

# Eastern Nile Flood Forecasting System Training Document

# FLOOD FORECASTING AND EARLY WARNING ENHANCEMENT PROJECT

Submitted by

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ENTRO is an organ established to implement the Eastern Nile Subsidiary Action Program within the framework of Nile Basin Initiative **Egypt, Ethiopia, South Sudan, Sudan** 



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# **ACRONYMS AND ABBREVIATIONS**

BCM	Billion Cubic Meter
CC	Country Consultation
CRA	Cooperative Regional Assessment
ENID	Eastern Nile Irrigation and Drainage
ENCOM	Eastern Nile Committee Of Ministers
ENSAP	Eastern Nile Subsidiary Action Plan
ENSAPT	Eastern Nile Subsidiary Action Plan Team
ENTRO	Eastern Nile Technical Regional Office (NBI)
FAO	Food and Agriculture Organization
NBI	Nile Basin Initiative
NCORE	Nile Cooperation for result project
NELCOM	Nile Equatorial Lakes Council of Ministers
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELSAP-CU	NELSAP Coordination Unit
NGO	Non-Governmental Organization
NIB	National Irrigation Board
Nile-COM	Nile Council of Ministers
WB	World Bank

# 1. INTRODUCTION

East Nile Flood Forecasting and Early Warning system development project is the continuation of previously implemented flood forecasting system for Blue Nile watershed. The existing flood forecasting system consists of different software components that do not communicate well between one another and had issues with real time application. The East Nile watershed has 4 sub watersheds and each sub watershed has different models for producing forecast. The project herein build a unified forecasting model utilizing the software suit (MIKE Family) by DHI This software suit has been in used successfully for number of years in the and there may be many other places the suite has been used already.

The scope of the project is to develop an Early Flood Forecasting System (EWFFS) to four subbasins of the Eastern Nile basins, namely Lake Tana, Blue Nile, Baro Akobo Sobat and Atabara Tekeze-setit. The development of EWFF system include the following tasks:

- 1. Sourcing of different data (e.g. climate, Digital Elevation Model (DEM))
- 2. Development of Rainfall-runoff model for the four sub-basins of the Eastern Nile basin.
- 3. Development of hydraulic model for the four sub-basins
- 4. Integration of developed models into an EWFFS platform
- 5. Automate the EWFFS to send Flood Warnings when the system predicts possible flood



Eastern Nile Sub-Basin within the overall Nile Basin

Figure 1.1: The Eastern Nile Basin and sub-basins

# 1.1 OBJECTIVES

The objective of this project is;

•To ensure a robust forecasting, issuing and warning system that effectively minimize loss of life and damage by enhancing, expanding and developing a unified Flood Forecast and Early Warning (FFEW) system for EN basin

•To support other studies under FFEW that contribute in addressing flash flood, stakeholder analysis and flood related DSS development.

## 1.2 **Deliverables**

The deliverables of the project are as stated below:

- Task 1 deliverables are:
  - Inception report on
  - Review and gap analysis on the current system
  - Review of best practices
  - Gather, review, analyses and process data for use in building of hydrological models for the Blue Nile, Main Nile, Lake Tana, Baro-Akobo-Sobat and Atbara-Tekeze-Setit systems under a unified modelling platform
  - Work with the team leader and other team members and submit a document with the models proposed methodology and list of models(hydrological, hydraulic and flood forecast system) with work plan
- Task 2 deliverables are:
  - Set-up and calibrate and validate hydrologic model for Blue Nile, Lake Tana, Baro-Akobo-Sobat and Tekeze-Setit-Atbara sub basin flood prone areas
  - Set-up and calibrate and validate hydraulic/hydrodynamic models for Blue Nile, Lake Tana and Baro-Akobo-Sobat
  - Set-up a forecasting system for integration of forecast models and easy dissemination of forecast results
- Task 3 deliverable are:
  - Test the hydrological, hydraulic models for Blue Nile, Lake Tana ,Baro-Akobo-Sobat and Atbara-Tekeze-Setit systems
  - Prepare floodplain inundation maps for each of the Flood prone areas in the Eastern Nile basin at various flood levels and various return periods
  - In collaboration with the Web expert and IT unit make hydrodynamic model outputs (water level, inundation and impact maps) available to integration with the ENTRO portal/website

- In collaboration with the Web expert and IT unit test the integration of the forecast system with ENTRO portal/website
- Task 4 deliverables are:
  - Design and provide at least two necessary trainings and capacity development for sustainable operation of the flood forecast early warning system
  - Conduct at least one validation workshop
  - Participate and present in consultation workshops
  - Prepare relevant reports and prepare relevant section of modelling reports and user's manual
  - o Other tasks requested by Senior FFEW Expert
  - Support procurement process of necessary equipment and software, in collaboration with the other team members and support the setting-up of the forecast models on the workstations

