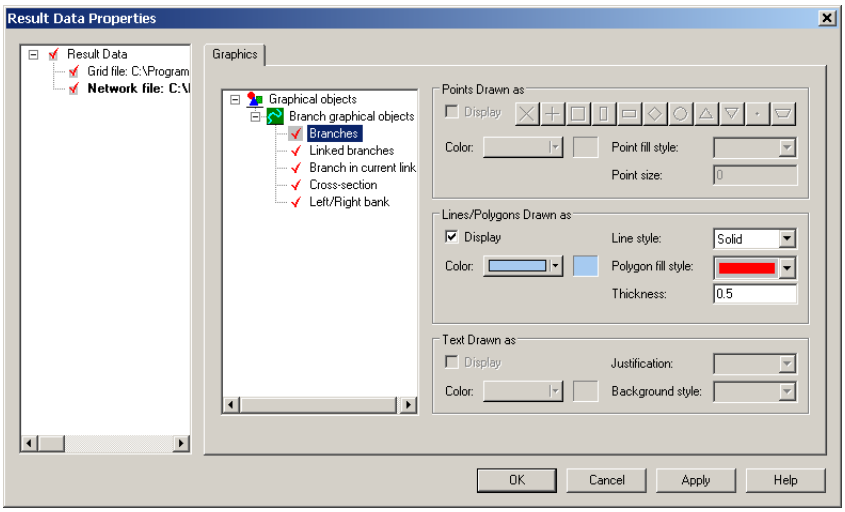


Figure 3.34 Layers Properties dialog for MIKE 11 Network appearance on the Graphical View

Colours and symbol settings can be made for the following features:

- 'Branches'
  General settings for river branches in the river network file.
- 'Linked Branches'
  Settings for river branches included in a link definition.
- 'Branch in Current Link'
  Settings for the river branch line in the active link (activated link in the links overview table)
- 'Cross sections'
  Settings for cross section lines in the river model.
- 'Left/Right Bank'
  Settings for Left and Right bank lines

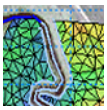


Figure 3.35 presents the Layer Properties for the MIKE 21 Flexible mesh file, where options specific for the Flexible Mesh can be defined

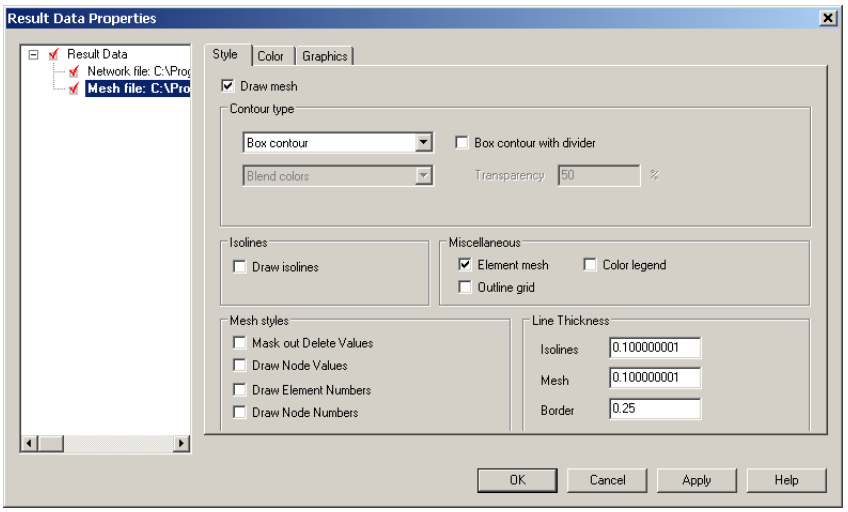


Figure 3.35 Layer Properties dialog for MIKE 21 FM mesh file appearance in the Graphical View

Options available for the Flexible Mesh settings are:

- Draw Mesh:
  Activate / de-activate the drawing of the 2D mesh
- Contour Type:
  Defines the contours presentation. Options are: Box contour with or without transparency, Shaded contour or no control.
- Isolines:
  Draw isolines in the view.
- Miscellaneous:
  Options for drawing of 2D Mesh, activate colour palette/legend.
- Mesh Styles:
  Miscellaneous options for Mesh features presented in the Graphical View.
- Line Thickness:
  Line settings for drawing of the 2D Mesh

The Graphical settings page for MIKE 21 Flexible mesh model is presented in Figure 3.36.

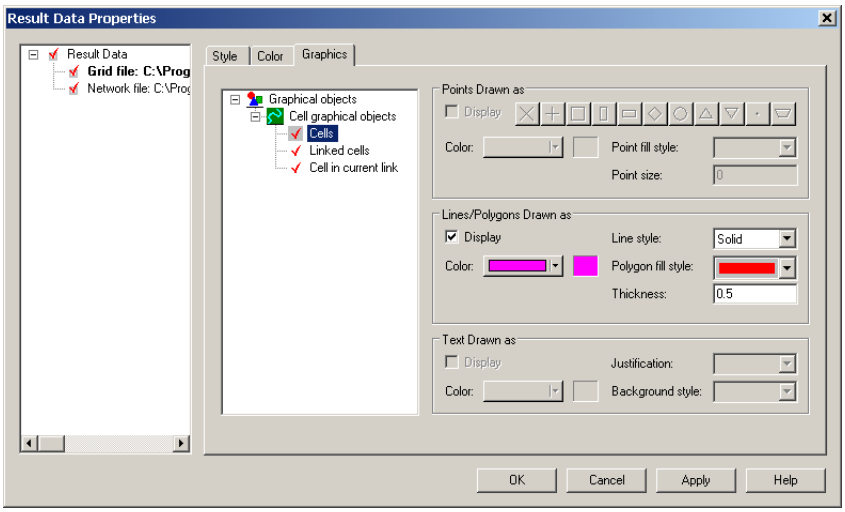


Figure 3.36 Layer Properties dialog; Graphical settings page for MIKE 21 FM mesh file coupling

Graphical settings can be made for:

- 'Links'
  Line definition for all link lines defined for the MIKE 21 FM model.
- 'Current Link'
  Settings for the link line in the selected/active link in the Graphical view (active link in the links overview table).
- 'Selected Point'
  Symbol definition for the single active point in the actual MIKE 21 FM link (active point selected in the MIKE 21 coordinates table for the selected link)

When MIKE 21 FM is set up with a rectangular grid domain, the Layer Properties are the same as when using MIKE 21 rectangular grid.

3.4.6 Add/Remove images...

This menu controls image files to be presented as layers in the Graphical View.

It is possible to display the following types of files:

- graphical image files: *.bmp, *.jpg and *.gif.
- GIS shape files: *.shp.
- XYZ ASCII files: *.xyz
- MIKE 11 network files: *.nwk11

- mesh files: *.mesh
- dfs files: *.dfs0, *.dfs2
- Enhanced metafiles: *.emf

For each of the different files some of the display settings may be edited by clicking the ‘edit’ button found in the same row as the image file to be edited.

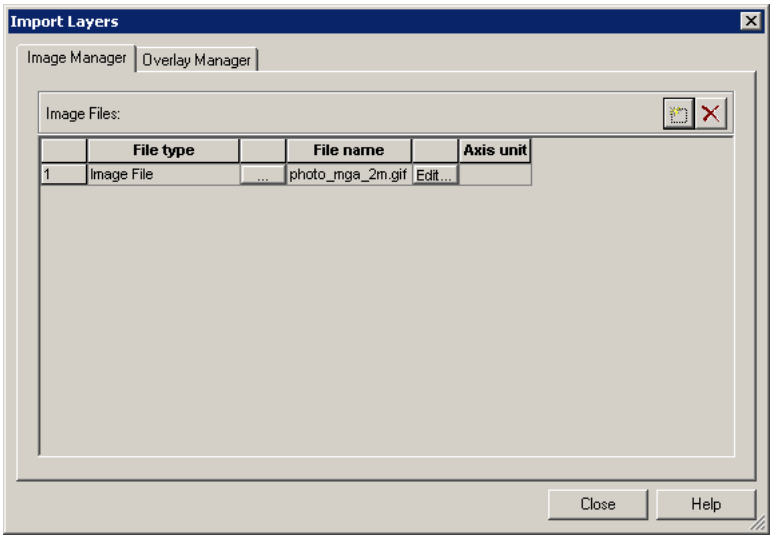
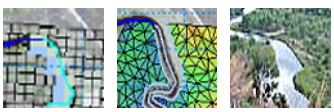


Figure 3.37 The Add/Remove Images dialog

Images may be added or removed using the two buttons in the upper right hand corner. inserts a new image line and removes an existing line from the table.

The second tab-page in this dialog is the standard Overlay manager for Layer files presented in the Graphical view and identical in behaviour and performance to the overlay manager presented and described in the ‘Add/Remove layers...’ section (see Figure 3.30).

3.4.7 Link river branches to MIKE 21



The MIKE FLOOD interface has an automatic linkage tool available for linking the river branches in MIKE HYDRO River or MIKE 11 to MIKE 21.

Several different linkage types can be processed using this tool:

- Lateral links
- Standard and Structure links
- Side Structures Link

The Automatic selection and definition of Lateral Standard/Structure and Side Structure links are made through the 'Link River Branch to M21...' dialog, which can be opened from the Graphical view, right-mouse pop-up menu. This dialog is presented in Figure 3.38 below:

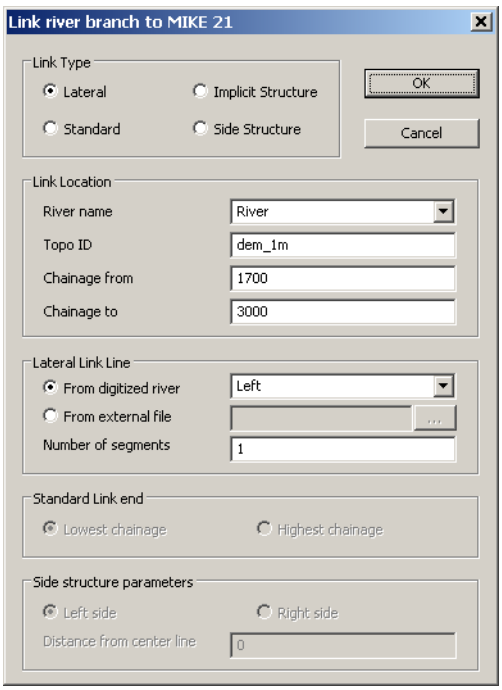


Figure 3.38 The 'link branch to MIKE 21' sub-menu. Note that for a lateral link two chainages are required whereas for standard/structure links only information on whether the link is to be applied to the upstream or the downstream end of a branch is needed

Once a link has been established, the location of the link may be inspected by stepping through the link in the M21 coords table, whereby the active cell/point is highlighted in the graphical view and thereby it can be ensured, that links are defined according to expectations.

Lateral link definition

The lateral link requires the user to supply the river branch name and the topo-ID used. River name can be selected from the drop-down selection box and the Topo-ID as defined in the network file is then listed in the Topo ID field.

A lateral link is generated for a user-defined length of the river. Upon selection of the river name and Topo ID the 'Chainage from' and 'Chainage to' fields are automatically defined with the start and end chainage of the river as defined in the River network file. If it is requested to only include a part of the actual river in the lateral link then it is required to adjust the chainage-values to adjust to the specific reach where the link must be defined.

The determination of which 2D cells/elements are to be included in the link can be made either by use of an external file, or from an automatic cell selection based on the extent of the cross sections in the river reach.

- Lateral link line from External file:
  This option requires the user to supply a *.xyz ASCII file, or a shape file containing one single polyline (only the x and the y values are required). The *.xyz file should be space delimited and should not have any comments within it. Only one link line per file can be processed.

- Lateral link line from Digitized river:
  For the automatic cell selection the user must specify whether the actual linkage are to be made along the centre line of the river, along the right side or the left side of the river defined by the left or right levee definition in river cross sections.
  Cross sections are generally defined such that Marker 2 represents the centre line and Markers 1 and 3 represents the Left and Right levee positions respectively.
  Note that it is also possible to create lateral linkage lines on both right and left side in only one operation.

A lateral link can be automatically divided in a number of links using the 'Number of Segments' field. This variable defines the number of sub-segments the actual river reach will be divided into during link-generation, and an equivalent number of lateral links are then automatically generated and added to the overall links-table.

Using the Number of Segments variable, each of the links generated will be defined from sub-reaches of the total river reach length with sub-reach lengths calculated as:
(Chainage To - Chainage From)/NumberOfSegments.

Based on the information entered by the user, the tool automatically selects either:

- the MIKE 21 grid cells intersected by the left/right/centre line for the rectangular grid version, or

- if Flexible Mesh is applied, the coordinates of the left and the right end points of the cross sections.

Implicit structure or standard structure link definition

The definition of a Standard link or a Structure link requires the user to specify the branch name (from the drop-down selection box) and the Topo-ID initially.

Secondly, it must be defined whether the actual link is to be applied at the upstream end of the river (Lowest Chainage) or at the downstream end of the river (Highest Chainage).

Note that for Implicit Structure link, a link upstream and a link downstream are automatically generated.

The link generation routine creates a link between the river at the selected point and one or more 2D calculation grids/elements depending on the width of the cross section at the connection point and the size of grids/elements in the 2D model.

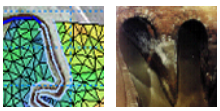
Side structure link definition

The Side Structure Link definition requires the specification of the location of the side structure in the network file. That is, the River Name, the Topo ID as well as the Chainage where the actual Side Structure has been defined in the Network file (the structure chainage is supplied in the 'Chainage From' field).

In the lowest section of the dialog, a selection can be made on which side of the river the actual side structure will be linked (Right or Left) and additionally, the distance from the centre-line of the river is given, which determines how far away from the river the side structure branch in MIKE 11 will be connected to the 2D model area.

The link generation routine typically creates a link with just one M21 coordinate set - indicating that the link is only using a single 2D cell. However, if additional cells are required for linking (due to stability problems or other issues) it is possible to manually add additional coordinate sets to the M21 coordinate table in the lowest section of the dialog.

3.4.8 Link natural channels to MIKE 21



The MIKE FLOOD interface has an automatic linkage tool available for linking the natural channels in MIKE+ to MIKE 21 FM.

The automatic selection and definition of Lateral (urban) links are made through the 'Link natural channels to MIKE 21...' dialog, which can be opened from the Graphical view, from the map's contextual menu. This dialog is presented in Figure 3.39 below:

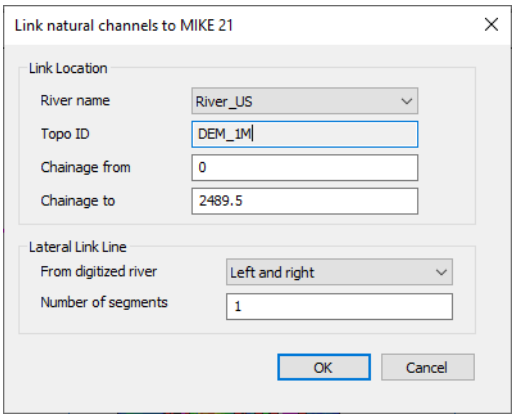


Figure 3.39 The 'link natural channels to MIKE 21' sub-menu.

The lateral link requires the user to supply the river (natural channel) name and the topo-ID used. River name can be selected from the drop-down selection box, and the Topo-ID as defined in MIKE+ is then shown in the Topo ID field.

A lateral link is generated for a user-defined length of the river. Upon selection of the river name and Topo ID the 'Chainage from' and 'Chainage to' fields are automatically defined with the start and end chainage of the river as defined in MIKE+. If it is requested to only include a part of the actual river in the lateral link then it is required to adjust the chainage-values to adjust to the specific reach where the link must be defined.

The determination of which 2D elements faces are to be coupled is made from an automatic selection based on the extent of the cross sections in the river reach. The user must specify whether the actual linkage is to be made along the right side of the river, the left side, or both sides. In the latter case, two lateral links will be created.

A lateral link can be automatically divided in a number of links using the 'Number of Segments' field. This variable defines the number of sub-segments the actual river reach will be divided into during link-generation, and an equivalent number of lateral links are then automatically generated and added to the overall links-table.

Once a link has been established, the location of the link may be inspected by stepping through the link in the MIKE 21 coordinates table, where the active point is highlighted in the graphical view and thereby it can be ensured that links are defined according to expectations.

3.4.9 Block out river cells...

If cross sections of the rivers in a set-up are generally wider than one cell size in the 2D Grid, then it may be appropriate to block out the cells in the 2D bathymetry lying within the main river bed and hence avoid, that any flow calculation is performed by the 2D model in these cells. Thereby, it can be ensured that the water body within the main river is not included twice in the coupled model simulations.

Blocking out cells in the 2D bathymetry is a process where single or multiple cells are set equal to the 'Land Value' defined in the bathymetry editor, and therefore, the blocking out of cells requires the user to edit the MIKE 21 bathymetry in the grid editor.

The MIKE FLOOD interface can (based on the cross sectional widths or external files) identify and select all the 2D grid cells obtained as a function of the defined blockage option, and the selection is exported to a so-called selection-file. This selection-file may then subsequently be used in the grid editor to ease the selection and editing of cells to be blocked within the main river bed. To access the selection tool for blocking out cells simply right click in the graphical view and select the 'Block out river cells' menu item. The dialog that appears is presented in Figure 3.40.

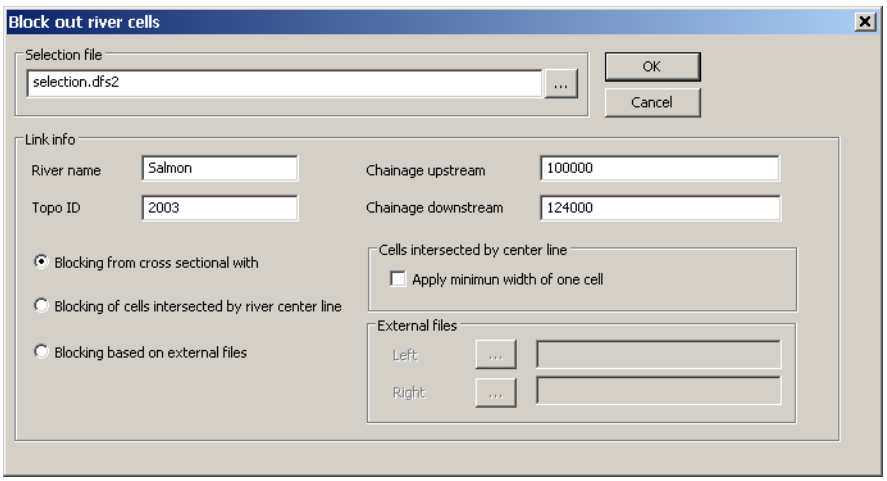


Figure 3.40 The dialog box for selecting which cells to block out in the MIKE 21 bathymetry

Multiple options for selection of 2D grid cells are available:

- Blocking from cross sectional width
  Selected grid cells will be fully located within a polygon deliniated by the left and right embankment lines (defined by markers 1 and 3 in cross sections) within the linkage reach.
  It is important to notice, that the river width can be smaller than the grid cell size in the 2D model and in that case, no cell will be selected as this option per default requires that the entire cell must be covered by the embankment polygon. Consequently, the possibility for obtaining a selection of cells with 'gaps' present is big for smaller river applications.
  To avoid this problem and secure that a full, connected line of cells are selected from this option, it is possible to activate the 'Apply minimum width of one cell' option, which will secure that even for very small and narrow rivers, at least cells following the river centre line will be selected at locations where the river width is smaller than the grid cell size.

- Blocking of cells intersected by river center line
  Choose this option to select only the grid cells which are overlaid by the river centre line.
  This option secures that a full, connected line of cells are selected without including any information about the local width of the river.

- Blocking based on external files
  Selection of cells can be made from external files (either *.xyz ascii file or shape-file). Two external files are required in order to define the area between right and left side of the river where cells shall be selected.

The block out tool must be applied to each river reach separately, as the block out reach is selected based on the river name, the topo-ID and the upstream/downstream chainages.

The selection file is a dfs2 file with the extent of the 2D bathymetry and a value of 1 in all selected cells as illustrated in Figure 3.41.

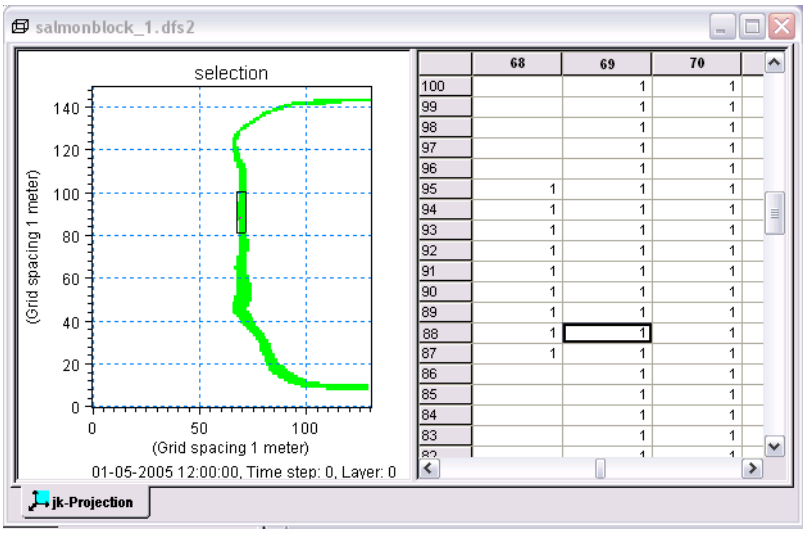


Figure 3.41 A selection file opened in the grid editor of MIKE Zero

As MIKE FLOOD can be used also with nested grids (provided a nested MIKE 21 is available) the selection tool may export multiple files for the same river reach i.e. a selection file for each grid in the MIKE 21 set-up. To distinguish between these different selection files MIKE FLOOD inserts the area number at the end of the file name e.g. if the file name ‘selection.dfs2’ is chosen the actual selection files are named ‘selection_1.dfs2’, selection_2.dfs2, etc. depending on the number of nested grids in the MIKE 21 set-up.

Step by step procedure for blocking out cells in the river bed

1. In the MIKE FLOOD graphical view right click and select the ‘Block out river cells...’ option (see Figure 3.42).

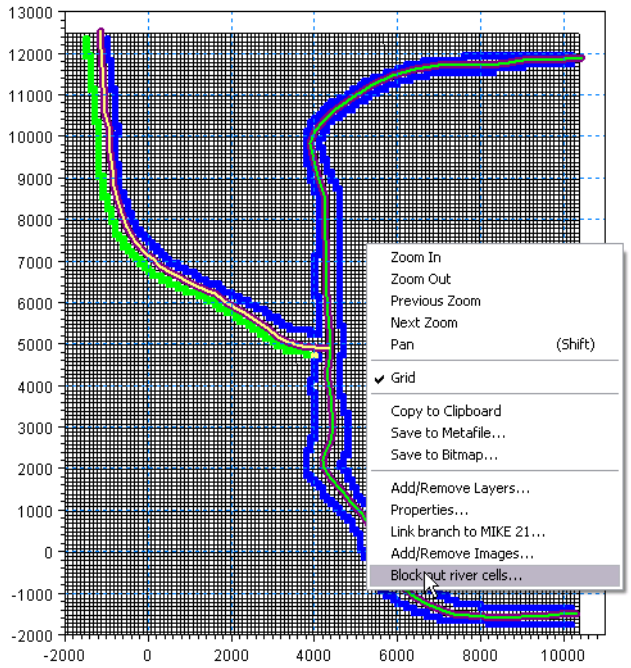


Figure 3.42 Accessing the blockage tool in MIKE FLOOD

2. In the dialog that appears select the river reach that the blockage is to be applied to. Please ensure that the river name is typed correctly and that the correct topo-ID is also supplied. If chainages are given which are beyond the river reach the values are modified to coincide with the reach ends. Also supply the name to be used for the selection file including the .dfs2 extension (see Figure 3.40).

   When everything is defined, pressing OK creates the requested .dfs2 selection file. Note, that only one river can be saved to a selection file and hence, if multiple rivers are to be blocked out, multiple selections files have to be created using this tool.

3. Open the bathymetry file used in the MIKE 21 set-up. The file may be accessed through a right-click on graphical view and selecting “Edit topography”. This automatically opens the bathymetry file in the Grid Editor. The file can also be opened from the ‘file -> open’ menu of MIKE Zero or through the MIKE 21 interface by clicking the ‘view’ button found in the bathymetry menu. The latter automatically opens the bathymetry

file in the Grid Editor.