## 1.3 EASTERNILE EWFFS TRAINING

The purpose of this document is to facilitate the training process of the EasterNile EWFFS (Early Warning Flood Forecasting System). The initial chapters follow training guidelines, in order for the participants to get familiar with various processes of how the EasterNile EWFFS was created. These include relatively simple examples, which the trainer will go through with the participants and at the end of these chapters are exercises for the participants to complete. This document incorporates the following chapters:

- How to set up a 1D model: participants will learn how a 1-dimentional model is created, followed by exercises for them to complete.
- How to register a 1D model in MIKE Operations Workbench: participants will learn how a model is imported into MIKE Operations Workbench.
- How to setup a MIKE Operations configuration: using the imported model, participants will learn how to configure various setups within the MIKE Operations application.
- BlueNile EWFFS: using what they have learned from the above sections, participants will be taken through the actual configuration of the BlueNile EWFFS configuration in MIKE Operations.

# 2. How to setup a 1 Dimensional Model

## 2.1 INTRODUCTION

The name of the 1-dimensional model setup used within the Early Warning Flood Forecasting System (EWFFS) is called MIKE 11. MIKE 11 is a tool developed by DHI, for simulating hydraulics, water quality and sediment transport in estuaries, rivers, irrigation systems and other inland waters. The hydrodynamic module of MIKE 11 uses an implicit finite-difference scheme to calculate unsteady flow described by the Saint-Venant equations of conservation of mass and momentum. The scheme is independent of the wave approximation chosen (kinematic, diffusive, or dynamic wave), where a computational grid of Q-points and h-points is used. The topography of the river network is defined using cross-sections and the bed resistance calculation can be done using the Chezy or Manning equations. Cross-sections constitute h-points, between which a Q-point is introduced. MIKE 11 handles looped as well as dendritic systems, backwater effects, flows in flood plains, as well as a wide range of control structures such as pumps, weirs, or controllable gates.

The HD module is the nucleus of the MIKE 11 modelling system and forms the basis for most modules including Flood Forecasting, Advection-Dispersion, Water Quality and Non-cohesive sediment transport modules. The MIKE 11 HD module solves the vertically integrated equations for the conservation of continuity and momentum, i.e. the Saint Venant equations. For the purpose of this training, we will focus on the hydrodynamic (HD) module of MIKE 11, whereby a simple model will be created and run.

# 2.2 Step by Step how to setup a simple 1 dimensional model in MIKE 11

Within MIKE 11, in order to setup a HD model, four files are required. These include:

- o Network file
- o Cross-section file
- Boundary file
- Hydrodynamic (HD) parameters file

In the following exercise, you will learn how to run a simple MIKE 11 HD model.

#### 2.2.1 Getting Started

Before the four individual files are created above, the MIKE 11 simulation file needs to be created. This is the file that is used to define the type of modules to include (in this case it will only be HD). It also houses the four HD files, where the start and end date of the simulation is defined, and where the results are stored. To create a MIKE 11 simulation file (\*.sim11), do the following steps:

- Open MIKE Zero (Start menu)
- Click on File > New > File...(or click on the white paper icon)

• In the New File window, click on the MIKE 11 folder on the left, then click on the 'Simulation (.sim11)' file on the right (see screenshot below).



 A new sim11 file should now be open. Before continuing, save this file in an appropriate location on your PC (File > Save As...) with an appropriate name (e.g. BlueNile\_demo.sim11). See screenshot below.

AIKE Zero - [BlueNile.sim11]	_	
💽 File Edit View Window Help		_ & ×
Models Input Simulation Docute Start	Project Explorer	<u>д ×</u>
Models         Hydrodynamic         Advection-Dispersion         Sediment transport         MIKE ECO Lab         Rainfall-Runoff         Flood Forecast         Data assimilation         Ice         Simulation Mode		
Unsteady		
Quasi steady QSS default	🖻 P 🚇 Fi	.   🎒 T   🔁
Ready No Tracking	_	

Now that the simulation file has been created, we will begin creating the four HD files. Firstly, the river network file.

#### 2.2.2 Network file

- Similarly to creating the sim11 file in the previous exercise, open MIKE Zero and select the 'River Network (.nwk11) file.
- In the 'Map Projection and Working Area' box that appears, insert the map projection and extent information that is shown in the screenshot below. For the map projection, you may have to select Browse...from the dropdown menu, then click the Find button and type in "WGS\_1984\_UTM\_Zone\_37N", to find the same projection as shown below. Once found, select it and click OK. Click OK again on the Map Projection and Working Area window.

Map Projection and Working Area X						
Map projection: WGS_1984_UTM	_Zone_37N	$\sim$	ОК			
Modify working area: Allow only manua	al changes	$\sim$	Cancel			
х:	Y:		Help			
Lower left corner: -336555	j.143 [m]	1249574.361 [m]				
Upper right corner: 115073	3.715 [m]	1754014.659 [m]				

- Before continuing, save the network file in the same folder as the sim11 file.
- To manage the background layer files, open the Layers > Add/Remove... menu and import the following files from the folder provided (in the folder called "Additional"):
- o BlueNile\_River.shp
- BlueNile\_photo.bmp

Layers ×					
Add/Remove Layers Overlay Manager					
	File type		Filename		
1	Shape File		F:\DHI\1_current\00437_ENTRO FEWS\WIP\Training\BlueNile\Shap		
2	Image File		F:\DHI\1_current\00437_ENTRO FEWS\WIP\Training\BlueNile\Shap		
<			>		
			OK Cancel Apply Help		

From the 'Layers' > 'Properties...' menu change the layer-properties:

- For the image file, change the following co-ordinates:
  - Lower left corner: X = -336555.143; Y = 249574.361
  - Upper right corner: X = 115073.715; Y = 1754014.659
  - Change the Image Map projection to the same as the network file

These coordinates need to be inserted in order for the background aerial image of the BlueNile to be visible.

• For the "BlueNile\_River.shp', change the line colour to red and the thickness to 0.3 (see screenshot below).

Layers	X
Graphics	
Image file: F:\DHI\_	Points Drawn as Display + D O O V V Color: Point fill style: Point size: 0 [mm] Color as point Background:
	Lines/Polygons Drawn as Display Line style: Solid ~ Color: Polygon fill style: ~
	Thickness: 0.3 [mm] Text Annotation Color as line/polygon Background: Transparent
	OK Cancel Apply Help

 If the river shapefile is not visible, it may be positioned beneath the aerial photo. To change the drawing order, click Layers > Add/Remove..., and click on the Overlay Manager tab. Select the shape overlay file and click the down arrow (as seen in the screenshot below). Then click OK.

ayers						×	
Add/Rer	dd/Remove Layers Overlay Manager						
Overlay drawing order:			<b>↑ ↓</b>				
	Display	Overlay name	Overlay type				
1		BlueNile.PNG	World Image Overlay	1			
2		BlueNile_River.shp	Shape Overlay				

You should now see something similar to the figure below, where the river shapefile is now drawn on top of the aerial photo.



- Save the nwk11 file again.
- Now go back to the sim11 file you created initially, and link the nwk11 file you
  just created by browsing for it under the Input tab (as shown in the screenshot
  below).

MIKE Zero - [BlueNile.sim11 - Modified]				- (		×
File Edit View Window Help					-	e x
			Prov	iast Evolarar		
Models Input Simulation Results Start				eccexplorer		^
Input Files						
Network 0437_ENTRO FEV	S\WIP\Training\BlueNile\BlueNile.nwk11	Edit				
Cross-sections		Edit				
Boundary data		Edit				
RR Parameters		Edit				
HD Parameters		Edit				
AD Parameters		Edit				
MIKE ECO Lab Param.		Edit				
ST Parameters		Edit				
FF Parameters		Edit				
DA Parameters		Edit				
Ice Parameters		Edit				
HD Results						
RR Results						
0 %				à P 🚇 Fi 🌡	Ј т   🦉	<b>)</b>
Ready	x = -178988.89 y	/ = 1745175.2				Se

### 2.2.3 Network digitisation

The River network can be defined in one of the following two ways (only apply one of the methods):

#### • Manual Digitisation (slowest method!):

Starting at approx. x-y coordinates of (15103.785, 1266040), roughly digitise the BlueNile River from the upstream end down to the end-point around coordinates (-201301.71, 1734134.5). Digitisation can be made on top of the red line of the shape file previously defined. This digitizing process is done using the 'Add new points' () and 'Define branch () tools. You'll notice that this process is very tedious and inaccurate. Delete the branch you just created.

#### • Automatic generation of network from shape file (Fastest and easiest!)

Select 'Network' >'Generate Branches from Shape files...'.