4. With the bathymetry file as the active window in MIKE Zero it is possible to access the menu 'Tools -> Load Selection' found in the main menu bar of MIKE Zero. At this point you are prompted for the selection file. Browse for the selection file previously generated remembering that the file name has been augmented with a number indicating the area number. The selected cells will by now be highlighted in the grid editor.

5. Access the 'set value' through the 'Tools' menu of the main MIKE Zero tool bar and provide the land value of the dfs2 file in the active box (see Figure 3.43).

6. Save the bathymetry file under a different name to ensure that the original data is not overridden.

7. Repeat the procedure for all rivers requiring blocking out of cells.

8. In the MIKE 21 editors bathymetry menu select the new edited bathymetry.

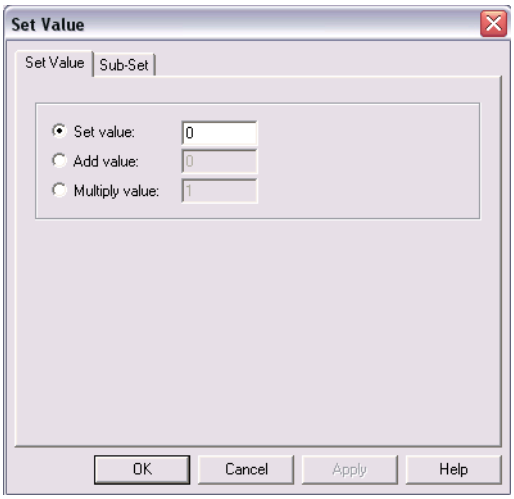


Figure 3.43 The set value dialog. Choose the appropriate land value for the dfs2 file

3.4.10 Link urban node to MIKE 21...

Urban nodes may be linked to MIKE 21 through the use of this tool. The tool can automate the linking of all urban nodes to the MIKE 21 grid/mesh or the user may select individual nodes to link based on either a drop down list or a node selection file (*.nse or .mus).

Urban nodes listed in the drop down list include manholes, outlets, basins, weirs and pumps available in the MIKE+ (Urban) setup.

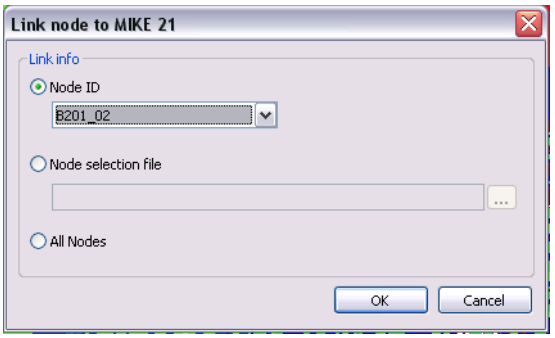
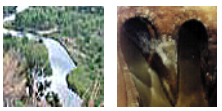


Figure 3.44 The link node menu. The user can either link all urban nodes in the set-up or a selection through the drop down list of node ID's

3.4.11 Link river branch to urban network...



MIKE 11 River branches can be linked to MIKE+ using the tool presented in Figure 3.45.

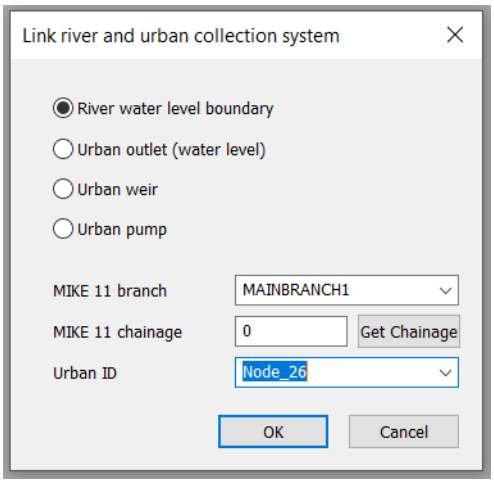


Figure 3.45 The Link River Branches to MIKE+ collection system dialog

Select the type of coupling from the radio buttons and thereafter; select the river branch to be linked from the branch list drop-down menu, specify the river branch chainage of the link location and finally, select the ID for the urban node which shall be coupled from the Urban ID drop-down selection menu.

3.4.12 Export links to selection File...

The 'Export Links to Selection File' is a feature which exports MIKE 21 grid cells for all or selected links in the Coupling file to a dfs2 grid file. The selection file generated is then typically used in the grid editor as a selection file when editing for instance bathymetry or model inputs such as resistance or eddy viscosity grid files.

This feature is only available for couplings with MIKE 21 Rectangular grid.

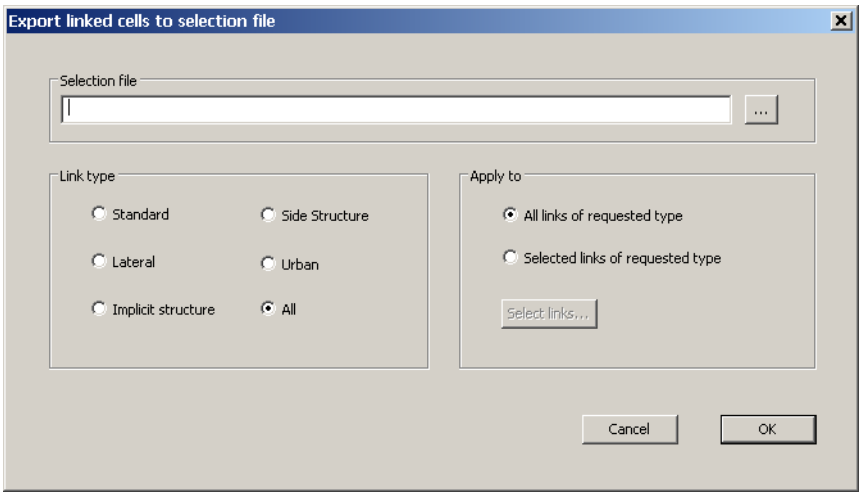


Figure 3.46 Dialog for Exporting linked MIKE 21 rectangular grid cells to a grid selection file

To generate a Selection file for Linked cells do the following:

- Define the file name for the selection file. Output file from this tool is a 2D rectangular grid file and hence, file extension must be '.dfs2'
- Select the type of links to be included in the exported links file (specific link type or simply All links in the model).
- In the 'Apply To' box it can be defined whether all links of the selected type in the model should be included in the export process or only a sub-set of links should be included. In the latter case, use the 'Selected links of requested type' and press the 'Select Links...' button to open the Links selection dialog (section 3.1.8).

Figure 3.47 below presents an example of a grid file generated from the Export Links to Selection file tool. The present example includes 'All' links in the actual setup.

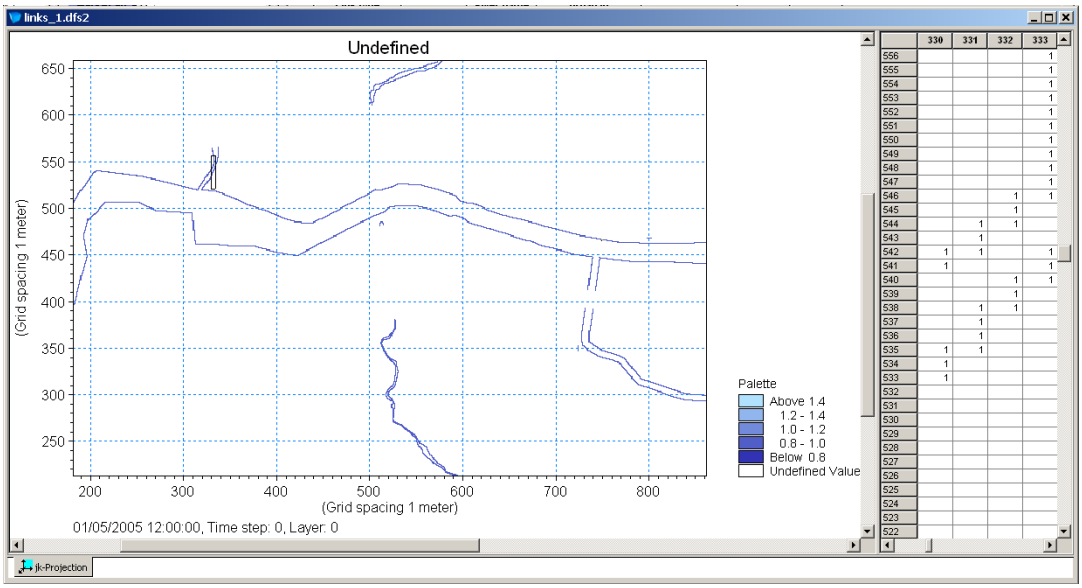


Figure 3.47 Example of selection file generated using the export linked MIKE 21 rectangular grid cells

The cells exported to the selection file are always defined with a value of 1 in order to use them for selections in the grid editor.

3.5 Details on Standard / Structure Links Options,

The options listed here are only applicable for Standard and Structure links.

Standard/ImplicitStructure Link Options

	Link type	River name	ChainageUS	Mom Fact	Ext Fact	Add/Replace Flow	Depth Adjst	Activation Depth(min)	Activation Depth(max)	Exponential smoothing factor
1	Lateral	RIVER	1660.000							1.000
2	Lateral	RIVER	1660.000							1.000
3	Lateral	TRIB	1350.000							1.000
4	Lateral	TRIB	1350.000							1.000
5	XFLOW=0							0.000	0.000	
6	YFLOW=0							0.000	0.000	
7	ImplicitStructure	CULV1	0.000			Replace	No			1.000
8	ImplicitStructure	CULV1	30.000			Replace	No			0.800
9	ImplicitStructure	CULV2	0.000			Add	Yes			0.800
10	ImplicitStructure	CULV2	30.000			Add	Yes			1.000
11	Standard(E)	CULV1	30.000	1.000	1.500		No			1.000
12	Standard(E)	CULV1	30.000	1.000	1.500		No			1.000

Figure 3.48 Overview of options for standard and structure links. Note that the first column is carried over from the Definition page and cannot be edited

The first column in the table is carried over from the Definition page and indicates the type of link for all links defined in the coupling file. The type definition cannot be edited.

Sorting of linkages is possible in the table by double-clicking on the column headers of either the Link type or the River name columns.

Columns two and three contain the location of the link. That is, the River name and the chainage of the river where the link has been defined.

The Link Options page includes the option of searching for a specific link in the list using a string search for either river names or urban ID's. The Search Link feature as illustrated in Figure 3.49 is activated by pressing keys 'CTRL+F' or through the main menu; Edit -> Search.

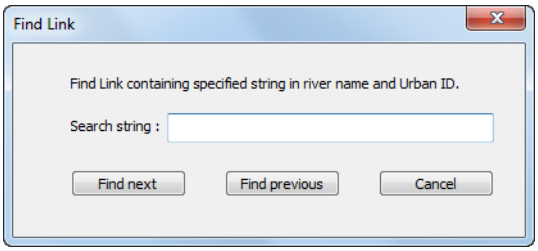


Figure 3.49 The Find Link dialog available in Link Details pages

3.5.1 Mom fact

'Mom Fac' is an abbreviation for Momentum Factor. The Momentum Factor is active for Standard Links only and applied to the momentum terms in MIKE 21 rectangular grid only.

Momentum Factor of 1 means that momentum is calculated through the link, whereas a value of 0 means that momentum through the link is not guaranteed.

Note that even if the factor is set to 0, the source term applied to the continuity equation still creates some momentum. While this is sufficient in cases where conservation is not critical (such as over weir structures or for very large 2D cell size relative to the river flow capacity), it will not be accurate enough for all cases. On the other hand, in some instances model stability may be improved by removing the momentum terms.

For the structure links, momentum is preserved via the implicit terms and this parameter is not applicable.

The momentum factor is not used with MIKE 21 FM. The transport of momentum is not exchanged between the river model and MIKE 21 FM, but there will be a calculation of momentum because the standard link is implemented as a discharge boundary in MIKE 21 FM (the same applies with lateral links when using MIKE 21 FM).

Specifically, at a standard link, the mean surface elevation is calculated in MIKE 21 Flow Model FM and sent to MIKE 1D. The mean surface elevation is calculated as the mean value of surface elevation in the real wet elements along the face section for the standard link. MIKE 1D calculates the discharge through the link and this discharge is sent to the MIKE 21 Flow Model FM. In the MIKE 21 Flow Model FM this discharge is applied as an internal discharge boundary. The flux at internal faces are calculated by distributing the discharge along the face section for the link. The contribution to the momentum equation at an internal face is calculated from the flux and the water depth, which is evaluated based on the value of the adjacent interior cell in the 2D domain. A consistent handling of the momentum across the link requires that both the bathymetry and the surface elevation in MIKE 1D and MIKE 21 Flow Model FM match. For the surface elevation to match the coupling must be stable.

3.5.2 Ext fact

'Ext Fac' is an abbreviation for Extrapolation Factor. For standard links, the extrapolation factor has a default value of 0. This factor controls the time predictor in MIKE 11, which establishes MIKE 21 link values for the next time step. If factor is set to zero, the same value at n+1 will be used as at n. Note! If the last q point in the linked branch is a structure, this factor is set to zero by the calculation kernel.

The extrapolation factor is not applied for lateral links or for structure links. For more information, see the scientific documentation (8.1 Hydrodynamics - Standard Links *(p. 109)*).

3.5.3 Add / replace momentum terms

This option is available for structure links.

- If the momentum terms are replaced, flow conditions calculated in MIKE 11 override flow conditions in the MIKE 21 cell.
- If momentum terms are added, the flow conditions calculated in MIKE 11 are added to the flow conditions in the MIKE 21 cell.

To illustrate, consider a situation where a weir structure in MIKE 11 represents a road embankment in a MIKE 21 grid (similar to that shown in Figure 2.3). The MIKE 11 structure flow would replace the MIKE 21 flow conditions.

Next, consider the same situation except with a culvert located under a section of the road. The culvert structure would be modelled in MIKE 11 (in a separate branch to the weir) and added to the flow conditions in the MIKE 21 cells. As long as this culvert structure link is listed in the coupling file after the weir structure link, both weir and culvert flow would be included in MIKE 21.

Note: the add / replace options mean that the order in which structure links are listed in the couple file will affect the model behaviour. By specifying “Replace” in a link, all previous link inflows from previous links will be overridden. Also note that MIKE 11 can handle composite structures e.g. a culvert and a weir at the same location. This may be used to handle a complex situation with flow both over topping and flowing under an embankment. The definition of such a structure is handled in MIKE 11 and does not require two explicit couplings pairs in the MIKE FLOOD interface.

3.5.4 Depth adjustment

If depth adjustment is active, flow through a link is distributed into the MIKE 21 cells according to the water depth in those MIKE 21 cells. This is considered appropriate for links on natural terrain or channels, but may not always be applicable for structures.

3.5.5 Activation depth (minimum and maximum)

The activation depth is valid only for the *zero flow (XFLOW=0 and YFLOW=0) links*. If specified then these links will be turned off once the activation depth is reached. A maximum and minimum value is available to gradually apply the flow conditions over a range to minimise instabilities. Note that the feature is only available with a MIKE 11 link.

If the minimum and maximum values are set to zero, the activation depth facility is inactive.

3.5.6 Exponential smoothing factor

The parameter introduces an exponential smoothing of the water level values transferred from one model to the other model. A value of 1 indicates no smoothing whereas a value closer to 0 creates strong smoothing in the model. Values are only valid in the range [0;1].

The exponential smoothing is available for the following link types:

- Lateral links. The smoothing is applied for the MIKE 11 and the MIKE 21 water levels separately.
- Standard links. The smoothing is applied to the MIKE 21 water level transferred to MIKE 11. Thus a lag may be evident when comparing MIKE 11 water levels at links with the corresponding linked cells/elements in MIKE 21.
- Implicit structure links. As above the smoothing is applied to the MIKE 21 water level and thus a deviation (time lag) may be present at the link points.

- Urban link from MIKE 21 to an outlet in the sewer model. The smoothing is applied to the MIKE 21 water level transferred to MIKE+.
- Urban link from MIKE 21 to an inlet in the sewer model. In this case the smoothing is applied to the node water level and the MIKE 21 water level used for calculating the interacting discharge.
- River urban link when either a sewer outlet is coupled to a MIKE 11 location or when a water level boundary in MIKE 11 is coupled to a node in MIKE+ (Urban). For a sewer outlet the smoothing is applied to the MIKE 11 water level while for a water level boundary in MIKE 11, the water level in the MIKE+ (Urban) manhole is smoothed.
- Side structure link. Smoothing is applied as described for Standard links above.

The smaller the value the greater the smoothing will be. The parameter impacts the dynamics by smoothing out steep gradients (in time) through the links.

In general the exponential smoothing factor should be adjusted when a structure exhibits unstable behaviour (oscillates wildly). The following approach should be followed if a link shows instability:

1. Set the exponential factor to 0.2 – 0.4
2. Run the model
3. If a link still “misbehaves” (i.e causes a blow-up OR the discharge hydrograph is very 'noisy') then check the results file, the model link location, the MIKE 21 topographic grid, the coupling, etc. for problems, and inconsistencies.
4. Re-run the model if changes are made.
5. If the link still “misbehaves” then the smoothing factor may be further reduced. Note that a small smoothing factor will cause a time lag in the transfer of the values from one model component to the other model component. As a rule of thumb the time scale at which the model changes over should be a factor greater than the time lag caused by the smoothing factor. As an estimate for the latter the following expression may be used:

$$T = \Delta t \frac{\log f}{\log(1-\alpha)} \tag{3.2}$$

where f = 0.001, α is the smoothing factor and Δt is the model time step. The estimate is based on the time it takes for an initial deviation in the coupled models water level to be reduced to within 0.1% of each other.

6. Rerun the model.

7. If a small value of the smoothing factor is required, you need to satisfy yourself that the results are reasonable and the results for the overall model have not been significantly delayed.

3.6 Details on Lateral Links Options

Except for the depth tolerance the options listed in this menu are only relevant for lateral links.

The depth tolerance may also be used in conjunction with the implicit structure links.

The overview of the options in shown in Figure 3.50.

Lateral Link Options

	Link type	River name	M11 Chainage		M11	Structure							External Files			
			US	DS	Side	Method	Type	Source	Depth Tol.	Weir C	Fric(n)	FLC	Geometry		OH Table	
1	Lateral	RIVER	1660.00	3230.00	Right	Cell to Cell	Weir 1	HGH	0.100	1.838	0.050			..		..
2	Lateral	RIVER	1660.00	3230.00	Left	Cell to Cell	Weir 1	HGH	0.100	1.838	0.050			..		..
3	Lateral	TRIB	1350.00	1885.00	Right	Cell to Cell	Weir 1	HGH	0.100	1.838	0.050			..		..
4	Lateral	TRIB	1350.00	1885.00	Left	Cell to Cell	Weir 1	HGH	0.100	1.838	0.050			..		..
5	XFLOW=0													..		..
6	YFLOW=0													..		..
7	ImplicitStructure	CULV1	0.000						0.100					..		..
8	ImplicitStructure	CULV1	30.000						0.100					..		..
9	ImplicitStructure	CULV2	0.000						0.100					..		..
10	ImplicitStructure	CULV2	30.000						0.100					..		..
11	Standard(E)	CULV1	30.000											..		..
12	Standard(E)	CULV1	30.000											..		..
13	Standard(E)	RIVERUS	1720.00											..		..

Figure 3.50 The overview for lateral links. Note that the link type is carried over from the 'Definition' page and cannot be edited

The first column in the table is carried over from the Definition page and indicate the type of link for all links defined in the coupling file. The type definition of link cannot be edited.

Columns two and three contain the location of the link. That is, the River name and the Upstream and Downstream chainages of the river where the lateral link is defined.

Sorting of linkages is possible in the table by double-clicking on the column headers of either the Link type or the River name columns.

Searching for a specific link is also possible in this page. The Search Link feature as illustrated in Figure 3.49 is activated by pressing keys ‘CTRL+F’ or through the main menu; Edit -> Search.

3.6.1 Side of river

Side of river defines whether the lateral link is a link on the left bank or the right bank of the river channel. The information in conjunction with the MIKE 21 topography is used to determine the levee height.

- Left bank is equivalent to Marker 1 in the MIKE 11 cross-section editor
- Right bank is equivalent to Marker 3 in the MIKE 11 cross-section editor

3.6.2 Method

The method defines how the flow is distributed between MIKE 11 and MIKE 21:

- The CELLTOCELL method performs a flow calculation for each individual point in the defined structure. Each calculated flow is then redistributed to MIKE 21 and MIKE 11. This means that the number of MIKE 11 points doesn’t necessarily have to match the number of MIKE 21 cells.
- The SIMPLE method performs a single calculation of flow, then distributes that flow to each MIKE 21 cell and/or MIKE 11 computation (h) point. Note that this option is available for backward compatibility reasons. It is in general not recommended since it gives a uniform flow across the whole link which is typically far from the true flow picture.

The CelltoCell method is the default and is the only one available if linking with a flexible mesh.

3.6.3 Structure type

The structure type defines the type of flow calculation to be performed:

- *WEIR1*:
  MIKE 11 Weir Formula 1 with friction term included.
- *WEIR2 (H)*:
  MIKE 11 Weir Formula 2 (Honma) with friction term included.

- *QHTABLE*:
  A QH table is used, stored in an external file. Note that if using a CELL-TOCELL method, the Q in the QH table is the flow per unit width. Not available with the flexible mesh version of MIKE 21.

- *QDTABLE*:
  A QH table is used, except that water depth above the structure invert is used rather than water level. This could be useful if using a CELLTO-CELL method with different bed levels in each cell but similar flow characteristics. The table is read from an external file. Not available with the flexible mesh version of MIKE 21.

- *FORMLOSS*:
  Standard velocity head form loss equation ($\Delta h = \zeta v^2/2g$). The form loss coefficient can include a friction component.

The WEIR1 type is the default. See the Scientific Documentation for more information.

3.6.4 Source

The structure source determines where the levee level geometry information comes from and further the resolution used for the lateral link. Depending on whether a rectangular grid or a flexible mesh is used the lateral links are treated slightly differently.

Rectangular grid

- M11:
  Structure points are defined at each river computation (h) point. The cross-section left or right bank markers (marker 1 or marker 3) are extracted from the cross-section database and used as the link structure bed levels. Bank levels at h points without a cross-section are interpolated.

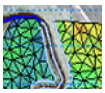
- M21:
  Structure points are defined at each MIKE 21 cell. Bed levels from MIKE 21 cells are used as the structure bed levels (for improved stability reasons, the drying depth is added to the MIKE 21 bed levels when applying these as the levee heights).

- HGH:
  Structure points are defined at either each MIKE 11 computational h point or each MIKE 21 cell, which ever has the highest resolution. The structure bed levels are the highest of the MIKE 11 bank markers and the MIKE 21 cells.

- EXT:
  Information on link elevations as a function of distance along the link is introduced either through an external ASCII file or through a dfs1-file. The latter file can be time varying and hence, can be used to simulate e.g. embankment levees changes and breaches during a simulation.

The HGH source type is the default.

Flexible mesh



For the flexible mesh the lateral link is divided up into segments. Each segment being defined by two consecutive sets of coordinates for the lateral link. A discharge is evaluated across each segment and distributed in MIKE 11 according to the chainage values for the segment end points. The source parameter only controls from where the levee height should be extracted:

- M11:
  The levee height is determined from the bank markers (marker 1 and 3) in MIKE 11.
- M21:
  The levee height is defined by the topography in MIKE 21 (for stability reasons the drying depth is added to the topography values when defining the levee height).
- HGH:
  Takes the max of the MIKE 21 topography and the MIKE 11 bank markers.
- EXT:
  Information on link elevations as a function of distance along the link is introduced either through an external ASCII file or through a dfs1-file. The latter file can be time varying and hence, can be used to simulate e.g. embankment levees changes and breaches during a simulation.

The HGH source type is the default.

Please note: The levee height is not allowed to be below the MIKE 21 topography (at the linkage point) nor below the bed level in MIKE 11. Thus if the selection is such that this occurs MIKE FLOOD will use the limiting value.

3.6.5 Depth tolerance

This parameter is used to smooth out the transition when the flow over the lateral link changes direction. The parameter is also available for the implicit structures. In this case the parameter is used to describe the water level difference across the structure at which point the discharge gradients are gradually suppressed. If such a suppression is not applied the model may experience numerical instability. The suppression varies with the water level

difference and is only active when the water level difference is less than the depth tolerance.