Select the option; 'Generate points and branch' and use the <u>BlueNile\_River.shp</u> shapefile. Select the appropriate River name attribute (RiverName) and TopoID attribute (Topo\_ID = 'TopoID') and press OK (see screenshot below).

Generate network from shape files X						
O Generate points						
Shape file	BlueNile_River.shp	~				
Generate points and branch						
Shape file	Shape file BlueNile_River.shp					
River name atribute	RiverName	~				
Topo ID attribute	TopolD	$\sim$				
Generate alignmen	tlines					
⊖ Generate vegetatio	on zones					
Shape file	BlueNile_River.shp	$\sim$				
Name attribute	(Auto generated)	$\sim$				
Type attribute	(Auto generated)	$\sim$				
Branch attribute	(Auto generated)	$\sim$				
U/S Chainage	(Auto generated)	$\sim$				
D/S Chainage	(Auto generated)	$\sim$				
Vegetation height	(Auto generated)	$\sim$				
	ОК	Cancel				

- The upstream point must defined as chainage 0 m and the downstream point as chainage 723103 m.
- HINT: Change the point properties to 'User Defined' by opening the network Tabular View or double-clicking on the point in the graphical view (as shown in the screenshot below).
- $\circ$  Save the network file.



## 2.2.4 Cross-sections

Ideally, river cross-section information would be obtained from an accurate digital elevation model (DEM) or from LiDAR data (this can be done using another product by DHI called MIKE Hydro). Alternatively, data obtained from manual river cross-section assessments would be used to insert at various positions along the river branches. However, for the purpose of creating a simple 1D model, a different method could be used. This involves creating one cross-section at the upper-most end of the branch (BlueNile chainage 0 m) and the lower-most (BlueNile chainage 723103.25). Thereafter, interpolating cross-sections in-between these at constant intervals.

Note: a more accurate cross-section file has been provided, where cross-sections have been obtained from ENTRO.

To interpolate in-between cross-sections, follow these steps:

• Create a river cross-section file (.xns11). Save it in the same location as the rest of the files that have been created.

- Now go to the already-opened simulation editor (sim11), and browse for this cross-section file zas input into the sim11 file (like you did for the nwk11 file earlier).
- Click on "Edit..." next to the network file in the simulation editor (see screenshot below) to open up the network file

📸 MIKE Zero - [BlueNile.	sim11]	-	
File Edit View Win		_ & ×	
🛛 🗅 🕞 🔚   🐰 🖻 💼 🎒	9 <b>8</b>		
Models Input Simulation	Results Start	Project Explorer	Ť X
Network	0437_ENTRO FEWS\WIP\Training\BlueNile\BlueNile.nwk11		
Cross-sections	0437_ENTRO FEWS\WIP\Training\BlueNile\BlueNile.xns11		
Boundary data	Edit		
RR Parameters	Edit		

- Zoom to the upstream point (BlueNile chainage 0 m), If there is no cross-section at the chainage and right-click on it, then scroll to Insert > Network > Crosssection (see screenshot below).
- This opens up the cross-section file that was created earlier from the simulation editor. The purpose of inserting a cross-section this way is that the branch name and chainage number are automatically inserted for the cross-section.

MIKE Zero - [	Incomati_demo.nwk11]		International Contractory of
▶ Eile Edit	<u>V</u> iew <u>N</u> etwork <u>L</u> ayers <u>S</u> ettings <u>W</u> ir % ⓑ ⓑ ⓑ [♣] ∰ ? № []] Q, Q, ॡ	ndow <u>H</u> elp :	' %
7228500			Untitled
7228000			
7227500	Point Properties Insert	Network 🔸	Cross Sections
7227000	Edit Delete Zoom In	Boundary + HD Parameters + AD Parameters + ST Parameters +	Weirs Culverts Bridges
7226500	Previous Zoom Next Zoom Pan (Shift)		Pumps Regulating Structures Control Structures Dambreak Structures
7226000	Refresh		User Defined Tabulated Structures

 Now within the cross-section editor, insert the following information for BlueNile at chainage 0 (left columns in table below), so that the cross-section looks like the one in the screenshot below.

Rive C	r BlueNile <mark>h. 0 m</mark>	River BlueNile Ch. 206374 m				
X [m]	Z [m]	X [m]	Z [m]			
0.00	32	0.00	4			
50	29	100	2			
100	27	200	1			
150	26.5	300	0.5			
200	26	400	0.25			
250	26.5	500	0			
300	27	600	0.25			
350	29	700	0.5			
400	32	800	1			
		900	2			
		1000	4			



 Once the cross-section for chainage 0 m has been inserted, right-click on it and select Insert... (see screenshot above). In the small 'Insert branch' window that appears, insert the downstream chainage number 206374 in the space for 'First chainage' (see screenshot below). Click OK.

Insert branch	<b>X</b>
River name	Incomati
Topo ID	Topo?
First chainage	206374
Cross section ID	
(	OK Cancel

- Now insert the cross-section information in the right-hand columns from the table above.
- Ensure that the markers 1, 2 and 3 look the same by clicking the 'Update markers' button (see screenshot below). This assigns a bank marker to the left-most (1) and right-most (3) points, along with the lowest (2) point.



- Now that we have the cross-sections for the upper and lower-most points on the river branch, it's time to interpolate cross-sections in-between these.
- To do this, right-click on the 0 m chainage and select "Insert interpolated...".
- Select the 'Multiple sections' radio button, and specify 0.00 as 'From existing cross section', and 206374.00 as 'To existing cross-section'. Specify the 'With max. distance value to be 10000 m, and check the 'Calculate processed data' box (see screenshot below). Click OK.

Insert Interpo	lated Cross Section	ons 💌						
River name	Incomati	Topo ID Topo?						
) Single se	ction at chainage	0						
<ul> <li>Multiple sections</li> </ul>								
With max	. distance	10000						
From exis	ting cross section	0.000 -						
To existir	To existing cross section 206374.00 -							
Calculate	Calculate processed data							
Extract cr	Extract cross section informations from river editor							
V Include e	xisting interpolated o	cross sections in interpolation						
		OK Cancel						

- You will now notice several cross-sections now added to the cross-section editor, where the symbol '\*' indicates that the cross-sections have been generated from an interpolation process.
- Click on the 'View Processed Data..." button to see the data for each crosssection, where the dropdown menu at the top of the screen allows you to see various types of processed data. (see screenshot below).



 Click Save to save the cross-section editor. Then click on the small grey cross at the top-right corner

() to close the cross-section editor.

• You will now notice that all the cross-sections that have been created, are symbolised by the red and white squares within the network editor. (See example in the screenshot below).



## 2.2.5 Boundary Conditions

Within MIKE 11, a boundary condition needs to be specified at every open branch end. In the case of the model we are creating, one boundary condition will need to be specified upstream (chainage 0) and one downstream (chainage 723103.25).

#### Upstream boundary condition

- Create a Boundary Condition (.bnd11) file from MIKE Zero, within the MIKE 11 category folder.
- Save it in the same folder you have been using for all of the other MIKE 11 files, then close the boundary file.
- Go to the simulation editor (sim11) and browse for this bnd11 file under the Boundary data section. You should now have the network, cross-section and boundary files all selected from within the simulation editor.
- Similarly to how a cross-section was inserted at chainage 0, within the network editor view, right-click on the upstream point, and select Insert > Boundary > Hydro Dynamic.

- The boundary condition editor will open. Remove the default line (first one at the top), by selecting it and pressing the Delete button on your keyboard.
- For the BlueNile chainage 0 boundary, click on the browse button below the description, next to the Discharge (Data Type) and time series file (TS Type), and locate the "Roseres\_Dam\_Release.dfs0" file from the folder provided (in the folder called "TS"), then click OK.

🕋 MIKE :	Zero - [BlueNile.bnd11]							
File I	Edit View Tools Win	dow Help						
🗅 🖻 🖬	% 🖻 💼 🎒 💡 📢							
	Boundary Description	Boundary Type	Branch Name	Chainage	Chainage	Gate ID	Boundary ID	
1	Open	Inflow 🗸	Blue Nile Re	0	0			
2	Open	Inflow	Blue Nile Re	723103.2	0			
	e HD calculation e AD boundaries							
								_
1	Data Type TS Type	File / Value	TS Info Roseres					
			IN LACIES.					

#### Downstream boundary condition

MIKE Zero - [RiueNile bpd11]

 Now click on the Window menu at the top of the screen (which enables you to toggle between the other MIKE 11 files that may be open) and click the nwk11 file to go back to it (See screenshot below).

initia zero [bidertiteibild					
File Edit View Tools	Window Help				
🗅 🚅 🖬   👗 🗞 🖄 🎒 🚺	Cascade	1			
Boundary Descrip	Tile	inch Name Chain	age Chainage Ga	ate ID Boundary ID	
Open	Arrange Icons	e Nile Re	0 0		
Open	1 Start Page	e Nile Re 72310	03.2 0		
	2 BlueNile.sim11				
	<ul> <li>3 BlueNile.bnd11</li> </ul>				
	4 BlueNile.nwk11				
		-			
Include HD calculation					
Data Type TS T	ype File / Value TS	Info			
1 Discharge: TS Fi	e TS\Roseres_Da Edit Ros	seres			
1					