3.6.6 Structure coefficients

Coefficients controlling flow through the link structure include the weir coefficient (default = 1.838 $m^{1/2}/s$ ~3.329 $ft^{1/2}/s$), the weir exponent coefficient (default = 1.5), the Manning's n friction coefficient ($m^{1/3}/s$) and the form loss coefficient. Note that friction can be included in the weir equations - see the scientific documentation for more information.

3.6.7 External files for lateral links

Two types of lateral link variables can be defined by the usage of external files:

- Structure Source
- Structure Type

Structure source

If the structure source has been selected to 'EXT', an external file must be specified (either a txt-file or a dfs1-file) to define the level of embankment along the lateral link. The required format of the Ascii (txt) file is shown in Table 3.2. If a dfs1-file is required there is a possibility for creating such a file using the 'Levee Breach Generation' tool from the MIKE Flood Toolbox (Found at: File->New->MIKE FLOOD->MIKE Flood Toolbox).

The dfs1 file used to specify the levee levels must comply with the following rules:

- The time axis must be an equidistant relative time axis
- The item describing the temporal development of the levee must be item number 1
- The item type must be 'River structure geometry'
- The item unit must be meters or feet

Structure type

If the structure type has been defined as a QH Table or a QD Table, an external file is specified with information on Chainages and Water levels (QH) or Water Depths (QD). The format of the QH or QD file is shown in Table 3.3.

Table 3.2 Format of External Structure File

File Input Example	Description
// External file 4 0.0 2.0 100.0 0.0 500.0 0.0 1000.0 2.0	'//' is a comment marker - as many comment lines as desired can be included in this file. Line 1: Number of entries. Line 2 onwards: Column entries, Space delimited - first column is chainage, second column is bed level (units according to user units for chainage and bed level respectively).

Table 3.3 Format of External QH File

File Input Example	Description
// HQH file 5 3 0.0 1.0 2.0 0.0 0.1 0.2 0.3 1.0 0.3 0.3 0.3 2.0 0.4 0.5 0.7 3.0 0.9 1.9 2.9 5.0 10.0 20.0 50.0	'//' is a comment marker - as many comment lines as desired can be included in this file. Line 1: Number of upstream levels (rows = nr) and number of downstream levels (columns = nc), space delimited. Line 2: List of nc values of downstream levels, space delimited. Line 3 onwards (nr lines): List of nc values of upstream level, then nc values of discharge, space delimited. Notes: If QHTABLE, levels are water level If QDTABLE, levels are water depth If CELLTOCELL, discharge is flow per unit width Units according to user units for water level, water depth, discharge and flow flux

Note that values are space delimited.

3.6.8 Additional lateral Linkage feature; Linkage Level analysis

Defining a Lateral Link causes MIKE FLOOD to process the embankment levels along the link from the specified Source option. The processing of link elevations to be used during simulation takes place during the pre-processing

of a simulation and as such, the link-levels are not directly known and available to the user.

Therefore, a feature for analysing the applied invert levels of lateral links in a simulation is available. This feature extracts information from all lateral links in the model and saves this information to an external file named 'MFLateral.XNS11' and saved in the folder where the MIKE 11 Sim11-file is located.

The cross section file format has been chosen for storing the link levels data and when opening the file, information is visible for each lateral link in the model as described below.

The River Name of the links has been defined as the River Names in the cross section file and the Topo ID's in the file has been used to include information on the different links given by:

- M11 Chainage (actual MIKE 11 grid points of linked river reach)
- M11 Percentage (the above locations normalized)
- M21 Chainage (the cell height associated with the MIKE 21 cells/segments mapped onto the MIKE 11 grid locations)
- M21 Percentage (the above normalized with respect to the MIKE 11 chainages)
- Struc Chainage (the resulting structure link mapped onto the MIKE 11 grid locations)
- Struc Percentage (the above normalized with respect to the MIKE 11 chainages)

The entries listed above is added with a suffix; 'RIGHT' or 'LEFT' depending on which side of the river the lateral link is defined for ('Left M11 Chainage').

Chainages/length for the link is then included in the 'X'-column and the level elevations are included in the 'Z'-column for each 'cross section' in the file, and the inverts of each of the links may now be investigated for possible inconsistencies.

Please note that all chainages indicate the mapping onto the MIKE 11 grid points. They do not reflect the actual width of the levee segments used. The latter depends on the source for the levee height. If the source is MIKE 21 the length is based on the cell size. If MIKE 11 is the source then the distance between the grid points control the levee segment lengths.

MIKE FLOOD prior to Release 2011 can also save the lateral link elevations to an external file. In previous releases this feature generated an ASCII file instead of a xns11-file. The file created was named 'MFLateral.txt' and still contained the same information as the Xns11-file. The Ascii file has a format such that it can be directly imported into the cross section editor in which the

levee height along each lateral link defined in the model can then be investigated.

To generate this ASCII file in releases prior to Release 2011 the following procedure should be followed:

- Set-up the MIKE FLOOD model
- Place an empty file named "MFLateral.txt" in the same folder as where the *sim11 file is located.
- Start a MIKE FLOOD simulation.
- The ASCII file is exported in the first time step of the run. Once the first time step of the simulation has been completed the file in step 2 will have been overridden with values describing the inverts of the lateral links. Hence, if the purpose is primarily to generate and analyse the 'MFLateral.txt' file then the simulation can be stopped after one timestep.
- Open a new cross section file (*.xns11) and import the "MFLateral.txt" using File -> Import -> Import raw data.

For compatibility reasons, the writing to an ascii file has been kept and hence, both a Xns11-file and an Ascii file are being automatically created from simulations made in the actual version of MIKE FLOOD.

3.6.9 Lateral links in rectangular grids and flexible mesh

Internally within MIKE FLOOD lateral links are treated differently depending on whether a rectangular grid or a flexible mesh is used.

MIKE 21 Rectangular grid

When using the rectangular grid lateral links are treated in the following way

- The h-grid points within the linked river reach are identified.
- The linked MIKE 21 cells are given a chainage based on the cell size. That is the chainage runs from cell centre to cell centre plus additional contributions from the first and the last cell. The MIKE 21 chainages are subsequently normalised so that they span the lateral links chainage.
- Depending on the method used the lateral structures will be set up according to the 2D cells or the river grid points. The chainage of the structures will be based on the chainages in the river.
- The chainage of the structures are normalised so that they span the same as the river chainage. The code uses the location based on these normalised chainages to locate which cells and h-points match up with which lateral structure.

MIKE 21 Flexible mesh

MIKE FLOOD with MIKE 21 FM treats the lateral links in the following way

- The h-grid points within the linked river reach are identified.
- The linked MIKE 21 elements are given a chainages based on the segment chainage values. Each segment constitutes an internal lateral structure modelled as a weir.
- Depending on the method used the lateral structures will be set up according to the 2D topography or the river grid points. The chainage of the structures will be based on the chainages of the segments.
- Mesh face-lines which have been defined as a link through the MIKE FLOOD coupling is automatically being defined as a closed boundary inside the FM-calculation engine such that the only flow allowed to cross these face-lines are flow across the link between MIKE 11 and MIKE 21 FM.

3.7 Details on Urban Link Options

There are a number of options available for an urban coupling as illustrated in Figure 3.51.

Urban Link Options

	Link type	Urban ID	Type	Max flow	Inlet area	Inlet method	Crest wid	Discharge	Scaling	Exp.	QdH factor
1	Urban	B201_02	M21 to inlet	0.1	1	Orifice eq.		1.83			0
2	Urban	B20101	M21 to inlet	0.1	1	Orifice eq.		1.83			0
3	River/Urban	B20102	M21 to inlet			Orifice eq.					
4	Urban	B20103	M21 to inlet	0.1	1	Orifice eq.		1.83			0

Figure 3.51 The overview page for Urban Link options

The first column in the table is carried over from the Definition page and indicate the type of link for all links defined in the coupling file. The link type definition cannot be edited.

Column two contains the defined Urban ID of the link.

Sorting of linkages is possible by double-clicking on the column headers of either the Link type, the Urban ID or the Type columns.

Searching for a specific link is also possible in this page. The Search Link feature as illustrated in Figure 3.49 is activated by pressing keys ‘CTRL+F’ or through the main menu; Edit -> Search.

Urban Link options are described below.

3.7.1 Type

There are four different types of links available.

- M21 to inlet:
  A link between the overland and a manhole/basin in MIKE+ (Urban). The urban ID is the node ID in this case.

- M21 to outlet:
  A link to an outlet in MIKE+ (Urban). The urban ID is the node ID in this case. The water level in MIKE 21 is used as a boundary condition in MIKE+ (Urban) which subsequently runs a time step and evaluates the boundary condition. From the time step taken, the discharge is calculated in MIKE+ (Urban) and introduced as a source in MIKE 21. Thus the MIKE+ (Urban) time step has the discharge as output.

- Weir to M21:
  A link between MIKE 21 and a MIKE+ (Urban) weir discharging out of the sewer/storm water system. The urban ID is the weir ID.

- Pump to M21:
  A link between a MIKE+ (Urban) pump discharging out of the sewer/storm water system and the MIKE 21 topography. Urban ID is here understood as a pump identifier.

The links may be coupled to multiple cells in the MIKE 21 rectangular grid or alternatively an area in the flexible mesh. If the latter is used at least 3 points must be supplied to constitute an area (polygon). If only one point is supplied in a given urban link then the discharge is introduced as a single source/sink in the in the element of the mesh where the link is defined. If three points or more are supplied, then the discharge is distributed as sources/sinks in the elements enclosed in the polygon defined by the link points.

It is important to note that the remaining parameters are only applicable for the MIKE 21 to inlet type of couplings.

3.7.2 Inlet method

The exchange of water between MIKE 21 and an inlet may be described through 3 different methods:

- Orifice equation:
  The flow between MIKE+ (Urban) and MIKE 21 is governed by a standard orifice equation.

- Weir equation:
  The flow is described through a weir equation.

- Exponential function:
  The flow is governed by a simple exponential function.

- Curb inlet function:
  The flow between MIKE+ (Urban) and MIKE 21 is transferred at a grate or inlet from a surface overland flow network to the sub-surface pipe network. The transfer capacity of the connection is specified as a DQ-relation (tabular data type). When water is transferred to the surface from the sewer pipe network the flow is calculated with the orifice equation.

Depending on the calculation method used additional information is required.

By default the MIKE 21 ground level is used as the level of the manhole inlet. If the user selects to do so the manhole ground level may be defined by the MIKE+ (Urban) model. Though the latter will always be overruled by the MIKE 21 ground level if this is higher. For a grid based 2D model the MIKE 21 ground level is by default the highest coupled grid cell of a particular coupling. The latter may be changed through the use of a MIKE 21 option parameter. To achieve the latter you must edit the options paragraph of the hydrodynamic section in the MIKE 21 file (*.M21). The following keyword will control the crest elevation definition:

Mouse_Couple_Elevation_Definition = 0 // 0: highest level (default), 1: lowest level, 2: average level.

The *M21 file may be edited in any standard editor.

3.7.3 Max flow

This parameters gives an upper limit on the discharge that can flow through the urban link. If the exchange calculated from the flow equation is above this value the discharge is reduced to this value. Only applicable to inlet couplings.

3.7.4 Inlet area

The inlet area is only used when applying the orifice equation for describing the flow exchange between the urban and the 2D grid/mesh. The greater the cross sectional area the greater the conveyance capacity of the coupling. This parameter corresponds physically to the area of the man-hole cover. When coupling to a basin this value is neglected.

3.7.5 Crest width

The crest width is used when the flow exchange is described through a weir equation. The weir crest should typically be the circumference of the manhole cover.

3.7.6 Discharge coefficient

The discharge coefficient is a non-dimensional factor that may be used to scale the weir flow and the orifice flow. By default the parameter should be set to 1.

3.7.7 Scaling factor

Only applicable if the simple exponential expression is used to describe the flow exchange. The scaling factor has a linear effect on the discharge. Thus an increase in this value will generate a larger flow for a certain water level difference in the urban and the MIKE 21 model.

3.7.8 Exponent factor

Only applicable if the simple exponential expression is used to describe the flow exchange. An increase in the exponent factor has a strong impact on the discharge. An increase in this value will generate a larger flow for a certain water level difference in the urban and the MIKE 21 model.

3.7.9 Qdh factor

A parameter indicating the water level difference from which the calculated discharge should be progressively surpressed. May be used for stabilizing set-ups where the instability is caused by a small difference in the water level in the two coupled models. Only applicable at inlet couplings. See the Scientific Background 8.5 for additional description.

3.7.10 Freeboard

The freeboard defines a critical water level (Invert level- Freeboard) at the connection node in the pipe network below which the defined DQ relation apply. For submerged and reverse flow (surcharge), the transfer capacity of the connection reverts to a standard orifice relationship.

3.7.11 Capacity curve DQ Relation

The DQ relation specifies the depth based capacity curve for the curb inlet. Values must be monotonously increasing in depth and discharge starting at (0,0). For depths in excess of the maximum value specified in the last row of the table, the last corresponding discharge is used. Positive discharge is considered to flow from MIKE 21 into MIKE+ (Urban) (overland to sewer network).

3.8 Details on River - Urban Link Options

The options page for River - Urban Links is presented in Figure 3.52.

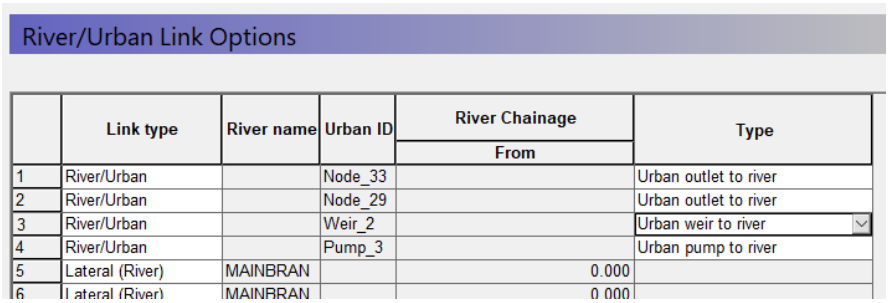


Figure 3.52 Overview page of River - Urban Link Options

The first column in the table is carried over from the Definition page and indicate the type of link for all links defined in the coupling file. The link type definition cannot be edited.

Columns two, three and four contain the location specifications of the link. That is, the River name, The Urban ID and the river chainages where the river-urban link has been defined.

Sorting of linkages is possible in the table by double-clicking on the column headers of either the Link type, the River name or the Urban ID columns.

Searching for a specific link is possible in this page. The Search Link feature as illustrated in Figure 3.49 is activated by pressing keys ‘CTRL+F’ or through the main menu; Edit -> Search.

The options for the river urban links essentially consists of choosing the river urban link type. There are four possibilities

- River water level boundary.
  This link is used when coupling a water level boundary in a river network to an inlet in the urban network. The user specifies the river boundary location through the use of a branch name and a chainage and the node ID of the inlet to be coupled.

- Urban outlet to river.
  The user selects the node ID of an outlet in the urban network along with the river location. Note that the river location should not coincide with a water level boundary in the river network (use the previous link type in this case). The link should be located along a river branch.

- Urban pump to river.
  The user selects a pump which discharges out of the urban system along with a river location. This type of link is uni-directional i.e. only from the urban network to the river.

- Urban weir to river.
  The location is defined through the ID of the weir and a branch name along with a chainage in the river network. This type of link is uni-directional i.e. only from the urban network to the river.

Note that the context sensitive menu (right click) in the graphical overview grants access to an automatic linkage tool as shown below.

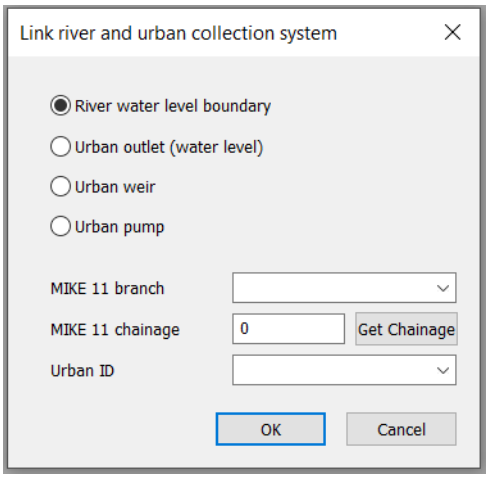


Figure 3.53 The automatic linkage tool to be used for setting up links between the river and urban network. Note that the functionality of combo boxes varies depending on the selections in the upper part of the dialog

The linkage tool may be used for all of the above listed link types. The user selects the type of link along with a specific branch for linking. The Urban ID combo box then lists the types of objects of the required type (pump, weir etc.). Once an urban ID has been selected the user may click on the Get Chainage button which will locate the nearest point on the selected branch. The procedure may be repeated for each link to be set-up.

3.9 Details on Side Structure Link Options

Side structures Link options page is presented in Figure 3.54.

Side structure link from river options

	Link type	River name	ChainageUS	Depth Adjst	Exponential smoothing factor
1	Lateral	RIVER	1660.000		
2	SideStructure	RIVER	1660.000	No	1.000
3	SideStructure	TRIB	1350.000	No	1.000
4	Lateral	TRIB	1350.000		
5	XFLOW=0				
6	YFLOW=0				
7	ImplicitStructure	CULV1	0.000		
8	ImplicitStructure	CULV1	30.000		
9	ImplicitStructure	CULV2	0.000		
10	ImplicitStructure	CULV2	30.000		
11	Standard(E)	CULV1	30.000		
12	Standard(E)	CULV1	30.000		
13	Standard(E)	RIVERUS	1720.000		

Figure 3.54 Overview page for Side Structure Link Options

The first column in the table is carried over from the Definition page and indicate the type of link for all links defined in the coupling file. The link type definition cannot be edited.

Sorting of linkages is possible in the table by double-clicking on the column headers of either the Link type or the River name columns.

Columns two and three contain the location specifications of the link. That is, the River name and the river chainage where the Side structure link is located.

Searching for a specific Side structure link is possible. The Search Link feature as illustrated in Figure 3.49 is activated by pressing keys ‘CTRL+F’ or through the main menu; Edit -> Search.

Flow characteristics for side structures are primarily defined from the structure definitions in the MIKE 11 model (structure geometry, loss factors etc.). Two parameters can be defined for the Side Structures link in the couple file:

- Depth Adjustment (further details in section 3.5.4), and
- Exponential smoothening factor (further details in section 3.5.6 and in the scientific documentation).

3.10 AD Components

The page is activated by selecting the tick box on the definition page. In this page the user simply lists the components in the MIKE+ (Urban), MIKE 21 and the MIKE 11 set-ups and match the individual components. Note that the

component names available may be listed by clicking in the component name fields.

It is possible (but not recommended) to have non-matching components in the three models i.e. a component may only be available in two of the three models. In such cases the component field is left blank for the model without the specific component. The other two models will assume that water entering from the model without the specific component will have a concentration (temperature) equal to the existing components concentration (temperature).

Along with the matching components the user must supply conversion factors between the various models. The intrinsic units for concentrations and temperature are

MIKE 11: g/m^3 and ^oC

MIKE+ (Urban): g/m^3 and ^oC

MIKE 21: The concentration is defined by the user and the temperature is ^oC

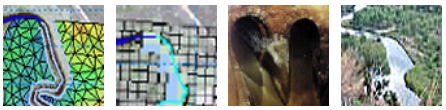
The conversion factors are defined as follows

- The internal MIKE 21 concentration is multiplied by the conversion factor between MIKE 21 and MIKE 11 before being supplied as a boundary condition in MIKE 11.
- The internal MIKE+ concentration is multiplied by the conversion factor between MIKE+ and MIKE 11 before being supplied as a boundary condition in MIKE 11.
- The internal MIKE 21 concentration is multiplied by the conversion factor between MIKE 21 and MIKE+ before being supplied as a boundary condition in MIKE+.

4 Simulation Results

Simulation results from a MIKE FLOOD simulation include output from the different models being coupled through the MIKE FLOOD editor.

4.1 Defining Result Files for a MIKE FLOOD Simulation



The primary purpose of the MIKE FLOOD coupling editor is to couple different model-types for an optimal, integrated description of the flow conditions in the specific environment you are investigating. Consequently, the MIKE FLOOD editor does not include any options for defining result file names, and the output files from a MIKE FLOOD simulation is therefore generated using specifications in the pre-defined model-setup files which are included in the coupled setup.

The MIKE FLOOD simulation will therefore produce result files following the specification by the user in the different model setup-files:

- MIKE 21 (.m21)
- MIKE 21 FM (.m21fm)
- MIKE 11 (.sim11)
- MIKE+ (Urban) (.mupp)

Consequently, simulation results will be divided into results from the individual model with e.g. surface flow calculated and stored in the MIKE 21 result files and e.g. river flow stored in the MIKE 11 result file. Results from the different models can be presented and analysed in one of the MIKE Zero post processing tools (e.g. Result-viewer or Plot composer) as described in Chapter 6.

4.2 Seamless Integrated 1D and 2D River Flooding Results

A feature for generating a ‘seamless’, 2-dimensional result-file, which includes a combination of results produced from the MIKE 21 Rectangular grid model and the MIKE 11 results is available.

Specifications for the seamless result-file integrating the 2D and 1D simulation results is defined through the MIKE 11 User Interface using the HD Parameters file --> 'Maps'.

Steps for producing a seamless result-file integrating MIKE 21 and MIKE 11 results into one 2-dimensional result-file (.dfs2) are:

- Open the MIKE 11 simulation file to be used in the coupled simulation
- Open the HD Parameter File included in the MIKE 11 project (.hd11)
- Select the 'Maps' tab-page and activate the MIKE 11 mapping feature by activating the tick-box named 'Generate Maps'.
- Define your map (i.e. a 2-dimensional grid) by the Origo coordinates, Grid size definitions and Map file name (this file name will be the file name for the seamless integrated 1D and 2D simulation results)
- In the 'Item' column, make sure to select the option '(h, p, q)'
- Save the hd11-file and run eventually the MIKE 11 model to see, that the output-file (map) you obtain from your specifications are as expected with respect to location and resolution.
- Close the MIKE 11 files and run the MIKE FLOOD simulation to create the result-file with result from both the 2D and 1D simulations.

Further details on the MIKE 11 mapping feature can be found in the MIKE 11 User Guide and the MIKE 11 Reference manual, App. 1.

5 Running MIKE FLOOD- recommended Steps

Errors and inconsistencies in a model setup will occur. While every effort has been made to produce clear error messages, it can be difficult to keep track of all components in the model setup. To ensure that errors are minimised, we recommend following a clear, step by step procedure to develop and run MIKE FLOOD.

5.1 Define Model Layout

A MIKE FLOOD model is often a compromise between model resolution (grid/mesh size) and computational time required for a simulation. Note that computational time is mostly influenced by the total number of wet, computational points that occur over an entire simulation. This means that a flood simulation with a short duration, sharp peaked hydrograph will use much less computational effort compared to a long duration, flat peaked flood event. Consider this when deciding on grid resolution. Other things to consider include:

- The 1D model extent. Ensure that the working area in MIKE 11/MIKE+ (Urban) includes the full 2D extent.
- The 2D model extent
- Where model boundaries will be located - remember that often a MIKE FLOOD link is more flexible than applying a boundary condition directly in MIKE 21
- The alignment of the 2D grid - this may depend upon the alignment of main channels, flood plain features, etc.
- The type of links to be used.
- The geographical projection used must be identical for MIKE 11/MIKE+ (Urban) and MIKE 21.

5.2 Setup and Run 1D Models

MIKE FLOOD is a combination of MIKE 11/MIKE+ (Urban) and MIKE 21. Set up the individual models separately, then join them together using MIKE FLOOD.

It should be possible to completely define the 1D models that will be linked in MIKE FLOOD. This should be done to ensure that no errors exist in the 1D models. While the results of the simulation will not be correct, they may provide an indication of potential problems.

5.3 Setup and Run MIKE 21 Model

As for the 1D setups, ensure no errors exist in the MIKE 21 definition files. Run the simulation and ensure that the results are reasonable. For flood plain applications this may include running a completely dry set-up with closed boundaries.

5.4 Setup MIKE FLOOD

The model layout should already be decided upon, and the individual models should already have the components ready for running the MIKE FLOOD model. This step is to create the MIKE FLOOD couple file and define the links to be applied.

5.5 Run MIKE FLOOD Simulation

Note that the standard links and the lateral links are explicit (Courant conditions cannot exceed 1). It is likely that stability problems related to the links will occur in the initial simulations if the Courant number condition is exceeded. Do not be surprised if several adjustments of the links need to be made at this stage, or that the time step required is much shorter than you expected.