- Insert a Hydro Dynamic boundary at the lowest point on the branch, then click the Window menu to go back to the boundary condition editor.
- In the newly added boundary, click the dropdown menu under 'Boundary Type' and select 'Q-h'. (See screenshot below). Generate the Q/h relationship using "Auto-calculation of Q-H Table".

moloo ~⊞ u⊒i ⊟≫ 8 ⊀≎								
Boundary Description	Boundary Type	Branch Name	Chainage	Chainage	Gate ID	Boundary ID		
Open	Inflow	Blue Nile Re	0	0				
Open	Q-h	Blue Nile Re	723103.2	0				
	1	0						
							Auto calculation of Q/h table	К
							Auto calculation of Q/h table Topo ID BLUE-NILE	Cancel
							Auto calculation of Q/h table Topo ID BLUE-NILE © Critical flow O Manning formula	Х ОК Cancel
							Auto calculation of Q/h table Topo ID BLUE-NILE  Critical flow Manning formula Slope 0.001	Х ОК Cancel

Image: Chain and the problem of the	MIKE Zero - [BlueNile.bnd11]	dann I lain						
Boundary Description       Boundary Type       Branch Name       Chainage       Gate ID       Boundary ID         Open       Inflow       Blue Nile Reach:Eddeim-Kartou       0       0       0         Open       Q-h       Blue Nile Reach:Eddeim-Kartou       723103.25       0       0         Include AD boundaries       h       Q       1       0       0       0         Include AD boundaries       1       0       0       2       371.917       0	File Edit View Tools Win	dow Help						
Open         Inflow         Blue Nile Reach:Eddeim-Kartou         0         0           Open         Q-h         Blue Nile Reach:Eddeim-Kartou         723103.25         0            Include AD boundaries         n         q         1         0             Include AD boundaries         1         0         2         371.917	Boundary Description	Boundary Type	В	ranch Name	Chainage	Chainage	Gate ID	Boundary ID
Open         Q-h         Blue Nile Reach:Eddeim-Kartou         723103.25         0           Include AD boundaries         n         Q         1         0         1         1         0         1 <td>Open</td> <td>Inflow</td> <td>Blue Nile Re</td> <td>each:Eddeim-Kartou</td> <td>0</td> <td>0</td> <td></td> <td></td>	Open	Inflow	Blue Nile Re	each:Eddeim-Kartou	0	0		
h         Q           1         0           2         371.917           3         372.2985102           4         372.6800204           5         373.0615306           6         373.4430408           1354.           7         373.824551           2434.	Open	Q-h	Blue Nile Re	each:Eddeim-Kartou	723103.25	0		
1       0         2       371.917         3       372.2985102         4       372.6800204         5       373.0615306         6       373.4430408         1354.         7       373.824551         2434.         ×	]Include AD boundaries		h	Q ^				
2     371.917       3     372.2985102       4     372.6800204       5     373.0615306       6     373.4430408       1354.       7     373.824551       2434.		1	0					
3       372.2985102       27.58         4       372.6800204       235.3         5       373.0615306       682.1         6       373.4430408       1354.         7       373.824551       2434. *         <		2	371.917					
4     372.6800204     235.3       5     373.0615306     682.1       6     373.4430408     1354.       7     373.824551     2434. ✓       <		3 3	72.2985102	27.58				
5         373.0615306         682.1           6         373.4430408         1354.           7         373.824551         2434. *           <		4 3	72.6800204	235.3				
6 373.4430408 1354. 7 373.824551 2434. × < >		5 3	73.0615306	682.1				
7 373.824551 2434. *		6 3	73.4430408	1354.				
		7	373.824551	2434. 🗡				
				>				

## 2.2.6 Hydrodynamic parameters

• Create a MIKE 11 HD parameter file (.hd11) and save it in the same folder as all the rest of the MIKE 11 files on your PC.