Check some of the tips available in this document (see Tips and Troubleshooting).

Once an initial MIKE FLOOD simulation has been completed, the modeller should have a good appreciation of the model layout and its various components, and be aware of the potential problems that may crop up in subsequent simulations and analyses.

6 Pre- and Post-processing

It is envisaged that much of the pre- and post-processing of MIKE FLOOD will be done in a GIS. The GIS provides superior tools for the management and storage of large amounts of data, which are required for many flood plain applications. However, not all GIS systems have specialised tools suitable for modelling (time series analysis, grid editing, surface interpolation etc.), so MIKE Zero has its place in the modelling method. Standard spread sheets (EXCEL) are also useful for data management.

Links to external programs are available at present through MIKE Zero. Linkage properties can be imported into MIKE FLOOD either through an external ASCII file (XYZ files from a GIS) or by cutting and pasting into the MIKE FLOOD interface.

The results from MIKE FLOOD (water levels, discharges, fluxes, AD components etc.) can be viewed using the Result Viewer (MIKE 21, MIKE 11 and MIKE1D), Plot Composer and Data Viewer (MIKE 21) and MIKE View (MIKE 11, MIKE+). Also, MIKE Zero allows MIKE 21 result files to be exported to an ARC-GIS ASCII input file.

The recommended tool to use is the Result Viewer, which is activated from MIKE Zero (File- New - MIKE Zero - Result Viewer). The viewer can present 1D, 2D and 3D results from different DHI Software models at the same time, including *.res11 result files from MIKE 11, *.res1d result files from MIKE+ (Urban) and MIKE HYDRO and *.dfs2/*.dfsu result files from MIKE 21:

- New files are added to the Result Viewer project by using Result Viewer - Projects - Add files to project and press the new “page” icon to the right. The “File Type” is a scroll-down menu, where the result file is chosen.
- The work area is defined under Result Viewer - Projects - Work Area.
- In order to display the results together, the various models need to be based on the same geo-reference. Thus, the MIKE 11 network and the pipe network must be described in the same UTM metric grid as the MIKE 21 bathymetry file.
- The type of result data to display (contours and/or vectors) is selected in Result Viewer - Projects - Active View Settings. On-line animation as well as production of videos can be done. Time series can be extracted by using the time series button at the upper tool bar (to the right). Use double click on the left mouse button to select a point graphically and display the time series in a separate window. Use Ctrl + Left click to select more points graphically, and display all the time series in a separate window by use Ctrl + Double Left mouse click.

Additionally there are the option of displaying grid based results in Google Earth using the flooding plug-in. Though note that to use these tools the grid

results must be geo-referenced (i.e. not NON-UTM) using a projection which conforms with the Google Earth standard i.e. datum WGS84.

6.1 Volume Balance Summary from Simulations

Running MIKE FLOOD produces separate volume balances for the MIKE 11, MIKE+ (Urban) and MIKE 21 components reported in three distinct file. The MIKE 11 and MIKE+ Collection System volume balances are described elsewhere (see the respective documentation for those products) the focus here will be the MIKE 21 component. The volume balance is presented in a file named m21file.HTML where the 'm21file' is the MIKE 21 (fm) simulation file name without extension. The file is overwritten for every simulation. An example of the volume balance file for a Cartesian grid run is shown below:

Volume balance Summary

A: Initial volume in model area					**149.04**	**m^3**
B: Final volume in model area					**260636.49**	**m^3**
MIKE 11 inflow	344072.19	m^3				
Inflow sources	0.00	m^3				
Open boundaries inflow	0.00	m^3				
Hydrology processes	0.00	m^3				
Water level correction	32.44	m^3				
C: Total inflow					**344104.63**	**m^3**
MIKE 11 outflow			83608.07	m^3		
Outflow sinks			0.00	m^3		
Open boundaries outflow			0.00	m^3		
D: Total outflow					**83608.07**	**m^3**
E: Continuity Balance = B-A-C+D =					**-9.12**	**m^3**
Relative deficit E/max(A,B,C,D) =					**-0.00**	**%**

Figure 6.1 Example of Volume Balance output file from MIKE FLOOD simulation (MIKE 21 Cartesian Grid simulation)

The volume balance is broken down into the following items:

- Initial volume (open boundary cells are not taken into account)
- Inflow through open boundaries
- Inflow from MIKE 11
- Inflow from MIKE+ Collection System
- The contribution from rainfall and evaporation

Deviations in the continuity balance (Relative deficit) may be caused by the numerical scheme and should remain as low as possible.

Additionally, deviations in volume balance may also be caused by corrections of water volumes during the simulation. These corrections represent artificial volumes of water added in the model in different situations:

- A large time step may give rise to water level below the bed level in a cell. If this happens MIKE 21 will correct the water level to just above the bed (0.0002 m default), by adding an artificial volume of water.
- Sinks/ links (MIKE 11 / MIKE HYDRO River or MIKE+ Collection System) at dry spots draining more water than present.
- Extraction of water from a dry section of the model area through MIKE 11, MIKE+ Collection System or evaporation
- Steep slopes in the model area drying out uphill cells

The total correction of water volume in the model is reported in the volume balance as 'Water level correction' (Cartesian model) or 'Inflow / outflow correction' (Flexible mesh model). These corrections should be checked after the simulation, as high corrections may affect the results and may be due to issues in the model setup.

To counter the effect of the steep slope in the Cartesian model one may choose an alternative flooding and drying scheme where the effect of the momentum equation is gradually suppressed as the water depth tends towards the drying value. The suppression starts at the flood depth. To activate this scheme either select the 'Inland flooding' option which has the alternative flooding drying scheme as default or alternatively set the following option parameter in the hydrodynamics options section of the M21 file:

```
[HYDRODYNAMIC_MODULE]

    [OPTION_PARAMETERS]

      Use_QZero_Method = true

    EndSect  // OPTION_PARAMETERS

…
```

7 Tips and Troubleshooting

7.1 General Considerations

- File Layout: MIKE FLOOD is designed so that all information relating to MIKE FLOOD is stored in the coupling file. The MIKE 11, MIKE+ (Urban) and MIKE 21 simulation files are standard, which means that the models can be run separately.

7.1.1 River modelling with MIKE HYDRO River or MIKE 11

- Initial Conditions: To obtain a stable MIKE FLOOD simulation, it is important that the hydraulic conditions are in dynamic equilibrium at the link point. This is especially important at standard links and structure links. For these link types the initial water levels in the River model and the MIKE 21 should be the same. Alternatively, hot-start files in the individual setup could be used.
- MIKE HYDRO River / MIKE 11: The DELTA coefficient dampens high frequency oscillations from a river model simulation. The frequency of the dampened oscillations depends upon the time step and the value of DELTA. Note that the time step for a typical MIKE FLOOD application is relatively small, which means that increasing DELTA is unlikely to have a significant effect upon the accuracy of model predictions. Increasing the DELTA parameter is therefore a very useful feature for eliminating minor wobbles and potential instabilities from a simulation. See the MIKE 11 Scientific Documentation for a more detailed description.
- Additional Options: Additional options can be specified in the MIKE 21 parameter file. In the couple file, the entry M21_Run_Info contains four variables:
  - The first is obsolete but is left in for compatibility.
  - The second parameter indicates the level of debug information reported (0 for none and 1, 2 or 3 for debug output). If the parameter is 3 then only Courant number warnings are printed in the log file.
  - The third parameter is default 1 indicating that the same time step is used in the river model and the 2D model. MIKE FLOOD may be run with a different time step in the two models. The default is that the time step is carried over from MIKE 21. Thus the time step specifications in the River model are over written when running MIKE FLOOD. If desired the time step in the river model may be chosen as a multiple of the time step in MIKE 21. The third parameter after the M21_Run_Info keyword specifies the time step multiplication factor used in MIKE HYDRO River or MIKE 11.

  - The last parameter is used to scale advection dispersion results (default 1.0). Incoming concentrations from the river model are divided by this value in MIKE 21. The MIKE 21 AD solver treats any pollutant or constituent as a scalar and thus does not consider the unit of the pollutant. This parameter is used to ensure that the same unit is used in the river model and in MIKE 21. Concentrations are calculates internally in the river model as g/m^3.

- The option M21_struc_dirtol applies a tolerance to linkage directions for links to MIKE 11. This can be used to force flow directions in MIKE 21 to be aligned with the grid. That is if the flow direction is within the tolerance in degrees it will be aligned with the grid.

7.1.2 MIKE 21 rectangular grid

- Wetting and Drying: Any link can be initially dry, or can be dry at any time in the simulation. If a link is completely dry, flow will be added to the dry MIKE 21 cells until cell water depth is above the cutoff flooding depth. Then the cell will become an active wet point.
  Note that the default values as defined when creating a new .m21 model file will always have to be adjusted as these are generally too high for inland river applications.

- Boundaries: MIKE FLOOD linkages in MIKE 21 rectangular grid do not necessarily need to be aligned with the MIKE 21 grid. This is different to the restrictions imposed on boundary locations in MIKE 21. Utilise this feature for any MIKE 21 simulation.

- Note that boundaries in MIKE 21 rectangular grid are not allowed to dry out. Therefore it is recommended for in land flood plain projects to close all open boundaries in the MIKE 21 bathymetry. Hereby all boundaries in the set up will be handled by the 1D models.

- MIKE 21: The default value for land in a MIKE 21 bathymetry is 10. If a flood plain model has bed elevations higher than this, ensure that the bathymetry file has this specified.

- MIKE 21: For applications with significant wetting and drying the Smagorinsky eddy viscosity formulation should not be used. This means that for the majority of MIKE FLOOD applications a constant eddy viscosity formulation should be applied. For overland flow conditions it is unlikely that eddy viscosity will have a major effect on model predictions (friction will dominate). However, for flow in and around structures, the value of eddy viscosity can have a significant effect upon predictions. Caution is advised in such cases.

7.1.3 MIKE 21 flexible mesh

- The MIKE FLOOD run time will be impacted by the mesh size. Thus it is advantageous to spend some time initially in generating a sound mesh which represents the major features of the topography without resorting to very small elements.

- When using the flexible mesh with lateral links, standard links, or side structure links, the code will locate the nearest mesh element faces and apply the discharge exchange along these faces. The discharge is distributed along these element faces and it is therefore of out most importance that these coupling lines are completely contained within the mesh. Ideally the lines may be integrated in the mesh. To achieve this, the linkage lines may be imported into the Mesh Generator while building the mesh. Files containing linkage lines may either be created from MIKE HYDRO River, using the tool Export embankment lines, or by use of the additional feature below which generates an ASCII file with XY-coordinates of the linkage lines after running a first MIKE FLOOD simulation.

  When manually editing the following section into the Structures section of the .m21fm file, setting the output_of_link_data = 3, the model will generate two link files that will be located in the MIKE 21 FM result files folder:

  [RIVER_LINKS]

  type_of_coupling = 2
  line_information = 2
  output_of_link_data = 3
  file_name_curve = 'river_curve.xyz'
  file_name_section = 'river_section.xyz'

  EndSect // RIVER_LINKS

  The link file river_section.xyz will contain the coordinates for the line following the nearest segment list in the mesh whereas the file river_curve.xyz will contain the coordinates for the digitized linkage lines. The latter file will contain information about coordinates of all digitization points in the river model and it is therefore possible to import this file as a ‘boundary file’ in the MIKE Zero Mesh Generator and thus incorporate the linkage lines directly into the mesh.

- The wetting and drying values should be decreased from the default values. A reduction of a factor in the order of 50 is recommended.

- The flexible mesh version of MIKE FLOOD uses an adaptive time step for the overland flow (2D). The 1D models use the overall time step defined in MIKE 21 FM in the *Time* menu, and information between MIKE 21 FM and 1D models is also exchanged at every overall time step. Thus the overall time step should be selected based on considerations of the 1D models.

7.1.4 MIKE 3 flexible mesh

- For a river (MIKE 1D), a standard link the discharge will be distributed uniformly over the water column in the 3D model.
- For a pipe (MIKE 1D), an urban link is implemented as a simple source (q specified and u and v equal to zero) in the bottom layer.

7.1.5 MIKE+

It is important to look at weirs and pumps in the system and find out if they should be coupled to the MIKE 21 model in such a way that the water flows naturally. Flow from weirs in MIKE+ (Urban) is one directional, i.e. the flow only flows into the MIKE 21 model and not back into the MIKE+ (Urban) model. This can be fixed if needed by adding a small pipe and an outlet to the MIKE+ (Urban) model and couple in the outlet instead.

- MIKE+ (Urban) will automatically allow MIKE 21 to change the ground levels in manholes so that they coincide with the terrain. The change is only allowed if the change is within an acceptable limit. The limit may be set in the 'DHIapp.ini' file (MM21_ALLOWEDGROUNDLEVELDIFFERENCE). It is in general recommended to ensure that manhole levels correspond to the topography.
- It is important to consider the artificial basins on top of manholes in MIKE+ (Urban) i.e. the reservoir height above ground. The reservoir height is the distance from the manhole ground level to where the expansion for ponding starts. 25 cm below the man hole level is the default value, but when coupling MIKE+ (Urban) with MIKE FLOOD this should be increased to e.g. 100 m above. Make sure the FLOODLIMIT parameter does not conflict with the reservoir height.

7.2 Stability Issues

7.2.1 General MIKE FLOOD issues

- The MIKE HYDRO River, MIKE 11, MIKE+ (Urban) and MIKE 21 documentation contain information on stability in numerical modelling. The comments made are equally applicable for MIKE FLOOD.
- Most issues relating to stability in MIKE FLOOD occur in the links themselves and in the wetting and drying in MIKE 21. The numerical solution of both is explicit, and the dominant constraint is the time step.

- Another important factor relating to stability is wetting and drying. To some extent this can be a model design issue and adjustments can be made to improve stability. For example, make troublesome link points fully wet if possible, or reduce the time step / increase the MIKE 21 grid/mesh size (decreasing the Courant number can minimise the impact of other sources of instability). Including a depth dependence to the link, which will reduce the flow rate in shallow cells (relative to deeper cells within the link), may also help.
- The Standard links are explicit while the Urban and lateral Links are semi-implicit. Meaning that time step considerations become very important. The numerical design of the links however means that the local Courant conditions inside the linked cells / h points cannot exceed 1. The local Courant number is defined as:

$$C_R = \frac{(v + \sqrt{gd})\Delta t}{\Delta x} \tag{7.1}$$

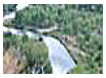
where
v = velocity,
g = gravity,
d = water depth,
Δt = time step and
Δx = grid spacing.

7.2.2 MIKE 11 specific issues

- See the description above in Section 6.1 (MIKE 11) pertaining to use of the DELTA coefficient in MIKE 11 to dampen potential instabilities. In most cases, increasing DELTA (to say 0.85) will not adversely affect model predictions.
- Set the momentum factor = 0.0 in links where momentum conservation is unlikely to be important.
- For lateral links, try to make the structure resolution is the same as or finer than the MIKE 11 Δx and the MIKE 21 grid size.
- If modelling a simple structure between adjacent MIKE 21 cells, use the implicit structure link. This link type is significantly more stable than a standard link.
- Stability in a link is improved if flow is continuous in one direction only through the link (for example, cascading flow over a weir). Try to utilize this when building the model by selecting link locations where backwater effects are less significant.

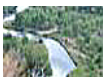
- Other adjustments, such as increasing friction and / or eddy viscosity, can be used to improve stability. However, such adjustments can compromise model performance.

7.3 Standard Links



- The end of branches in MIKE 11 that connect to MIKE 21 must have a water level boundary specified. This is a dummy boundary specification for initialisation purposes and will not affect the MIKE FLOOD simulation.
- Link points in MIKE 21 can be dry initially, and can be wet or dry during a simulation.
- MIKE 21 rectangular grid only: A predictor (extrapolation factor) is applied for obtaining proper time centring of the values that are exchanged between MIKE 11 and MIKE 21 rectangular grid. The predictor assumes that the flow between the last two cross-sections in MIKE 11 before the coupling is based on normal bed resistance flow (i.e. no structures). If there is a structure in the previous q-point before the coupling point, the extrapolation factor is set to 0. Note that this may affect stability of the link.
- MIKE FLOOD computes discharge from MIKE 11 and distributes it to the associated point(s) in MIKE 21. If the link in MIKE 21 consists of more points, the discharge is distributed uniformly to all points. If the depth distribution flag is used, flow is distributed according to water depth in each individual cell.
- The discharge from MIKE 11 influences the continuity equation as well as the momentum equation. The direction of the flow is derived from comparison of the orientation of the MIKE 21 grid and the direction of the MIKE 11 branch.
- MIKE FLOOD computes the water level from the link point/area in MIKE 21 and assigns it to the associated boundary point in MIKE 11. If the MIKE 21 link consists of more points, the average value from these points is transferred to MIKE 11. In general, more than one linked MIKE 21 grid point will tend to smooth and stabilise a coupling.

7.4 Lateral Links



- Lateral links can cause oscillations in the flow through the link when the difference in water levels between MIKE 11 and MIKE 21 is similar. To minimize such oscillations, use the depth tolerance factor. Also, consider using a friction coefficient in the links - it is considered physically correct in situations with vegetation on the river levees, and improves link stability. A value of 0.1 meter is recommended for the depth tolerance.

- When performing initial tests with MIKE 11 (with no MIKE FLOOD links), do you get the error message “Error no 25 : At the h-point: .... the water depth greater than 4 times max. depth.”? This can occur if the bank markers in the cross-sections (which will be laterally linked to MIKE 21) are low. To avoid this message, the MIKE11.INI file HD entry WL_EXCEEDANCE_FACTOR should be set to a higher value (say 50). However, it is thus also important not to set this value unrealistically high as the fluctuations observed from this error message may occur from a specific problem in the river model setup, and setting the Exceedance_factor to a very high value will then allow the model to continue the simulation even though incorrect oscillations occurs.
  Also use a local MIKE11.INI file by copying the file from the installation to the directory where the *.sim11 file is located. Hereby the settings in the MIKE11.INI file only affects the present set up.

- A high resolution of MIKE 11 grid points improves model stability.

- Use the CELLTOCELL method for lateral flows.

- The WEIR1 and WEIR2H types are linked to the MIKE 11 structure routines. They include drowned conditions and simulate lateral flows accurately. The FORMLOSS method is straightforward. If these methods are not sufficiently detailed then an external QHTABLE type is available. H is considered to be water level (either in MIKE 11 or MIKE 21). Otherwise, QDTABLE uses (water level - structure depth). Also, if a CELLTOCELL method is applied then Q is flow per unit width.

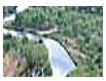
- Bed friction can be included in the weir calculation (see the Scientific Background). While this is normally uncommon for in-channel structures, river bank overflow can often occur across reasonable distance (the levee width) and through thick vegetation. Rather than estimating a new weir coefficient to account for this, specification of a friction term may be a desirable alternative. The length of the link used in this calculation is determined from the MIKE 21 cell size for the rectangular grid version. For the flexible mesh version a weighted distance from the river grid points and the individual linkage segments is used for describing the length.

- Lateral links can oscillate when the difference in water levels between MIKE 11 and MIKE 21 is similar. To avoid this, use the Depth Tolerance factor. A value of 0.1 meter~0.33 ft is recommended.

- Using the highest (HGH) structure source type is usually the most convenient method. This picks the highest resolution of points (MIKE 21 cells (plus the drying depth) or MIKE 11 h points), then assigns bed levels using the highest values from the MIKE 21 cells and MIKE 11 points. If available, external input from a GIS could be used to extract more detailed bank line information.

- To view the lateral flows in the MIKE 11 results file, tick the “Lateral Links” option in the Additional Output menu of the HD Parameter File (.HD11).
- The lateral links may be used with the exponential smoothing factor. The effect of this is that it will dampen out oscillations. The penalty is a time lag in the transfer of the water levels which compute the flow across the lateral link. For details please refer to section 3.5.6.
- In case of convex/inner banks of abrupt river bends (e.g. meanders) with MIKE 21 FM, certain elements along the lateral links may be excluded from the simulation when these elements have two faces along the lateral link. This is because the MIKE 21 FM engine cannot have elements with two faces being coupled to the river. So if some elements with two faces being coupled are identified, these elements and faces are removed from the linkage line, and eventually other neighbouring elements may iteratively be also removed for the same reason. This will result in the excluded elements showing no results in the result files. To avoid this, the solution is to add a mesh node in these troublesome elements (i.e. to subdivide the elements) so that only one face is being coupled.

7.5 Structure Links



- The structure links are implicit. This means that a simulation that uses these links will be more stable than the explicit links and simulations can be performed using longer time steps.
- In the structure links MIKE 11 lags one time step behind MIKE 21. Thus, the displayed value of flow in the q point of the MIKE 11 branch may not necessarily be the flow through the MIKE 21 cell. It is recommended that for structure links the MIKE 21 results be interrogated rather than the MIKE 11 results.
- The direction of the flow is derived from comparison of the orientation of the MIKE 21 grid and the direction of the MIKE 11 branch. A projection is made of the flow equation onto the grid cell faces.
- The MIKE 21 cells that define the inlet and outlet of the structure link must be adjacent to each other. Thus if the inlet cell is (J_1,K_1) then the outlet cell must satisfy at least one of the equations (7.2). However, more than one MIKE 21 cell can be specified and a list of cells can be in any direction or alignment.

$$\begin{aligned} K_2 &= K_1 - 1 \\ K_2 &= K_1 + 1 \\ J_2 &= J_1 - 1 \\ J_2 &= J_1 + 1 \end{aligned} \qquad (7.2)$$

- The river branch that defines the structure link can only be a 3 point branch (one h point at the inlet, one h point at the outlet, and one q point connecting them). The q point can have as many parallel structures as are needed, or can have no structures (it can simply be a cross-section).
- There is an option to add or replace momentum terms. If the momentum terms are replaced, the flow conditions calculated in MIKE 11 override flow conditions in the MIKE 21 cell. If the momentum terms are added, the flow conditions calculated in MIKE 11 are added to the flow conditions in the MIKE 21 cell.
- The exponential smoothing factor is available for the implicit links. The smoothing factor has a tendency to stabilize oscillating flow patterns. Though note that the smoothing factor causes the MIKE 11 values to lag behind the corresponding MIKE 21 values and undesirable effects can be obtained in simulation results.

7.6 Zero Flow Links

- A single link can be used to specify all XFLOW=0 cells in a MIKE 21 grid. The same applies for the YFLOW=0 cells.
- With regard to activation depth, the idea is that for most flooding conditions there will be left bank flood plain flow, in-bank channel flow and right bank flood plain flow. The interactions between these three will be governed by the MIKE FLOOD links. However, water depths could increase until the interactions between the separate flow paths are no longer relevant. At this stage, a MIKE 21 simulation without the MIKE FLOOD links would be more accurate. By using the activation depth to switch on 2D flows across a river channel this could be done.

7.7 Urban links

- It is possible to couple to multiple cells if using a rectangular grid. For the flexible mesh it is possible to couple to an area. In general using multiple cells or an area as opposed to coupling to only one point will enhance stability.
- The exponential smoothing factor is available for inlet and outlet couplings. For pumps and weirs this is not an option.
- If a link couples to multiple cells in MIKE 21 then the ground level in the overland model is taken as the highest level encountered. The MIKE 21 water level used in the calculation is the average water level over all the wet cells.

- The urban link gives the option of placing an upper limit on the flow. This is only available for inlet couplings. Be careful with this option. A simulation indicating that the max value is in effect constantly may be hiding an oscillating flow being overridden by a fixed value.
- When linking to basins the max flow area for an orifice is ignored.

7.8 River Urban links

- The exponential smoothing is available for all the link types between the river network and the sewer/storm water system.
- Keep in mind that pump and weir links are uni-directional and thus will simply function as a source in MIKE 21. These type of links should only be used when there is no feedback to the storm water system from the river.
- For the “River water level boundary” it is important that the bed level at the linking cross section is within the extent of the linked node.

8 Scientific Background

The scientific backgrounds of MIKE 11, MIKE+ (Urban) and MIKE 21 are also applicable for MIKE FLOOD.

8.1 Hydrodynamics - Standard Links

Standard links are treated slightly differently depending on whether a flexible mesh or a rectangular grid is used.

8.1.1 Rectangular grid

Discharge is extracted from the MIKE 11 boundary (the first *Q*-point), and imposed in MIKE 21 in a similar way as a MIKE 21 source discharge. The discharge is centred at time step n+1/2. The discharge from MIKE 11 has an impact on the continuity equation as well as the momentum equation in MIKE 21 as with a normal source discharge, (see MIKE 21 scientific documentation).

MIKE 11 requires a water level boundary from MIKE 21 at time step n+1 in order to step from time step n to n+1. Therefore, MIKE 21 will always be one time step ahead of MIKE 11. Thus, in order to provide a discharge to MIKE 21 at time step n+1/2, a predictor may be applied in MIKE 11 to estimate the discharge $Q^{n+1/2}$, given the computed discharges Q^n and water levels H^n at time step n:

$$\frac{\partial Q^{n+\frac{1}{2}}}{\partial t} = -\left(gA\frac{\partial H^n}{\partial x} + \frac{Q^n \cdot |Q^n|}{A \cdot C^2 \cdot R} \right) \tag{8.1}$$

where

t	=	the time,
x	=	the length,
A	=	the cross-sectional area,
C	=	the Chezy resistance number, and
R	=	the hydraulic radius.

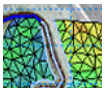
The gradient in water level is evaluated at the last *Q* point in MIKE 11. The calculated time derivative of discharge is transferred to MIKE 21 together with the discharge at time n in order to predict the discharge at a later time step (n+1/2).

The predictor assumes that the convective acceleration terms in the last grid point in MIKE 11 are negligible. Furthermore, it assumes that “normal” bed resistance represented by a Chezy (or Manning number) controls the flow. If

a structure is present in the last *Q* grid point in MIKE 11 a link to MIKE 21 the predictor is not used.

Please note: the predictor does not ensure that the actual discharge from MIKE 11 coincides with the one transferred to MIKE 21. Thus to ensure that the mass balance is perfect it is recommended to set the value to 0.

8.1.2 Flexible mesh



For the flexible mesh the standard link is designed is such a way that the linkage line is mapped onto one or more element faces. Thus from MIKE 21's point of view the link functions as a boundary condition. In return MIKE 21 transfers an average water level across the coupled element faces which is then subsequently used in MIKE 11. It is required that the whole of the coupling line is within the mesh to ensure that total discharge is transferred from the river model to the overland mesh model.

The predictor is not used for the flexible mesh solution.

8.2 Hydrodynamics - Lateral Links

For lateral links, flow from the river model goes via a lateral boundary, which is then applied into MIKE 21. The lateral link varies from the standard source / sinks in the following ways:

1. Flow through the link is dependent upon a structure equation and water levels in MIKE 11 and MIKE 21.

2. Flow through the link is distributed into several MIKE 11 *h* points and several MIKE 21 cells/elements.

3. The lateral links do not guarantee momentum conservation.

The latter point is not surprising since the 1D-model per definition does not consider cross channel momentum.

A structure is required to calculate the flow between MIKE 11 and MIKE 21. This structure is typically a weir that represents over topping of a river bank or levee. The geometry of the structure can be determined from cross section bank markers, MIKE 21 topographical levels, a combination of the highest of each, or from an external file.

8.2.1 Rectangular Grid

With a CELLTOCELL method, the structure geometry is subdivided into a series of internal structures. Each internal structure has a bed level and a

width determined from the resolution of points defined along the structure. Consider the schematic diagram in Figure 8.1 of a structure defined from MIKE 11 *h* points:

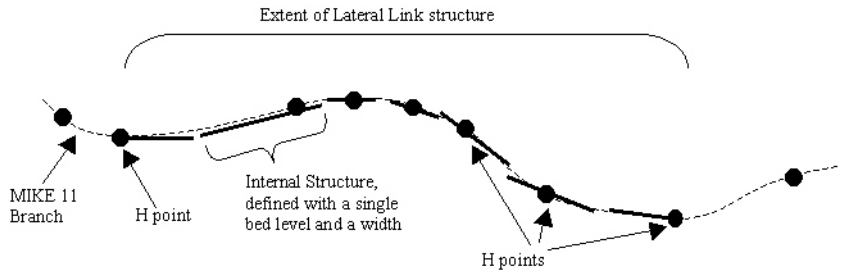


Figure 8.1 Lateral Link, Definition of Internal Structures

The internal structures are defined so that all of the information available in the structure geometry is utilised.

During computation, each internal structure is assigned a water level from the river and from the overland solver. These values are found by interpolating levels at existing calculation points onto the internal structures. Consider the schematic diagram in Figure 8.2 of an externally defined structure, where the internal structure locations differ from the MIKE 21 cell locations and the MIKE 11 h point locations. As shown, water levels are interpolated from the MIKE 21 cells and the MIKE 11 *h* points to the specific internal structure locations.

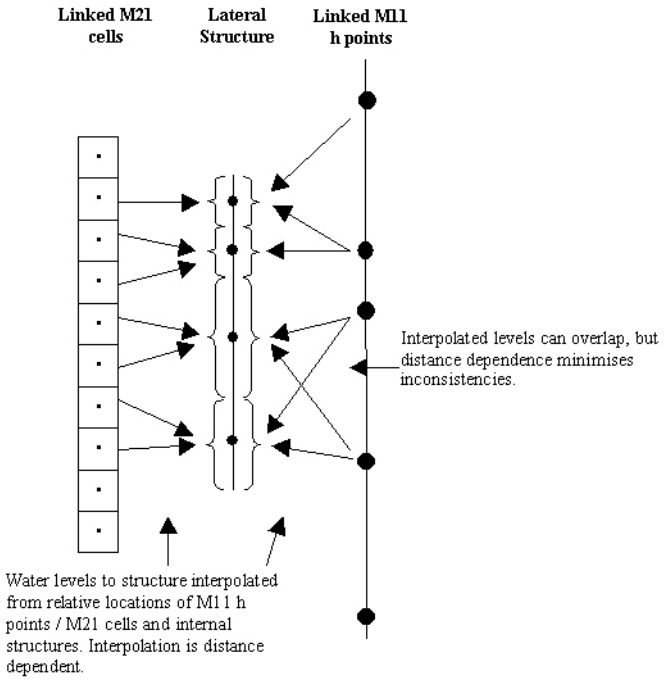


Figure 8.2 Lateral Link (defined by external file). Interpolation of Water Levels

Using the calculated width and bed level and interpolated water levels, the flow across each internal structure is calculated using a standard structure equation. These structure equations are the same equations used in MIKE 11. The flow from each internal structure is then distributed to / from the MIKE 11 h points and MIKE 21 cells. This is done by determining the range of influence that each internal structure has upon each linked MIKE 11 h point and MIKE 21 cell. As shown in Figure 8.3, if MIKE 11 *h* points lie within the range of influence of a given internal structure, flow is distributed across those points according to water depths in each point. If no MIKE 11 h points lie within the range of influence, flow is distributed to the nearest upstream and downstream points using a distance dependent interpolation. The same applies for MIKE 21 cells.

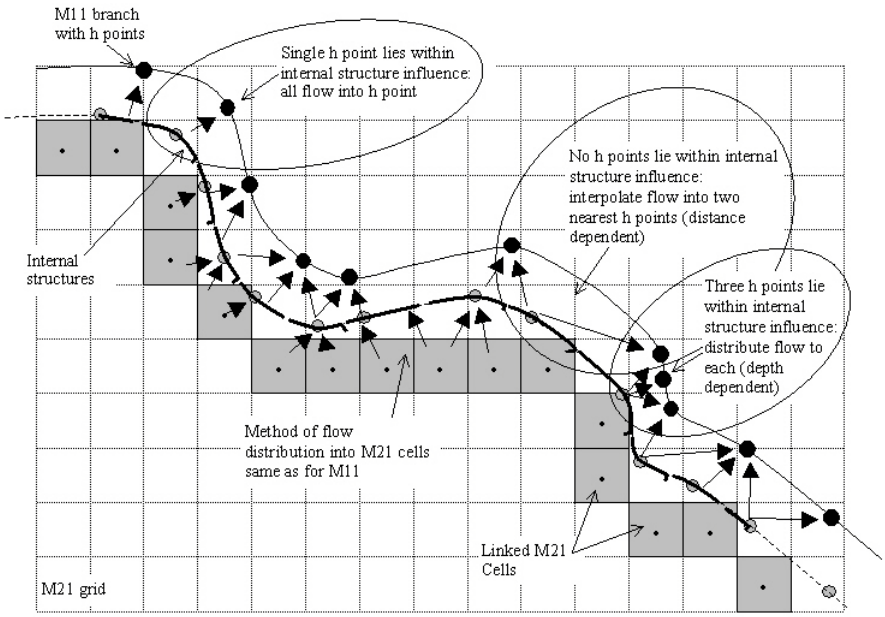


Figure 8.3 Lateral Link (externally defined). Interpolation of Flows

This approach allows a high level of flexibility when designing the lateral link. However, it is likely that a similar distribution of MIKE 11 *h* points, MIKE 21 cells and internal structures will produce the most accurate solution.

8.2.2 Automated cell selection

The automated cell selection tool may be used for the centre line or the left or the right levee line. The cell/element selection only varies in the way the line is defined. The centre line is defined through the digitised points in the MIKE 11 set-up. The construction of the levee lines follows through a number of fully automated steps (see Figure 8.4):

1. The cross sections located within the user selected reach are placed according to either the geo-referenced coordinates or the chainage. The latter only if the coordinates are not present or applied.

2. If the cross sections are placed according to the chainage (not geo referenced) then the distance from the centre line depends on the location of markers 1,2 and 3. If these markers are **not** present they are determined from the raw data with the Marker 2 normally being the lowest value (at the centre line) and the Markers 1 and 3 being the first and last point respectively of the cross section.

3. If cross sections are not present at the end points of the user defined reach then extrapolated widths are determined from the existing cross

sections.

4. At all digitised points without a cross section the width is interpolated from the existing cross sections.

5. The interpolated widths are placed so that they bisect the angle of the two adjoining line segments.

6. The levee lines are thus made up by joining the respective left or right end points of the combined interpolated widths and cross sections.

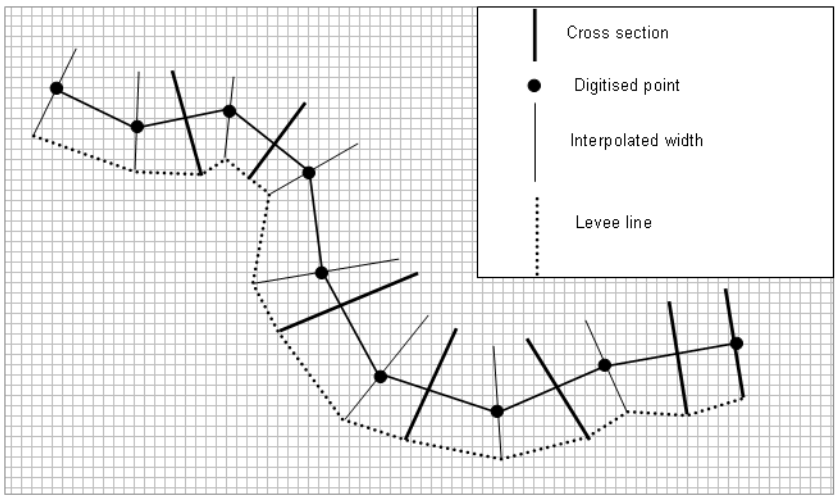


Figure 8.4 Definition of levee line used for lateral linkage

8.2.3 Definition of lateral linkage lines

The linkage tool in MIKE FLOOD can trace cells intersected by a line. The line being one of three types:

- Centre line
- Left levee line
- Right levee line

The only difference between the three is the construction of the line. The centre line is simply the digitised river from the MIKE 11 set-up. The left and the right levee lines are constructed based on the cross sectional widths.

When using the flexible mesh the individual elements to be coupled are identified at run time. Thus the linkage is independent of the element size. The linkage in this case is made up of the coordinates of the end points of the line

segments making up the linkage line. At run time the linkage line is mapped onto the element faces.

8.3 Hydrodynamics - Structure Links

The structure link takes the implicit terms describing momentum through a 3 point MIKE 11 branch and uses them to replace or modify the implicit terms describing momentum across the face of a MIKE 21 cell. In this way, the flow properties from one MIKE 21 cell to another are modified to represent a structure. Consider the following diagram:

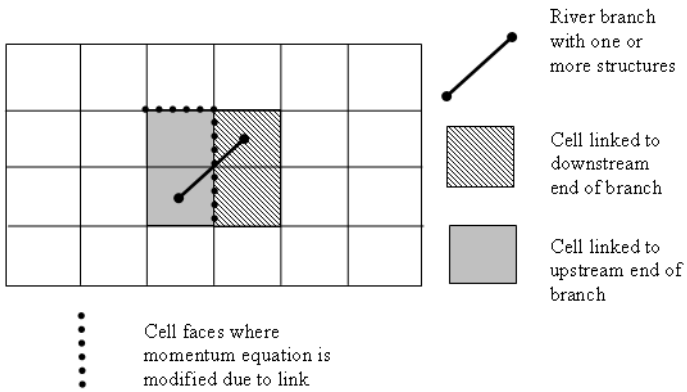


Figure 8.5 Structure Link Diagram

The momentum equation from the MIKE 11 q point replaces the x-momentum and y-momentum equation of the upstream MIKE 21 cell. This is the only thing that is modified within MIKE 21. Note that the cells at the downstream end of the branch are only used to extract a water level to be used when evaluating the momentum equation.

When the MIKE 11 momentum equation replaces the MIKE 21 momentum equation, the implicit terms for the momentum equation within the MIKE 21 cell are replaced. Adjustments are made for link direction (θ) and conversion

from discharge (Q) to flux ($q = Q/D$, D = 2D cell size). For the momentum equation in the x direction:

$$a_{M21} h_{j+1}^{n+1} + b_{M21} q_{j+1}^{n+1} + c_{M21} h_{j-1}^{n+1} = d_{M21} \tag{8.2}$$

$$a_{M21} = \frac{a_{M21} \cos\theta}{\Delta} \tag{8.3}$$

$$b_{M21} = b_{M11} \tag{8.4}$$

$$c_{M21} = \frac{c_{M21} \cos\theta}{\Delta} \tag{8.5}$$

$$d_{M21} = \frac{d_{M21} \cos\theta}{\Delta} \tag{8.6}$$

If the terms are added (for example if the structure link represents a structure flowing under the existing MIKE 21 topography), further adjustments are made to ensure consistency between the MIKE 11 and MIKE 21 terms. Again for the x direction:

$$a_{M21} h_{j+1}^{n+1} + b_{M21} q_{j+1}^{n+1} + c_{M21} h_{j-1}^{n+1} = d_{M21} \tag{8.7}$$

$$a_{M21}^{*} = a_{M21} + \frac{a_{M11} b_{M21} \cos\theta}{b_{M11} \Delta} \tag{8.8}$$

$$b_{M21} = b_{M11} \tag{8.9}$$

$$c_{M21}^{*} = c_{M21} + \frac{c_{M11} b_{M21} \cos\theta}{b_{M11} \Delta} \tag{8.10}$$

$$d_{M21}^{*} = d_{M21} + \frac{d_{M11} b_{M21} \cos\theta}{b_{M11} \Delta} \tag{8.11}$$

The same adjustments apply for the y direction momentum equation, except a sine direction adjustment is made rather than a cosine adjustment.

Note that the implicit terms from MIKE 11 used are from the MIKE 11 solution at the previous time step. In most applications, where flow conditions vary quite slowly relative to the time step, this is not a problem. It may become a problem if rapid (and relevant) changes do occur over a time step. Also, the displayed value of flow in the q point of the MIKE 11 branch may not neces-

sarily be the flow through the MIKE 21 cell. It is recommended that the MIKE 21 results are interrogated in this case rather than the MIKE 11 results.

8.3.1 Hydrodynamics - Exponential smoothing factor

The exponential smoothing factor may be used for links which are misbehaving causing oscillations. Though note that the smoothing factor will cause a time lag in the corresponding water levels between the coupled models. The exponential smoothing factor works by applying a weight to the transferred water level from MIKE 21 to MIKE 11. The expression reads

$$H_{M11}(n) = (1-\alpha)H_{M11}(n-1) + \alpha H_{M21}(n) \tag{8.12}$$

where α is the smoothing factor, H_{M11} is the MIKE 11 water level, H_{M21} the MIKE 21 water level and n is the time step. By applying this expression n times the water level may be given as

$$H_{M11}(n) = (1-\alpha)^n H_{M11}(0) + \alpha \sum_{i=0}^{n} (1-\alpha)^i H_{M21}(n-i) \tag{8.13}$$

Using the above expression a criteria for selection of the smoothing factor may be obtained. Assuming that the water level in MIKE 21 is constant then the number of time steps n it will take the MIKE 11 water level to be within a fraction f of the MIKE 21 water level is given by

$$n = \frac{\log f}{\log(1-\alpha)} \tag{8.14}$$

Thus the smoothing factor should be chosen in relation to the time scale at which the dynamics change in the model.

8.4 Hydrodynamics - Zero Flow Links

If the link type is a XFLOW = 0 link, the x direction momentum across the right face of the MIKE 21 cell is set so that p= 0. This is done by modifying the implicit terms:

$$a_{M21} h_{j+1}^{n+1} + b_{M21} q_{j+1}^{n+1} + c_{M21} h_{j-1}^{n+1} = d_{M21} \tag{8.15}$$

$$a_{M21} = c_{M21} = d_{M21} = 0 \tag{8.16}$$

$$b_{M21} = 1 \tag{8.17}$$

Similarly, if a YFLOW = 0 link, the y direction momentum across the top face of the MIKE 21 cell is set to $q = 0$.

8.5 Hydrodynamics - Urban links

The exchange of water (Q_{UM21}) at the inlet can be computed in three different ways:

- Orifice equation
- Weir equation
- Exponential function

The orifice calculation is given by:

$$Q_{UM21} = sign(H_U - H_{M21}) C_D Min(A_m, A_l) \sqrt{2g|H_U - H_{M21}|} \quad (8.18)$$

for $|Q_{UM21}| < Q_{max}$, where

Q_{UM21}:	Flow from sewer to MIKE 21 grid point.
H_U	Water level in sewer system.
H_{M21}:	The average water level on the ground.
A_m:	Cross-sectional area of manhole.
A_l:	Cross-sectional area of inlet (not used for basins) and
C_D	The discharge coefficient (typically 1).

Note that if the nodes ground level is greater than either the water level in the node or the water level in MIKE 21 then the corresponding water level is over-ridden by the ground level.

The weir equation depends on whether there is flooding on the surface or not. If the surface is not flooded at the time, then it is calculated as a free flowing weir:

$$Q_{UM21} = C(H_U - H_{M21}) W_{crest} \sqrt{2g|H_U - H_{M21}|} \quad (8.19)$$

for $|Q_{UM21}| < Q_{max}$, where W_{crest} is crest width to be used in the equation and C_D is the discharge coefficient. The same equation is used if surface is flooded and the water level in the node is below the nodes ground level.

If the surface is flooded (water level in MIKE 21 and MIKE+ (Urban) above the nodes ground level) then the weir is calculated as a submerged weir:

$$Q_{UM21} = C(H_U - H_{M21}) W_{crest} \sqrt{2g|H_U - H_{M21}|} \left(\frac{|H_U - H_{M21}|}{\max(H_{M21}, H_U) - H_g} \right) \quad (8.20)$$

The term is H_g is the ground level at the coupling.

The last function for computing the flow between MIKE+ (Urban) and MIKE 21 is given by:

$$Q_{UM21} = sign(H_U - H_{M21}) S(|\max(H_{M21}, H_g) - \max(H_U, H_g)|)^{Exp} \quad (8.21)$$

for $|Q_{UM21}| < Q_{max}$, where *S* is the Scaling factor and *Exp* the Exponent.

Note that in eq. (8.21) the values of H are given in meters and the discharge is given in m^3/s.

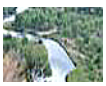
There is an option to suppress oscillations by use of the QdH factor. The value corresponds to the water level difference below which the suppression is applied. The suppression is designed for cases where the pressure level in the sewer system is close to the water level in MIKE 21 and may be applied individually at each urban coupling. If a value of 0.0 is given then no suppression is applied. When another QdH value is given, the discharge from equation (8.21) is multiplied by a suppression factor between 0 and 1. When the water level difference between the node and MIKE 21 is greater than Qdh then the factor is 1. For water level differences dh less than QdH, the suppression factor is:

$$Suppressionfactor = 1 - ((QdH - dh)/QdH)^2 \quad (8.22)$$

8.6 Urban River Links

Basically the urban river links may be of two types:

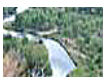
- two way couplings
- one way couplings



The former is used by the water level boundary in the river network coupling and the outlet coupling. The mechanism is that one model delivers a water level and in return receives a discharge.

The second type of coupling does not have feedback mechanism (weirs and pumps) so these simply act as source terms in the river.

8.7 Advection-Dispersion



Concentrations of AD components are transferred explicitly between MIKE 11 and MIKE 21 depending on the direction of the flow. For standard links with flow from MIKE 11 to MIKE 21, the concentration of the AD-component is imposed as with a standard MIKE 21 source, i.e. as a flux of mass into the

MIKE 21points:

$$\Delta\left(\frac{\partial V \cdot C_{M21}^{n+\frac{1}{2}}}{\partial t}\right) = Q^{n+\frac{1}{2}} \cdot C_{M11}^{n} \tag{8.23}$$

When flow is going from MIKE 21 to MIKE 11, the modification to the AD-equation in MIKE 21 is:

$$\Delta\left(\frac{\partial V \cdot C_{M21}^{n+\frac{1}{2}}}{\partial t}\right) = Q^{n+\frac{1}{2}} \cdot C_{M21}^{n} \tag{8.24}$$

The corresponding boundary condition in MIKE 11 can be either a transport boundary or a concentration boundary as usual. Furthermore, a mixing coefficient can be defined as normal. It is strongly recommended to use a transport boundary condition in MIKE 11.

For lateral links, the mass of the AD component being transferred is calculated from the lateral discharge and the concentration in MIKE 11 or MIKE 21 (depending upon flow direction). This is then applied as a source or sink term in the branches and cells. The source term into MIKE 21 is as for the standard links. For MIKE 11, the one dimensional advection dispersion equation is:

$$\frac{\partial AC}{\partial t} + \frac{\partial QC}{\partial x} - \frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right) = -AKC + C_2 q \tag{8.25}$$

where C is concentration, D dispersion coefficient, A cross-sectional area, K linear decay, C_2 the source/sink concentration and q lateral inflow per river length.

For zero flow links, no advection will occur across the link due to the zero flow specification, and dispersion is turned off.

8.8 Flow Distribution by Depth

Flow is distributed according to the Chezy equation for resistance:

$$Q = AC\sqrt{RS} \tag{8.26}$$

where:

Q	=	Flow;
A	=	Area (= width · depth = $w \cdot h$);
C	=	Chezy coefficient;
R	=	Hydraulic radius (approx. = depth = h); and
S	=	slope.

Rearranging this equation gives:

$$Q = whCh^{0.5}S^{0.5} = h^{1.5}wCS^{0.5} \tag{8.27}$$

Thus, proportionality can be derived between flow and water depth (h):

$$Q \sim h^{1.5} \tag{8.28}$$

Flow is then distributed across a number (n) of MIKE 21 cells. For each cell (count i = 1...n), the distributed flow Q_i is calculated from the total flow Q_{TOT}:

$$Q_i = Q_{TOT}\frac{h_i^{1.5}}{\sum_{i=1}^{n} h_i^{1.5}} \tag{8.29}$$

8.9 Inclusion of Friction Term in Weir Formulae 1 and 2 (Honma)

The equation for the Weir Formula 1 is:

$$Q = wCh_1^k\left[1-\left(\frac{h_2}{h_1}\right)^k\right]^{0.385} \tag{8.30}$$

where w = width, C = weir coefficient, k = exponential coefficient (1.5), h_1 = depth of water above weir level upstream (H_{us} - H_w) and h_2 = depth of water above weir level downstream (H_{ds} - H_w). This equation is actually a free overflow term (wCh^k) combined with a scaling term for submergence ([...]$^{0.385}$) that approaches 0 as h_1 approaches h_2. The equation for the Weir Formula 2 (Honma) is:

$$\begin{aligned} Q &= wCh_1\sqrt{h_1} && \text{for } \frac{h_2}{h_1} \le 2/3: \\ Q &= w\frac{3}{2}\sqrt{3}Ch_2\sqrt{h_1-h_2} && \text{for } \frac{h_2}{h_1} > 2/3: \end{aligned} \tag{8.31}$$

The first equation is free overflow (identical to Formula 1 with free overflow), while the second is for submerged conditions.