- Within the simulation editor, browse for this HD parameter file, so that all four files for a MIKE 11 HD simulation are selected.
- Click on the edit button and click on the 'Bed Resistance' tab to change the global Manning M number to 30 (See screenshot below). Save and close the HD parameter file.

	ood Plain Resist.	User Def. Marks Encroa	achment Heat B	alance Stratifica	tion Time Serie	s Output Maps
Groundwate	er Leakage	Mix. Coef.	W. L. Inc	r Curves	W. L. Incr.	- Sand Bars
Initial Wind	Bed Resist.	Bed Resist. Toolbox	Wave Approx	Default Values	Quasi Steady	Reach Lengths
Control Values	ber: 30	Manning (M)	~			
	ne Chainage	Resistanc				
River Nar	ine channage					

#### 2.2.7 Simulation parameters – run a simulation

- Ensure that all four MIKE 11 files (except the sim11 editor) have been saved and closed, by clicking on the Window menu to see if any of them are still open.
- Within the simulation editor, click on the Simulation tab and specify the following:
  - Fixed time step: 30/15 sec
  - Simulation start: 2019/06/30
  - Simulation end:2019/07/30
  - Initial conditions: Parameter File (see screenshot below)

i 🖉 🔛	X 🖻 🖻 🖨 🤋	₩?	<b>2</b> : 1				
Simula	tion Poriod	sults	Start				
Time Fixed	step type	T 1	ime step Unit 5 Sec.	~			
Perio	Simulation Sta d: 2019/06/30	art	Simulation 2019/07/3	n End 30		Apply Default	
ST tim	ne step multiplier		RR time s	tep multi	plier	1	
Initial C	onditions						
	Type of condition		Hotstart filename		file	Date and Time:	
HD:	Hotstart	$\sim$	C:\DHI\01_current\004	43:		2019/06/30	
AD:	Parameter File	$\sim$				1990/01/01 12:00:00	
ST:	Parameter File	$\sim$				1990/01/01 12:00:00	
	Parameter File	$\sim$				1990/01/01 12:00:00	

- Click on the Results tab, and specify the results to be stored in a "Results" folder in the same directory as all the other MIKE 11 files. Set the storing frequency to be every 1/6 hours.
- Now click on the Start tab, and run the simulation using the MIKE 11 Classic engine.

#### 2.2.8 Analysing Results using MIKE View

MIKE View is an application used to analyse the results from a MIKE 11 simulation.

- Open MIKE View from Start > MIKE View 2019/2020 > MIKE View. MIKE View is a program used to load MIKE 11 results in \*.res11 format. (MIKE View can also be used to open \*.res1d files if the new MIKE 1D engine has been used.)
- As the MIKE View application is opened, browse to the folder where the results were saved and click "Open". Leave the default Data Load Selection as it is, and click OK (see the resulting res11 view in the screenshot below).



- Make Time series Plots:
  - Look at different result items at different locations (WL, discharge)
  - Add multiple time series to one time series Plot
  - Show values (which can be used to copy data into Excel)
  - Investigate the pop-up menu options by right-clicking the mouse button in the horizontal plan view
- Make Longitudinal plots:
  - Change plot settings
  - Investigate the popup menu options by right-clicking the mouse button
  - Add multiple result items to the same longitudinal plot
  - Multiple Areas plots
- Animate simulations:

- Start animation with multiple plots open
- Change animation settings
- Save Layouts (for re-using the same layout when opening new result file):
  - oWindow Layout
  - oComplete Layout
- Calculate 'Depth' and 'Flood':
  - Use the internal tools in MIKE View to calculate the 'Depth' and 'Flood' results (if not already calculated).
  - What are Flood and Depth values as calculated by MIKE View?



• Make a Longitudinal plot of flood in the BlueNile River.

And just play around to become familiar and experienced in using MIKE View.

You might even find the fish!

#### 2.2.9 Rainfall-Runoff (NAM)

The Rainfall-Runoff will be demonstrated in the BlueNile EWFFS and please proceed to Exercise 1.

There is a similar setup to the one from above, with the addition of an extra river branch. The reason for the additional branch is to demonstrate how the rainfall-runoff component of the MIKE 11 configuration works.

Within the simulation editor, the addition to the models tab is the Rainfall-Runoff model, where previously it was only Hydrodynamic. See the screenshot below where this is now included.

A MIKE Zero - [Incomati_demo_RR.sim11]
<u>File Edit View Window Help</u>
D 🚅 🖬   X 🖻 💼   🚑 🤋 📢
Models Input Simulation Results Start
Models
V Hydrodynamic Encroachment
Advection-Dispersion
Sediment transport
ECOLab
Rainfall-Runoff
Rood Forecast
Data assimilation
Ce lce
Simulation Mode
O Unsteady
Quasi steady QSS default ▼

The following steps are how one would create a rainfall-runoff (.rr11) file to include this model within the hydrodynamic one.

 Similarly to the other files that were created, a "RR Parameters (.rr11)" needs to be created and saved in the same folder as all the other files. Thereafter, browse for it in the Input tab, so that there are now 5 files included (see screenshot below).