Both equations are derived from the equation for form loss across a structure, where

$$\Delta h = \zeta\frac{v^2}{2g} \tag{8.32}$$

If a friction loss is added this becomes:

$$\Delta h = (\zeta + F)\frac{v^2}{2g} \tag{8.33}$$

where:

$$F = \frac{2gLn^2}{h_1^{4/3}} \tag{8.34}$$

L = length of structure,
n = Manning's number.

L is calculated as length between opposite corners in a MIKE 21 grid cell (= the hypotenuse) :

$$L = \sqrt{((\Delta X_{M21})^2 + (\Delta Y_{M21})^2)} \tag{8.35}$$

Expanding:

$$Q = w\sqrt{\frac{2g}{(\zeta + F)}}h_1\sqrt{\Delta h} \tag{8.36}$$

This equation is similar in form to Weir Formulae 1 and 2 for free overflow, except that the weir coefficient is replaced:

$$C = \sqrt{\frac{2g}{\zeta + F}} \tag{8.37}$$

Assuming that the entrance and exit losses are identical, a new weir coefficient C_f can be derived from the original coefficient C and the additional friction:

$$C = \sqrt{\frac{2g}{\zeta}} \quad <=> \quad \zeta = \frac{2g}{C^2} \tag{8.38}$$

$$C_f = \sqrt{\frac{2g}{\zeta + F}} = \sqrt{\frac{2g}{2g/C^2 + F}} \tag{8.39}$$

So, the existing equations for weir flow calculations can be used, except that the weir coefficient is modified according to:

$$C_f = \sqrt{\frac{2g}{2g/C^2 + \frac{2gLn^2}{h_1^{4/3}}}} \tag{8.40}$$

This equation is applied to the weir calculations in the lateral link specifications.

9 Examples

The examples presented below are designed to test the operation of the features of MIKE FLOOD and to demonstrate the use of these features. Most are available with the DHI software in the “Examples” folder. Otherwise, check www.mikebydhi.com, where the input files can be downloaded.

Various MIKE Zero tools can be used to view the results, including the Result Viewer, MIKE View (not in MIKE Zero), Plot Composer, and the time series, profile series and grid series editors.

A brief outline of the examples is provided:

- Standing Wave: examines momentum transfer through standard links
- Lateral Link 1: investigates lateral link flow over a bank of varying bed levels and includes an AD component
- Lateral Link 1: investigates lateral link flow and compares results to a standard MIKE 11 weir
- Flow Direction: examines flow directions through various links
- Flood plain Flow: examines the transition from in-bank to flood plain flow in a simplified setup
- Floodplain Demonstration: demonstration of a real flood plain application. The example is available both for the rectangular case as well as the flexible mesh version.
- 2 urban flooding examples are included: Urban and Waterville. They investigate the different urban links available between MIKE+ (Urban) and MIKE 21.
- MIKE FLOOD 3way: a 3-way coupling example with MIKE HYDRO, MIKE+ (Urban) and MIKE 21 (flexible mesh).

9.1 Standing Wave

Consider an 8 km long basin closed at both ends:

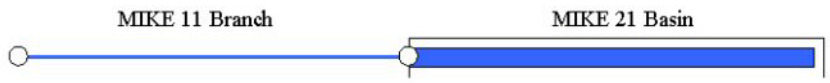


Figure 9.1 Standing Wave Test Layout

The width of the basin is 100 m and the mean water depth is 2.0 m. The bed resistance is C = 50 m1/2/s. An initial disturbance of the water surface is imposed corresponding to a sinusoidal variation of range 0.10 m.

The basin is described using MIKE FLOOD. 4 km is described in MIKE 11, and 4 km is described in MIKE 21. In both models, the longitudinal grid spacing is 100 m. MIKE FLOOD simulates the transfer of mass as well as momentum between the 1D MIKE 11 model and the 2D MIKE 21 model. The water level at different times after start of the simulation is depicted below.

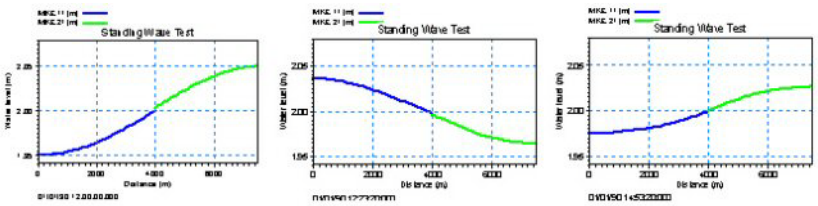


Figure 9.2 Standing Wave Test Results - Water Level Profiles

The files required to setup and run this example are available. These files take this example further than presented here, with tests using:

- the standard link type;
- a 10 cell / 1000 m wide setup of the same test case;
- a MIKE 11 model of the entire test (no MIKE FLOOD link); and
- a MIKE 21 model of the entire test (no MIKE FLOOD link).

Thus, four separate tests are included in this single MIKE FLOOD setup. The results are shown as water level profiles at various time steps:

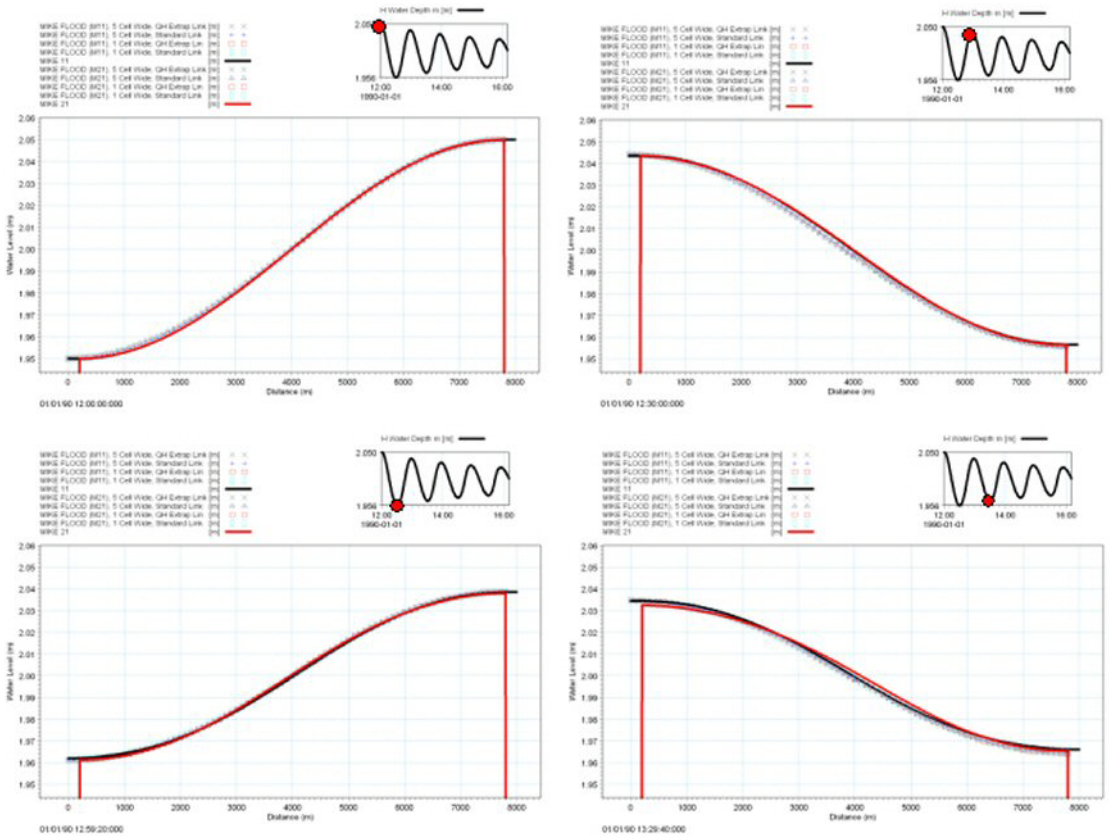


Figure 9.3 Standing Wave Test Results - Water Level Profiles (2)

While it is difficult to examine the individual curves, the plots shown above demonstrate that the various link types are performing satisfactorily. See the examples provided for further interrogation.

9.2 Lateral Link 1

This is a test to assess the performance of the lateral links and to illustrate their implementation. The test represents an inflow channel with over topping onto a broad flat basin (or flood plain), as shown:

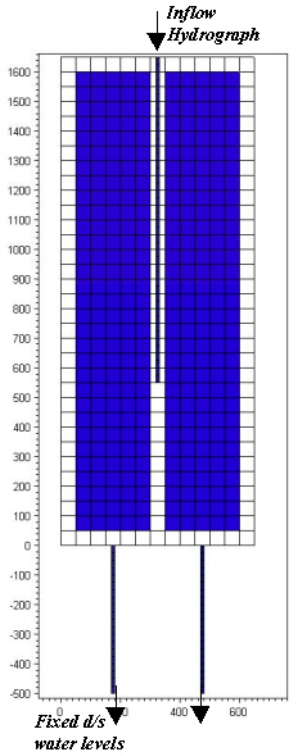


Figure 9.4 Lateral Link Test 1 Layout

An inflow hydrograph discharges into the upstream MIKE 11 river branch. Flow spills over the banks of the river channel and into the MIKE 21 basins. The left and right basins are separated by land. Two downstream MIKE 11 branches are connected to the end of the left and right basins. Water level boundary conditions are applied to the downstream branches. A closed boundary is applied to the downstream end of the upstream river branch.

The MIKE 11 network uses a 50 m spacing between h points, and the MIKE 21 grid has a spacing of 50 m. A simulation time step of 5 s is used.

The links at the downstream end of the MIKE 21 basin are standard links. The main interest in this test however is the lateral links. The left bank of the upstream branch (chainage 100 m to 1100 m) is connected to the MIKE 21 cells in the right basin (7, 31 to 7, 11). The right bank is connected to the left basin (5, 31 to 5, 11).

The left and right bank markers of the branch are defined by a sinusoidal curve as shown:

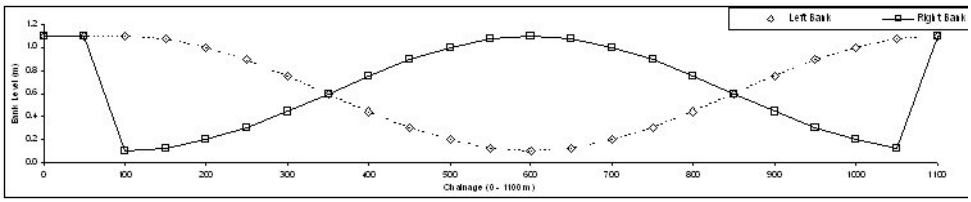


Figure 9.5 Lateral Link Test 1, Left and Right Bank Levels

Lateral flow spilling out of the river channel into the basin will be distributed across the length of the branch, depending upon the bank levels, the water level profile along the branch, and the flow distribution will vary between the left and right sides of the river.

The MIKE FLOOD couple file is “mf.couple”. Run this simulation, then inspect results using the Result Viewer in MIKE Zero. Contours of water depth and vectors of velocity at two instances in the simulation are shown below:

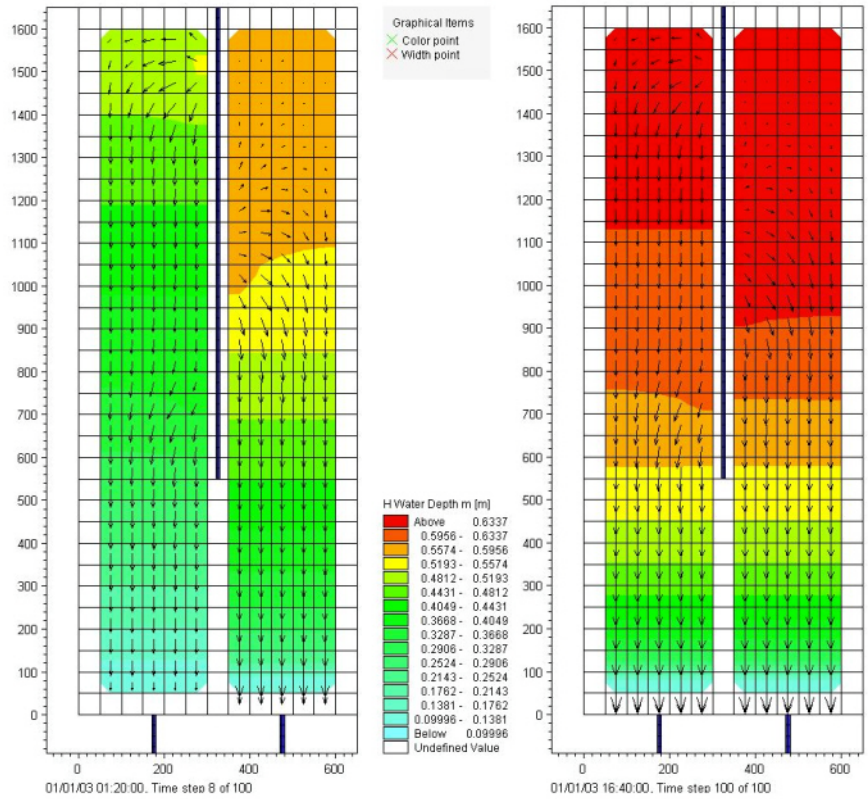


Figure 9.6 Lateral Link Test 1 Results -Water Depth and Velocity

There is a distinct difference in flow patterns between the left and right basins. Using MIKE View, look at the longitudinal profile of the upstream branch:

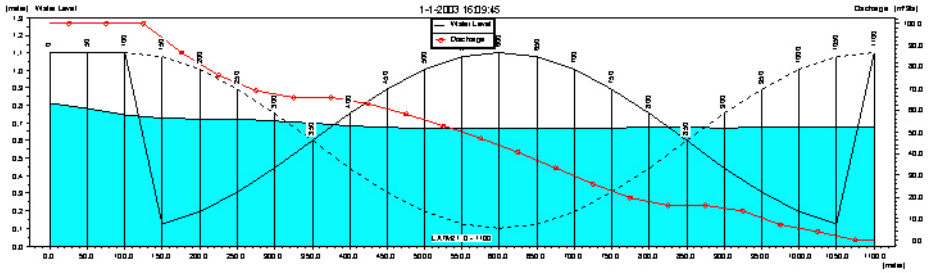


Figure 9.7 Lateral Link Test 1 Results -Water Level and Flow Profile

Similarly, the lateral discharges can also be presented (tick the “Lateral Inflows” button in the Additional Output Menu in HD Parameters):

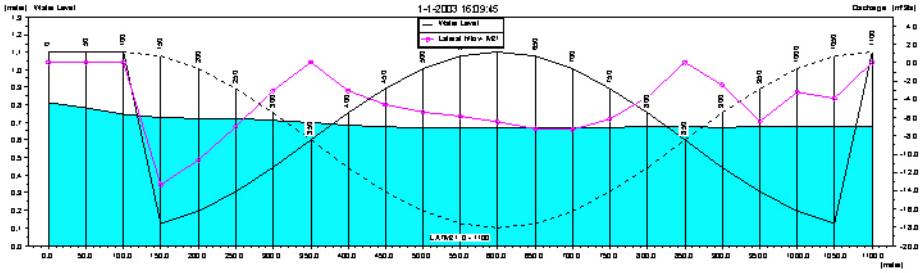


Figure 9.8 Lateral Link Test 1 Results - Lateral Flow Profile

Last (but not least), a check of the mass in the system can be made by comparing the total discharge into the model (the upstream inflow from the upstream branch) with the discharge out of the model (from the downstream branches):

As shown, 100 m3/s enters from upstream. The flows are distributed so that 47.76 m^3/s flows through the left branch and 52.24 m^3/s through the right.

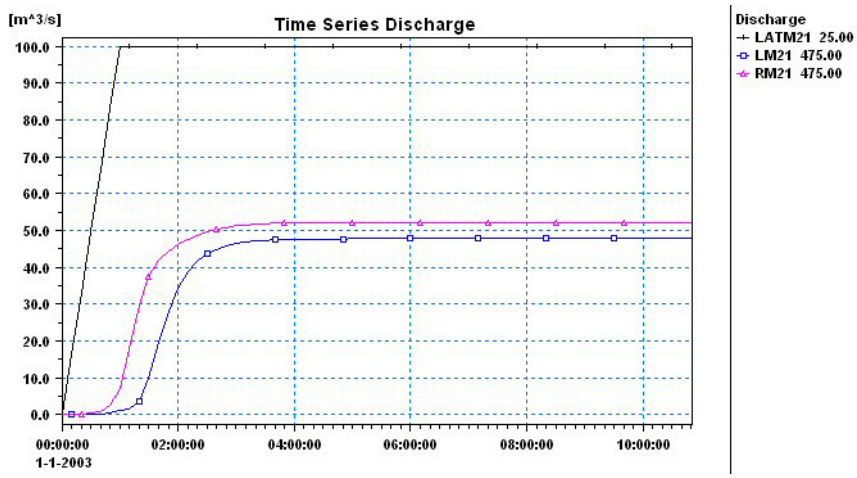


Figure 9.9 Lateral Link Test 1 Results -Time Series of Discharge

For comparison, the same setup has been done using MIKE 11. For the MIKE 11 setup, the left and right basins are represented using branches. Flow from the upstream branch to the basins occurs through two additional branches with cross-sections representing the bank levels. The MIKE 11 test has been combined with the original MIKE FLOOD application (see mf2.couple):

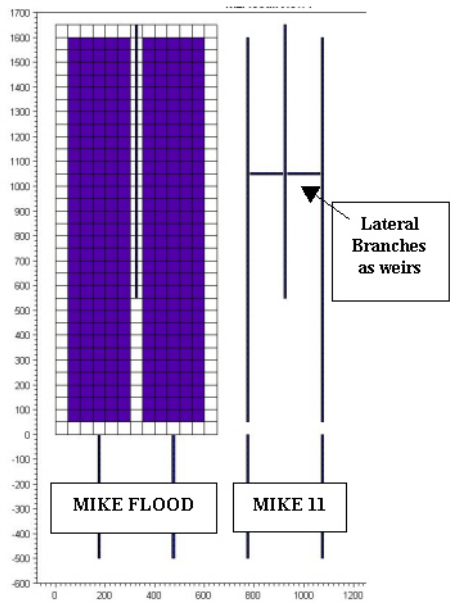


Figure 9.10 Lateral Link Test 1 Layout (2)

The MIKE 11 test has two branches representing lateral flow aligned equally at the centre of the upstream branch. Comparison of discharges from the

downstream branches for the MIKE FLOOD and MIKE 11 tests are presented below:

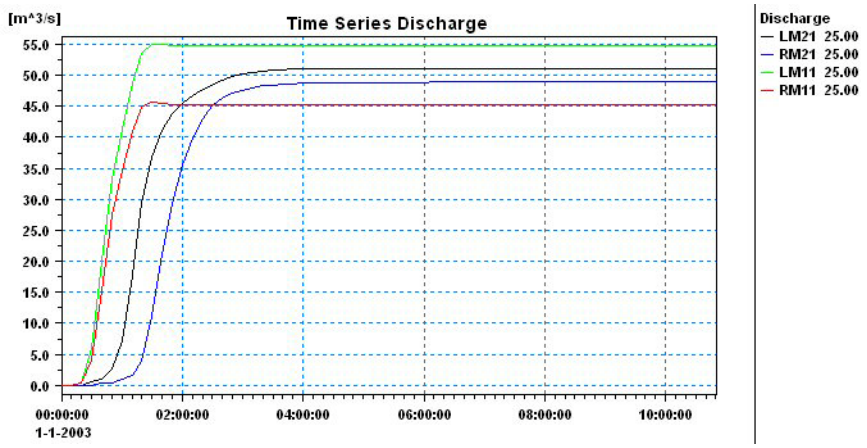


Figure 9.11 Lateral Link Test 1 Results - Time Series of Discharge (2)

Both the MIKE FLOOD and MIKE 11 simulations preserve mass, with the amount of flow leaving the system exactly the same as the amount entering. However, the MIKE FLOOD and MIKE 11 simulations each give different distributions between the left and right banks. There are several possible reasons for this:

- MIKE FLOOD accounts for the water level gradient in the channel. This increases the accuracy of over bank flow calculations.
- MIKE FLOOD calculates weir flow across each calculation point (20 in total), whereas the MIKE 11 simulation calculates weir flow at one calculation point.
- It is possible that additional losses from 2D effects (such as eddy formations) in MIKE 21 are contributing to the lateral link structure losses. This may create a variation between a MIKE 11 prediction and the MIKE FLOOD prediction.

The findings of this test show that the lateral links are mass preserving and behave as expected. Further, the test highlights the importance of using lateral links in situations where there is a significant water level gradient in the in-bank river channel.

Finally, an AD simulation is added to the test. To do this, add the AD computation to MIKE 11 and MIKE 21, then set the MIKE FLOOD Coupling Type to be “HD and AD”.

The time series plot displays pollutant concentrations entering the upstream boundary and flowing out the two downstream boundaries:

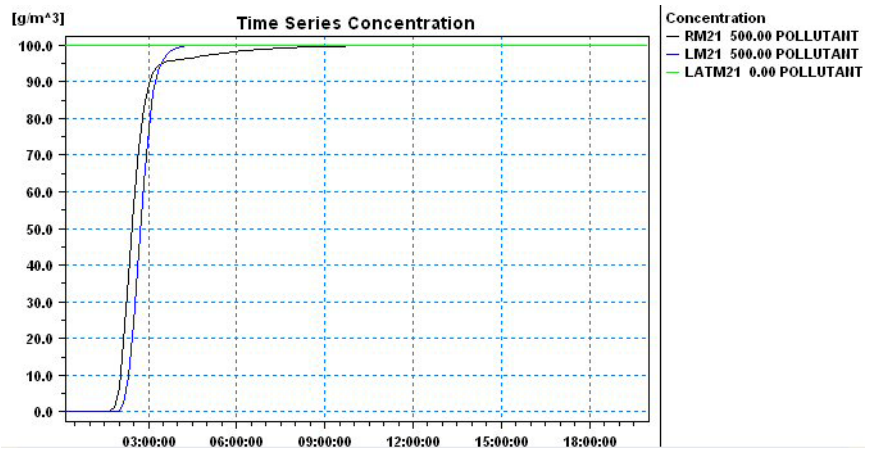


Figure 9.12 Lateral Link Test 1 Results - Time Series of Concentration

Also, contour plots of concentration in the MIKE 21 domain are shown at two instances:

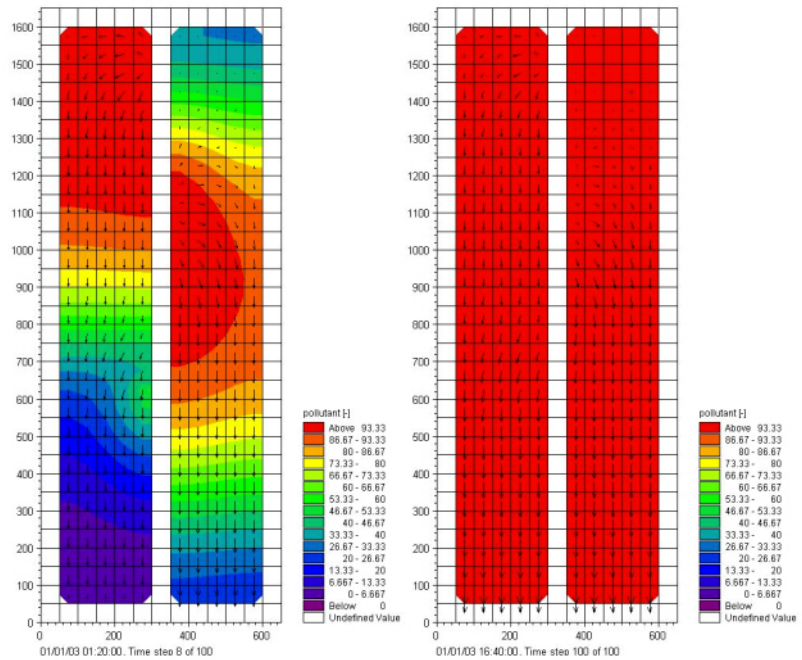


Figure 9.13 Lateral Link Test 1 Results - Concentration

9.3 Lateral Link 2

This is a test to ensure that the structure equation in the lateral link is consistent with that in a standard MIKE 11 simulation. The first test is a simple MIKE

FLOOD model that has a MIKE 11 branch linked to a MIKE 21 basin using a standard link:

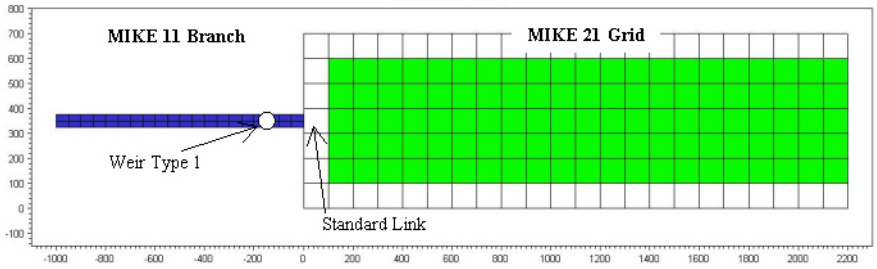


Figure 9.14 Lateral Link Test 2 - Standard Link Layout

The MIKE 11 branch is 1000 m long with a uniform cross-section of width 500 and bed level 0 m. The MIKE 21 basin is also 500 m wide with a bed level of 0 m, and is 1000 m long. Grid spacing is 100 m. The MIKE 11 branch has a weir located near the link (chainage 850 m). This weir has a height of 2.2 m and is 500 m wide. A weir formula 1 is applied.

The second test aims to replicate the first, except using a lateral link rather than a standard link. The MIKE 11 branch (branch1) is the same as the first test except it is truncated at the weir location (at chainage 800 m) where another branch (latb) is attached. This branch has a length of 500 m, and the left banks of the cross-sections have a bed level of 2.2 m. The lateral link connects this branch to the MIKE 21 basin. A weir formula 1 is applied in the lateral link.

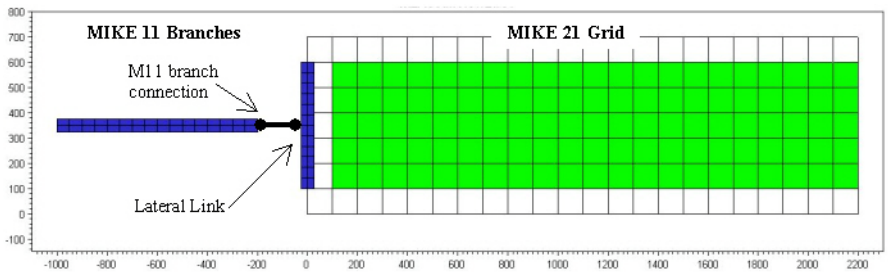


Figure 9.15 Lateral Link Test 2 - Lateral Link Layout

The initial water level and the downstream water level at the MIKE 21 boundary is 2 m (so water depth is 2 m in the upstream branch and in the MIKE 21 grid). The simulations are performed using a time step of 30 s (explicit Courant conditions). The upstream flow boundary in MIKE 11 gradually rises from 0 m3/s to 100 m3/s and remains steady at this flow rate.

The resulting water level at the upstream end of the MIKE 11 branch and the discharge at the downstream end are presented below:

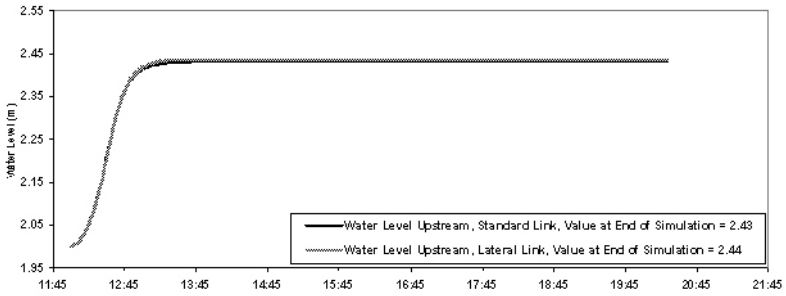


Figure 9.16 Lateral Link Test 2 Results - Time Series of Water Level

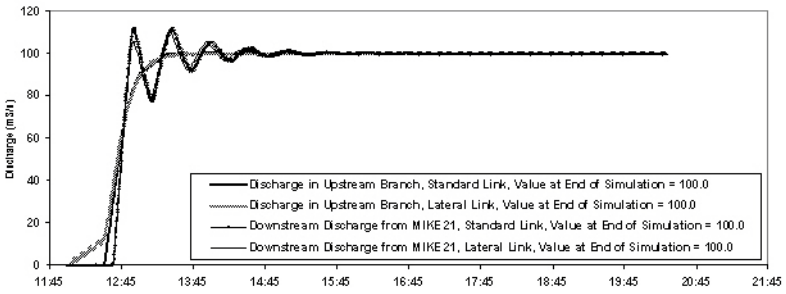


Figure 9.17 Lateral Link Test 2 Results - Time Series of Discharge

There is a slight variation in water levels as the discharge increases, but the steady state levels are similar for both simulations (2.43 m and 2.44 m). These variations may be due to the missing momentum transfer across the lateral links. Steady state discharge is the same for both simulations (100 m3/s), indicating that mass is conserved through the links. Notice the oscillations in the discharge at the downstream end of the MIKE 21 basin. This is a result of reflections in the MIKE 21 model, created as the initial wave front produced by the rising discharge enters the MIKE 21 domain.

The water level contours and current vectors in MIKE 21 for each simulation are presented below. Notice that there is a slight variation in flow distributions in the laterally linked case (the variations are shown by the velocity vectors in the link cells).

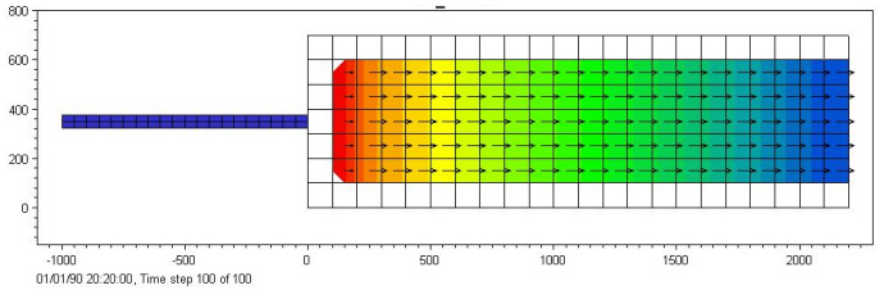


Figure 9.18 Lateral Link Test 2 Results - Standard Link

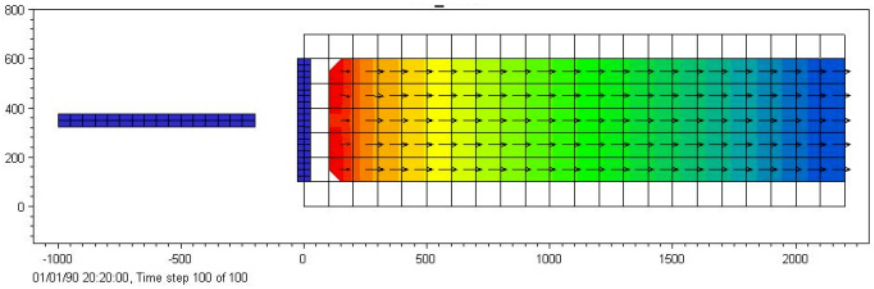


Figure 9.19 Lateral Link Test 2 Results - Lateral Link

9.4 Flow Direction

This test was initially designed to test links applied in a direction that is not aligned with the MIKE 21 grid. However, it evolved into a demonstration of all the link types available in MIKE FLOOD.

The test consists of a square MIKE 21 basin with a variety of MIKE HYDRO branches discharging flow into it. The branches are aligned at different angles to the MIKE 21 grid, and consist of standard and lateral links. In the centre of the basin is a lateral link that drains the basin. Using the zero flow links, the bottom right corner has been isolated from the rest of the basin, except for two structure links on each side. The structure links are connected to 3 point MIKE HYDRO branches with a weir. Some of the link cells in MIKE 21 are completely surrounded by wet cells. Others have land cells, or alternatively zero flow links, inserted behind the link cells.

The MIKE 21 grid size is 10 m and the initial water level is 1 m. A constant discharge of 10 m3/s is applied to the upstream end of each branch, and the time step in both MIKE HYDRO and MIKE 21 is 2 s.

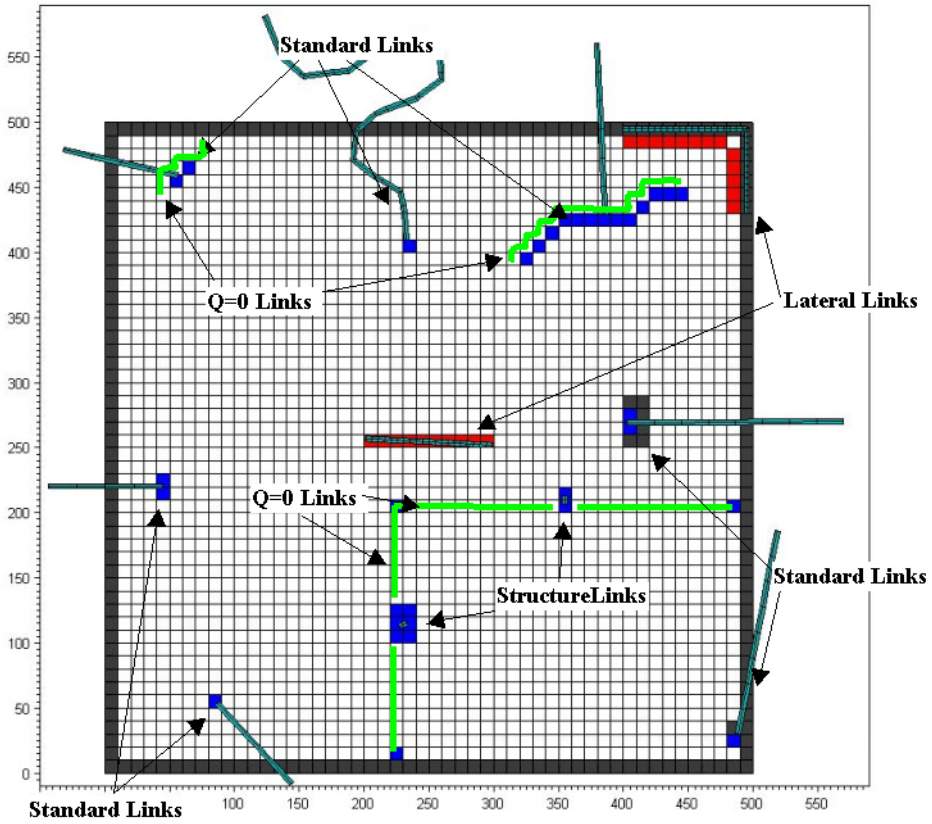


Figure 9.20 Flow Direction Test Layout

The HD simulation, run to steady state conditions, is presented below:

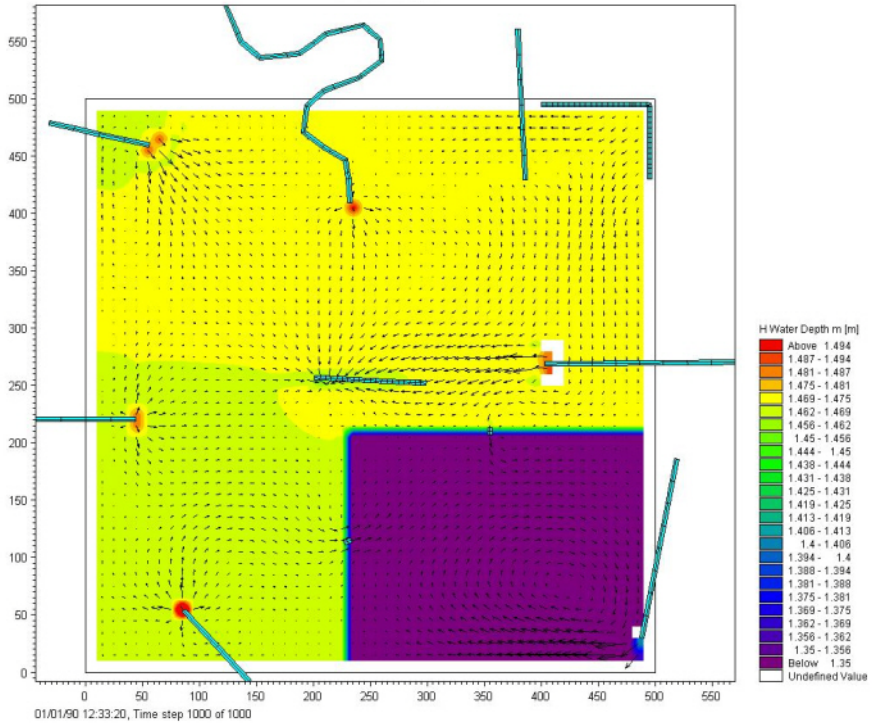


Figure 9.21 Flow Direction Test Results - Water Depth and Velocity

As shown, the direction of flow discharging from each linkage point is consistent with the branch alignment. The link points that have land or zero flow links behind them show slightly different flow patterns. As a result of the zero flow links, water levels in the bottom right corner are lower than the rest of the model. This is driving flow through the structure links.

An AD simulation was also performed. Initial concentration was set to zero and inflows apply a conservative concentration of 100. The contour plot below shows results:

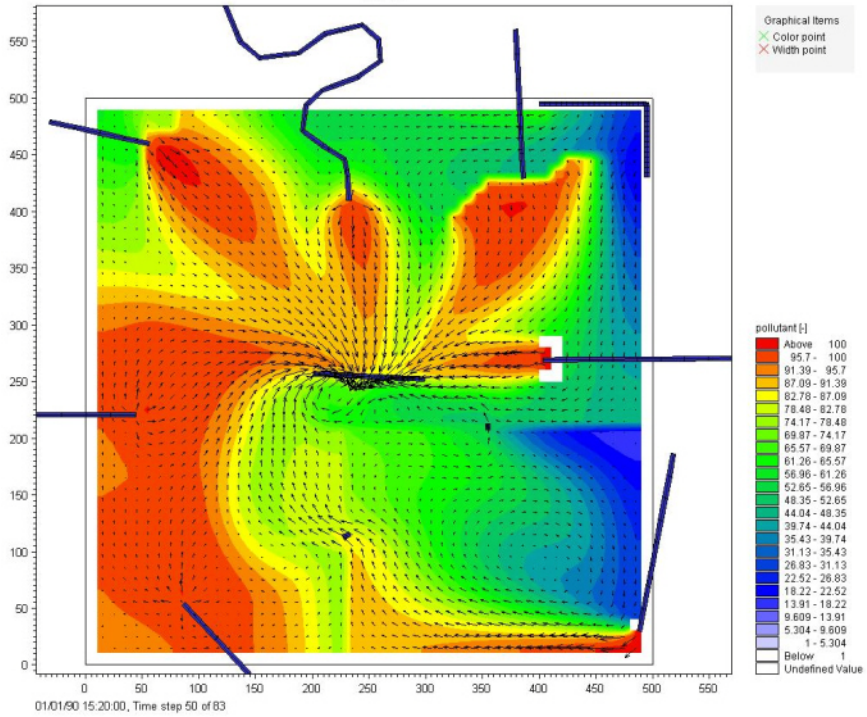


Figure 9.22 Flow Direction Test Results - Concentration

The flow directions from the links create a slight “whirlpool” pattern. The zero flow links are also zero concentration links - the plot above demonstrates that the zero flow links are a barrier to advection and dispersion.

Finally, a check of mass conservation in the model is made. With 8 separate inflow branches the total flow rate into the system is 80 m^3/s. The resulting discharge through the draining lateral link in the centre of the basin is shown below. At the completion of the simulation, the flow rate shown in MIKE View at the last point in the lateral flow branch is 77 m^3/s. While this may appear to be a mass loss error, in fact it is a minor presentation bug caused by having a lateral link at the last h point in the branch. The discharge presented in MIKE View is at the last q point. As lateral flows are added to the h points, this means that the flow rate of 77 m^3/s does not include an additional 3 m^3/s entering the last h point.

To check this, rerun this simulation with the lateral link connected between chainage 20 to 100 m on the MIKE HYDRO branch (branch9). The discharge at the last point will then be presented as 80 m^3/s, indicating that mass is preserved.

9.5 Flood plain Flow

This is another test of the lateral links. It compares model performance over a broad flood plain application. This is a simplified representation of a typical lateral link application - flood plain in MIKE 21, river channel in MIKE 11, and flow between them in MIKE FLOOD.

The test consists of four separate setups:

- MIKE FLOOD -river channel modelled in MIKE 11, footplates in MIKE 21, connected with MIKE FLOOD lateral links (“mf.couple”)
- MIKE 11 - single branch for main channel and footplates (“mf.couple”)
- MIKE 11 - separate main channel and flood plain branches, interconnected by link channels (“mf.couple”)
- MIKE 21 - both river channel and floodplains modelled in MIKE 21 (“m21a.M21”)

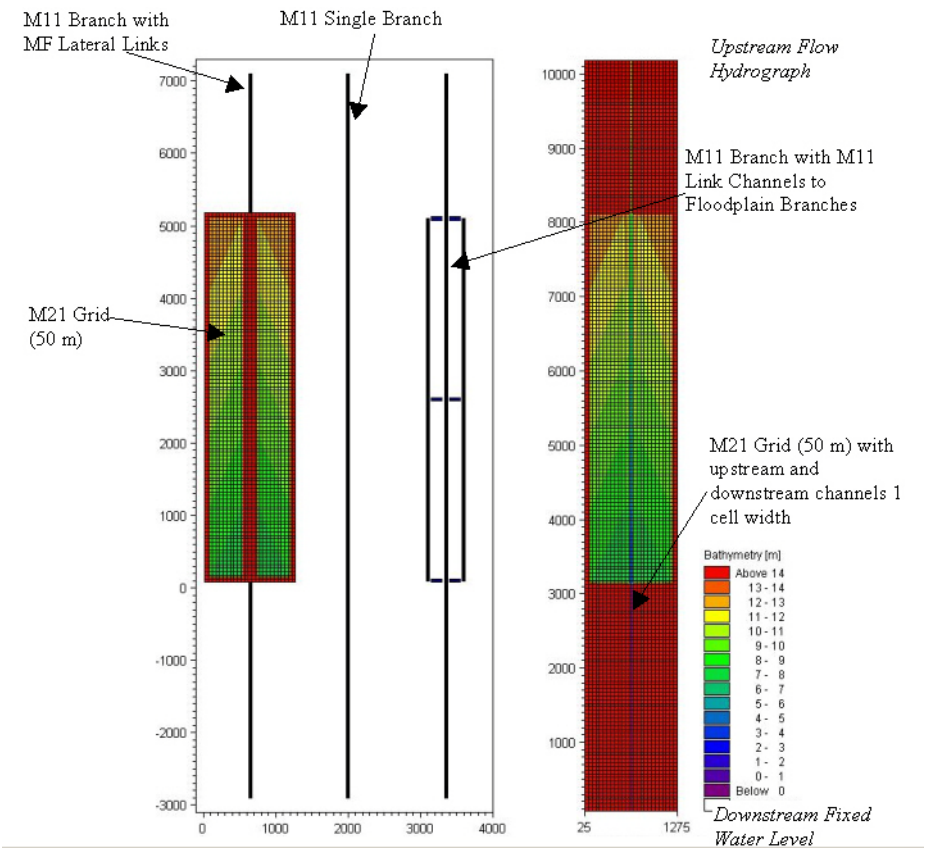


Figure 9.23 Floodplain Flow Test Layout

Each test represents the same geometry, consisting of a 50 m wide, 5 m deep channel. On each side of the channel is a 50 m wide levee. Beyond the levees the floodplains are initially 1 m below the levees, and rise laterally by 1 m over a distance of 250 m. A typical cross-section is shown:

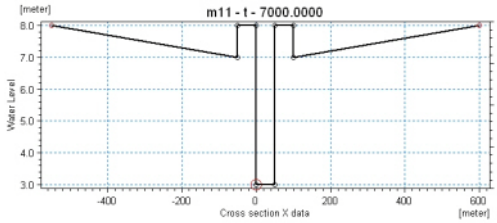


Figure 9.24 Floodplain Flow Test - Typical Cross-section

The total length is 10000 m. The river has a uniform slope of 1:1000 - the bed of the main river channel upstream is 10 m, and the bed downstream is 0 m.

To each of these setups, an upstream flow hydrograph is applied, which has a peak discharge of 2000 m3/s. A downstream water depth of 4 m is maintained.

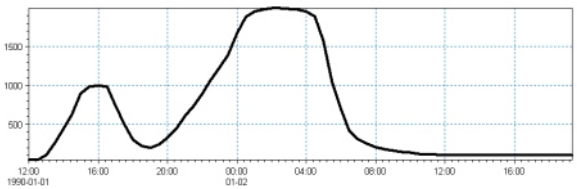


Figure 9.25 Floodplain Flow Test - Upstream Hydrograph

The water level at the upstream end of each of the four models is presented:

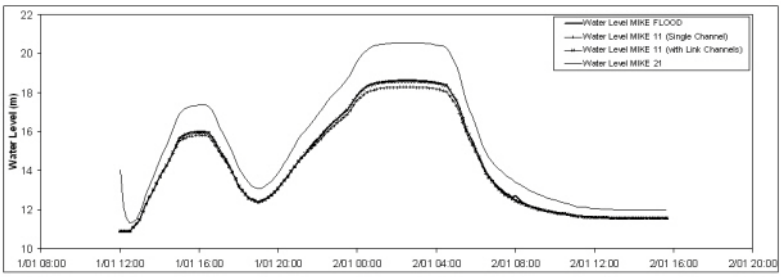


Figure 9.26 Floodplain Flow Test Results - Upstream Water Level

Further, the discharge at the downstream ends of each model is presented with the upstream hydrograph:

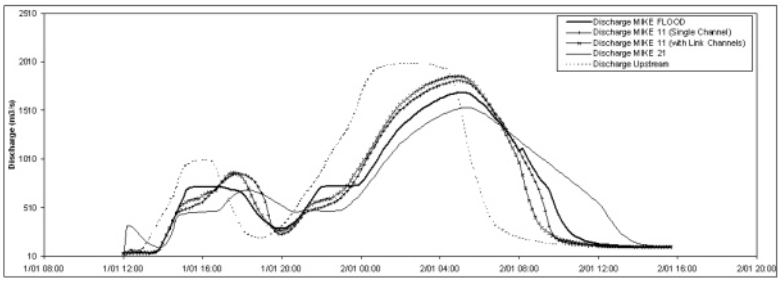


Figure 9.27 Floodplain Flow Test Results - Downstream Discharge

For each test case the upstream water levels are reasonably consistent with the other. However, the MIKE 21 simulation predicts a higher water level, suggesting more losses along the length of the model. The downstream discharges are also reasonably consistent, although again the MIKE 21 simulation (and to a lesser extent the MIKE FLOOD simulation) have a reduced, more dampened discharge peak. This again suggests more losses in the model.

A possible reason for this variation in model predictions between MIKE 11 and MIKE 21 could be due to wetting and drying in MIKE 21.

9.6 Floodplain Demonstration

This example is available as a demonstration model to illustrate a real application of MIKE FLOOD using the rectangular grid. The application consists of a flood simulation through a river system. The area of interest is at a confluence with a tributary, where a road embankment has been proposed. Culverts under the road are located on each side of the river.

The river system is represented in MIKE 11. A MIKE 21 grid is inserted into the broader MIKE 11 network to represent flood plain flow, as shown in Figure 9.28:

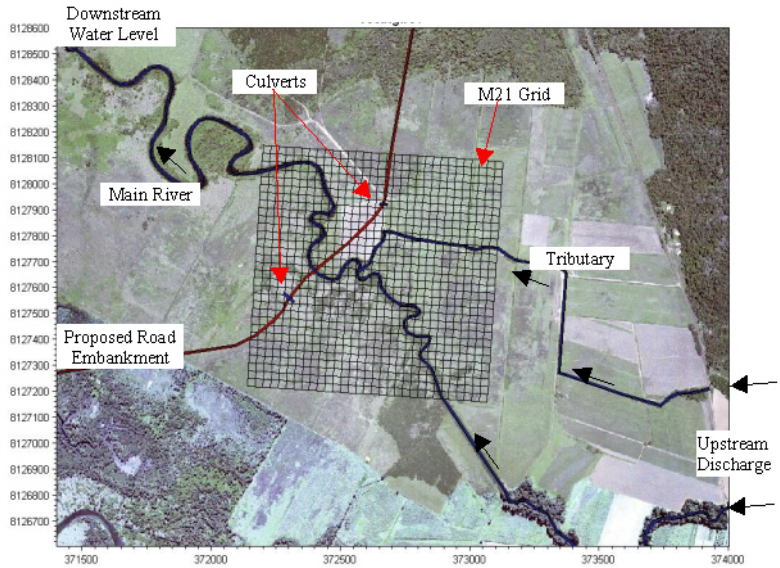


Figure 9.28 Floodplain Demonstration Layout

- A 5 s time step is used in the simulation and the MIKE 21 grid size is 30 m. The model has been developed with the following MIKE FLOOD links:
- lateral links between the main river channel and floodplain and the tributary and floodplain
- zero flow links along the centre line of the river channel, to ensure that water flows from one side of the floodplain to the other via the main channel
- similarly, zero flow links along the centre line of the tributary
- zero flow links defining the road embankment (assuming that the road does not over top)
- implicit structure links for flow through the culverts

A diagram illustrating the locations of the links is shown:

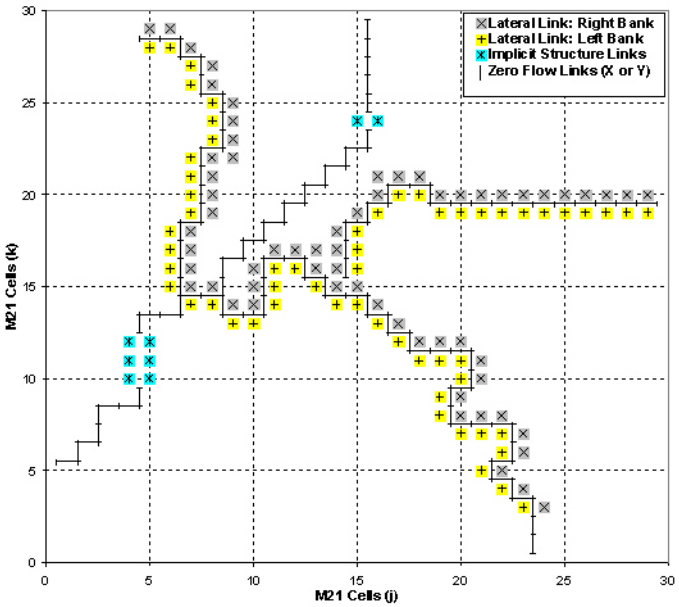


Figure 9.29 Floodplain Demonstration, Diagram of MIKE FLOOD Links

The upstream discharge hydrographs for the river and tributary and the downstream water level boundary condition (which is tidal), are shown below:

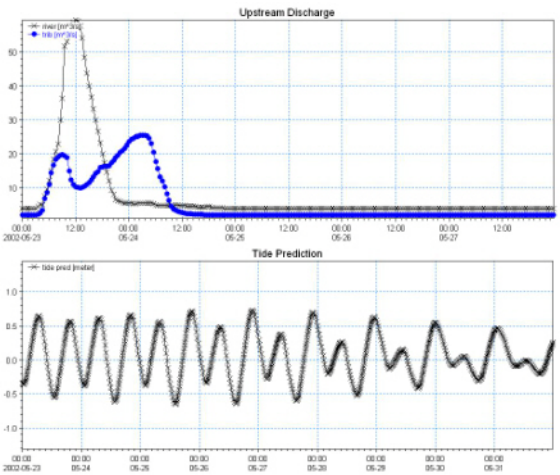


Figure 9.30 Floodplain Demonstration Boundary Conditions

Model results showing water surface contours and velocity vectors near the peak of the flood event are presented in Figure 40. The time series plots in Figure 9.32 show water levels immediately upstream and downstream of the road embankment, and water level difference across the road embankment.

Also shown is discharge through the main river channel and through each culvert.

The model results show that for this particular flood event there is a peak 0.36 m head drop across the road embankment. However, the peak head drop at the peak of the flood is 0.16 m. Peak discharge through the main river channel is 44.2 m3/s, which is much higher than the culvert flows of (1.7 m3/s and 3.8 m3/s).

If this model was intended to investigate the hydraulic impacts of the road embankment, a model of the existing situation (no road) could also be performed. Comparing model results with and without the road embankment could give an indication of the likely impacts. Also, the performance of the culverts could be assessed (maybe more are needed?).

Note that this is a demonstration model - not a real example. Other modelling considerations that could be of relevance in this example include:

- The MIKE 21 grid does not cover the entire floodplain width.
- The proposed road crosses over the main channel. Any hydraulic effects (bridge structure or pier losses) created by this situation are ignored.
- The roughness parameter on the floodplain has been set to a constant value of M=20. The roughness may actually be varying spatially, particularly if there are a range of land use patterns.
- The upstream and downstream MIKE 11 branches only represent the main channel. They do not include the flood plains.

The flood plain example is also available as a flexible mesh version. Note that the flexible mesh version does not have zero-flow links available since these may easily be accomplished through the use of internal closed boundaries. The latter has also been done for the flood plain example to model the road cutting through the flood plain.

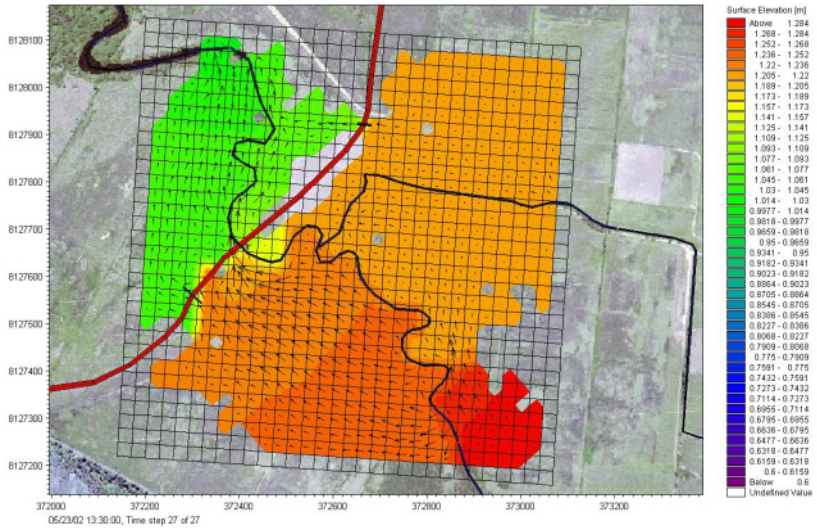


Figure 9.31 Floodplain Demonstration, Water Surface and Velocities near peak of flood

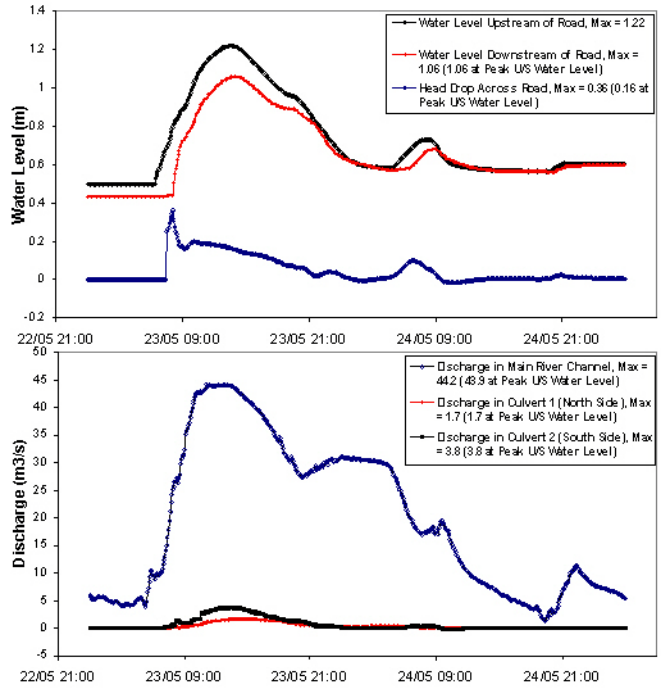


Figure 9.32 Flood plain Demonstration Results - Water Levels and Flows at Road Embankment

9.7 Urban examples

Two urban examples are also included with the installation: Urban and Waterville.

9.7.1 Urban

The first of these urban examples (Urban) is based on an area in Bangkok and is a reduced model from the full model. The present model represents a sub set of the sewer network and further only couples the 2D and the 1D sewer model at four locations (see Figure 9.33). More links between the 1D and 2D models can be added using the right-click option on the graphical view and choosing “Link urban node to MIKE 21”. You could for example link an urban outlet to MIKE 21 or more manholes to MIKE 21. You need to pre-process the MIKE+ (Urban) setup (Run > MIKE+ Preprocessing) before you can run the MIKE FLOOD simulation.

The set-up files are located in the folder

.\Examples\MIKE_FLOOD\Urban

The example mimics a storm event that results in the sewer system being surcharged causing inundation on the streets. The main buildings have been included in the bathymetry and appear in green on the image below.

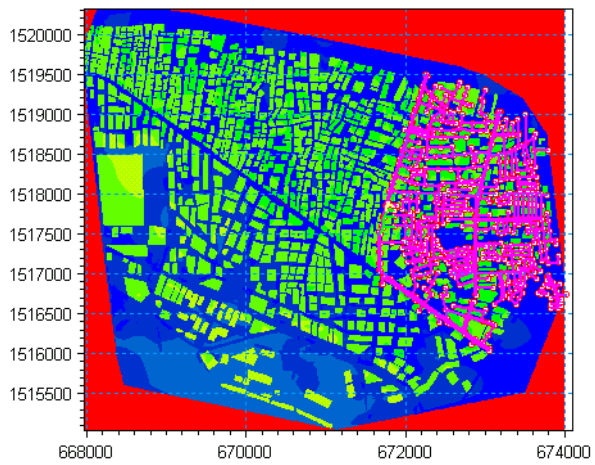


Figure 9.33 The grid with the sewer system shown in pink

9.7.2 Waterville

Waterville is a small urban setup that couples several manholes to a 2D surface.

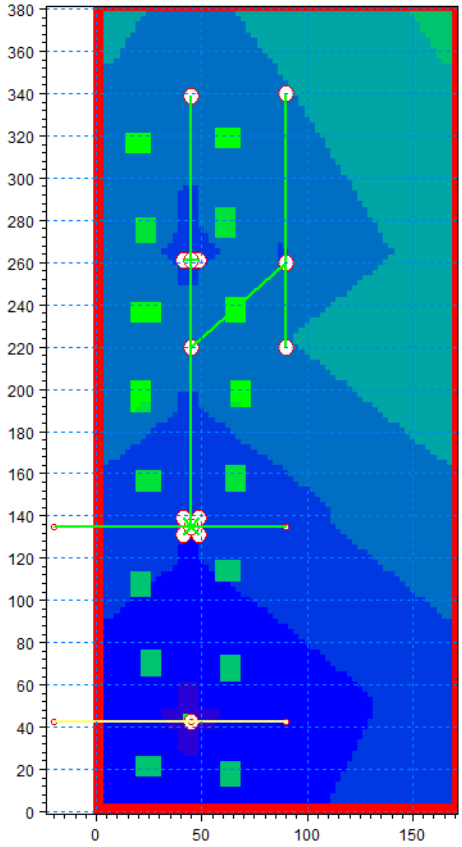


Figure 9.34 The sewer system in green and yellow, the urban bathymetry with some buildings represented in green and the couples manholes in red and white

9.8 MIKE FLOOD 3way

The MIKE FLOOD 3way example is an integrated flood model that includes a river channel, the storm water system and the surface of a city. It is the demonstration of a real flood modelling application of a 100 year flood event.

The model integrates:

- A river channel in MIKE HYDRO
- A storm water piped network in MIKE+ (Urban)
- A surface for 2D overland flow in MIKE 21 with flexible mesh.

All aspects of flow interactions are taken into account through the different links applied:

- pipe network / surface

- surface / open river channel
- open river channel / pipe network.

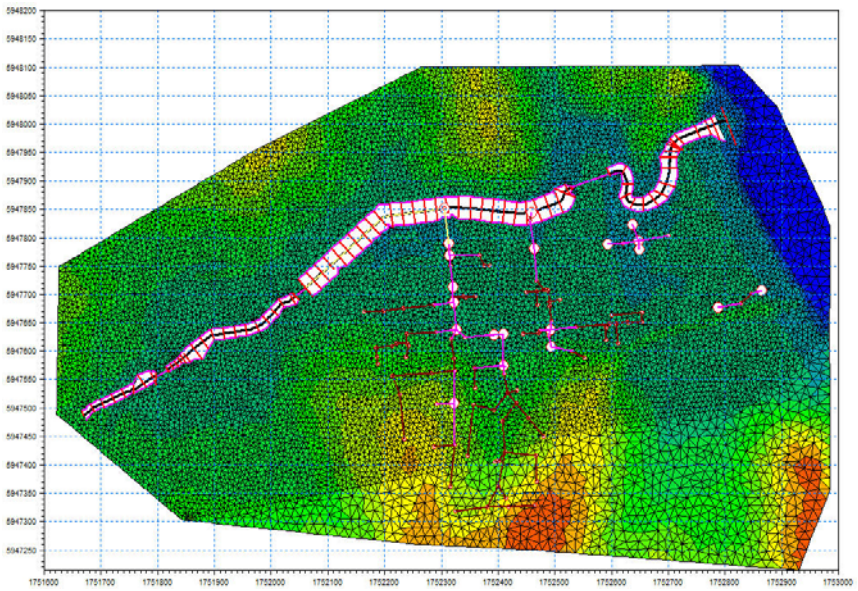


Figure 9.35 MIKE FLOOD 3way coupling setup (MIKE 11, MIKE+ (Urban) and MIKE 21 FM)

Note that the original data have been modified (hydrology, river geometry and structures, storm water system, topography) so the model and the results do not represent the reality.

The first step in building this MIKE FLOOD 3way example consisted in building and running the individual models: MIKE HYDRO, MIKE+ (Urban) and MIKE 21.

The hydrology is distributed in MIKE HYDRO and MIKE+ (Urban). Rainfall-runoff models have been run prior to this example and only the results are used as inflow boundary to the hydrodynamic simulation.

Once the individual models were fully stable and ran successfully, the MIKE FLOOD model was developed and links between the 3 models defined.

The order in which the links are defined is not important; you could start with the River/Urban links for example, then continue with the Urban links and finally define the River links. It is recommended that you check that the MIKE FLOOD model is running successfully once you have defined links and before you add another type of links. In this way it is easier to spot any errors with the links.

9.8.1 River links between MIKE 11 and MIKE 21

The MIKE HYDRO setup includes one river channel with several culvert and weir structures. The river was coupled to the floodplain using several lateral links and one standard link.

The river was linked laterally to MIKE 21 to represent spilling from the river to the floodplain and drainage back into the river. The left and the right banks of the channel were coupled to MIKE 21. Lateral links were discontinued where the river flows through long culverts.

Note that the extent of the river channel was removed from the bathymetry in order to avoid double conveyance. For MIKE 21 FM, the river was excluded from the flexible mesh using the MIKE11_curve.xyz file as a boundary in the Mesh Generator (see MIKE 21 flexible mesh *(p. 101)*).

A standard link couples the end of the MIKE HYDRO branch to the sea in MIKE 21.

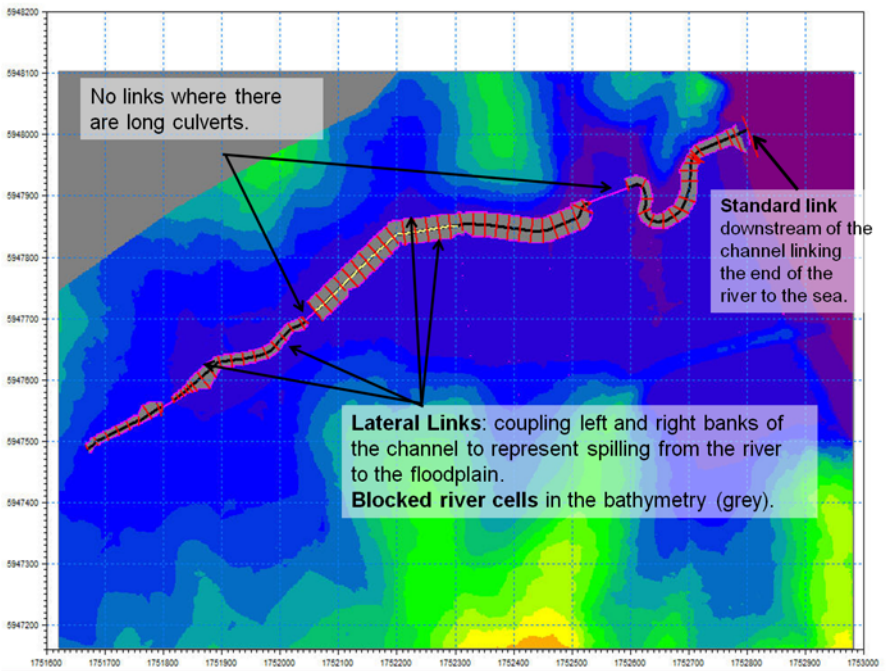


Figure 9.36 River links between MIKE 11 and MIKE 21

9.8.2 Urban links between MIKE+ and MIKE 21

The storm water system of the city has 115 manholes and 3 outlets. One outlet is discharging into the sea and the 2 others are discharging into the river. Runoff inflow from catchments is distributed to all nodes. During the 100 year

rain event, the storm water system is surcharged and overflows on the surface causing flooding.

18 urban links were defined between MIKE+ (Urban) and MIKE 21: 17 "M21 to inlet" links to couple manholes to the surface and one "M21 to outlet" link for the outlet to the sea.

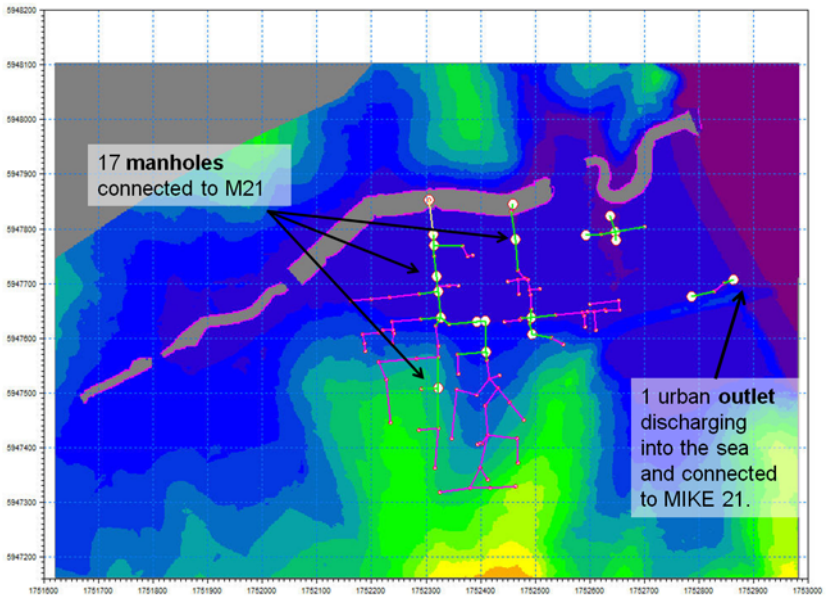


Figure 9.37 Urban Links between MIKE+ (Urban) and MIKE 21

Remember that you need to preprocess the MIKE+ (Urban) setup before you can run the MIKE FLOOD simulation.

9.8.3 River/Urban links between MIKE+ (Urban) and MIKE HYDRO

The storm water system is discharging into the river at 4 different locations so 4 River/Urban links were specified between MIKE 11 and MIKE+ (Urban):

- 1 MIKE+ (Urban) weir to MIKE HYDRO
- 1 MIKE+ (Urban) pump to MIKE HYDRO
- 2 MIKE+ (Urban) outlets to MIKE HYDRO

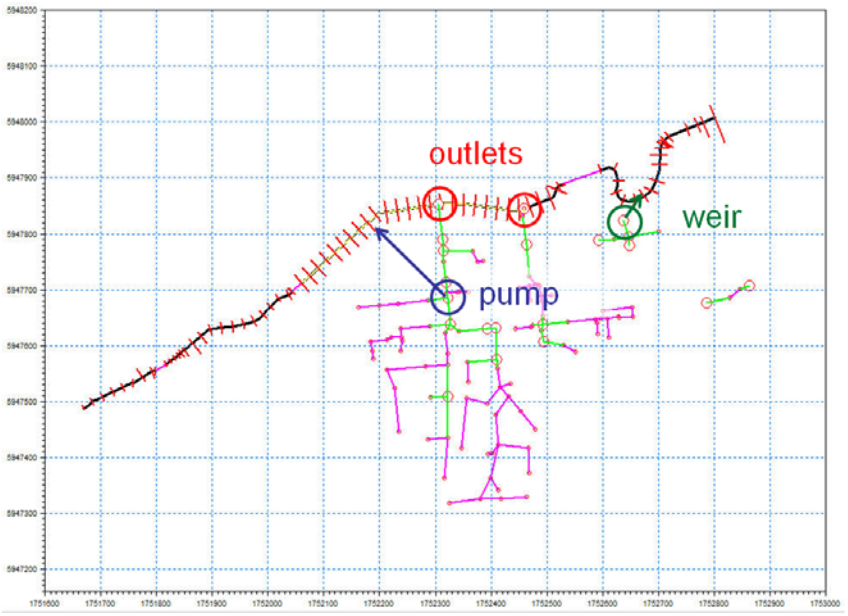


Figure 9.38 River/Urban links between MIKE HYDRO and MIKE+ (Urban)

The results of the maximum water depth for the 100 year rainfall event are presented below.

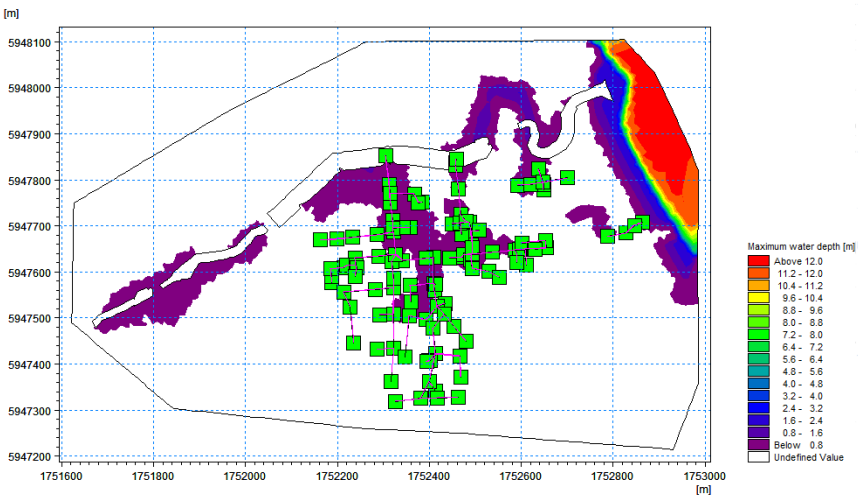


Figure 9.39 Maximum water depth during the 100 year rainfall event

INDEX

A

Activation Depth 73
AD components 89
Add/Remove Images 56
Add/Remove Layers 48
Add/Replace Momentum Terms 72
Advection Dispersion 100

C

Change existing Link values 28

D

Default Value for Land 100
Default values 25
DELTA parameter 99, 103
Depth Adjustment 73
Depth Tolerance 78

E

Explicit Links 103
Export Links to Selection File 68
Ext Fact 72
External Files 79

G

Graphical View 43

H

Hydrodynamics 109

L

Lateral Link Height 80
Lateral Links 16, 40, 103, 104
Link Parameters - Global link settings . 24
Link Type 39
Linkage Types 57

M

MFLateral 81
MIKE 21 34
MIKE 21 Area Number 40
MIKE 21 Cell indices 41
MIKE 21 Coordinates 40
MIKE Flood Editor 23, 89
MIKE Flood Editor, AD components . . 89
MIKE Flood Editor, Lateral Links 75
MIKE Flood Editor, Link Definitions . . . 35
MIKE Flood Editor, Linkage Files 33
MIKE Flood Editor, River-Urban Links . .87
MIKE Flood Editor, Side Structure Links .88
MIKE Flood Editor, Standard/Structure Links 70
MIKE Flood Editor, Urban Links 83
Model Layout 93
Model Linkages 15
Mom Fact 71

N

Nuber of Segments 59

P

Pre and Post Processing 95

R

Result Viewer 95
river name 39

S

Scientific Background 109
Seamless 1D and 2D Results 91
Side of River 76
Simulation Results 91
Smagorinsky Eddy Viscosity 100
Stability 102
Standard Links 15, 104
Structure 76, 77, 79
Structure Links 17, 106

T

Table editing toolbar 38
Tips and Troubleshooting 99

Z

Zero Flow 19, 40, 107