📸 MIKE Zero - [Incor	mati_demo_RR.sim11]						
🕘 <u>F</u> ile <u>E</u> dit <u>V</u> iev	v <u>W</u> indow <u>H</u> elp						
D 😅 🖬   % 🖻 💼   🚭 📍 😽							
Models Input Sin	nulation Results Start						
Input Files							
Network	IPO_Training\MIKE_11_RR\Incomati_demo_RR.nwk11						
Cross-sections	\IPO_Training\MIKE_11_RR\Incomati_demo_RR_xns11 Edit						
Boundary data	JPO_Training\MIKE_11_RR\Incomati_demo_RR.bnd11						
RR Parameters	ati\IPO_Training\MIKE_11_RR\Incomati_demo_RR.rr11 Edit						
HD Parameters	i\IPO_Training\MIKE_11_RR\Incomati_demo_RR.hd11 Edit						
AD Parameters	Edit						
ECOLab Param.	Edit						

- Edit the rr11 file, so that you see it open. Click on 'Insert catchment' and type in the following (screenshot provided), then click OK:
  - Catchment name: Y40D
  - Rainfall runoff model: NAM (the default)
  - Catchment area: 4536 (km2)

Insert Catchment	×
Catchment name : Y40D	Create as a copy of : DEFAULT
Rainfall runoff model	
Catchment area 4536	
	Cancel

Now that we have our catchment name with the size of it defined, we need to edit the parameters for the surface-rootzone and groundwater, along with inserting the rainfall and evaporation time series data.

- Click on the tab called 'NAM', where you'll see Surface-Rootzone tab displayed.
- Here you see a list of descriptions for each of the parameters required (press F1 on the keyboard to find out additional information).

 Insert the various surface-rootzone parameters as you see in the screenshot below:

MIKE Zero - [Incomati_demo_RR.rr11 - Modified]										
File Edit Grid \	/iew Paran	neters La	yers Basir	Work	Area	Window	Help			
🗅 🚅 🖬   % 🖻	6   5 1	? \?								
Catchments NAM UHM SMAP Urban FEH DRiFt Timeseries										
Surface-Rootzone Ground Water Snow Melt Irrigation Initial Conditions Autocalibration										
Y40D										
Storages				,						
Maximum water conte	nt in surface :	storage		Umax	10					
Maximum water conte	ent in root zon	e storage		Lmax	100					
D ((D))										
Runoff Parameters					_		_			
Overland flow runoff of	coefficient			CQOF	0.8	5				
Time constant for rou	uting interflow			CKIF	600					
Time constant for rou	uting overland	flow								
CK2				CK1,2	15					
Part and trackeld or				тог	0.2	17	71			
Root zone treshold value for overland flow IOF 0.237										
Root zone treshold value for interflow TIF 0.471										
Overview										
Name	Umax	Lmax	CQOF	СКІ	F	CK1,2	TOF	TIF		
1 Y40D	10	100	0.85		600	15	0.237	0.471		

- Next, click on the 'Ground Water' tab. Here you see a list of descriptions for each of the parameters required (press F1 on the keyboard to find out additional information).
- Insert the various ground water parameters as you see in the screenshot below (only for TG and CKBF):

🚠 MIKE Zero - [Incomati_d	emo_RR.rr11	- Modified	]				10000			
🔵 File Edit Grid Vie	w Paramete	rs Layers	Basin W	ork Area V	Vindow H	elp				
🗋 🗅 🚅 🔚 🛛 X 🖻 💼	1   🕹 🤋 N	?								
Catchments NAM UHM	SMAP Urb	an FEH	DRift	Timeseries						
Surface-Rootzone Ground Water Snow Melt Imigation Initial Conditions Autocalibration										
				Y4	40D					
Overall Parameters										
Root zone threshold value	e for GW recha	arge	TG	0.73						
Time constant for routing	baseflow		CKBF	1744						
Extended Component										
Change ratio of GW-a	area to catchme	ent area	Carea	1						
Change specific yield	of groundwate	r reservoir	Sy	0.1						
Threshold groundwat	er depth for bas	seflow	GWLBF0	10						
Seasonal variation of	maximum deptł	ı		Edit Season	al					
Capillary flux, depth fo	or unit flux		GWLBF1	0						
Abstraction	Specified in tim	eseries		Edit Abstrac	tion					
Lower baseflow, rech	arge to lower re	eservoir	Cqlow	0						
Time constant for rou	Time constant for routing lower baseflow Cklow 10000									
Name	TG	CKRE	Carea	Sv	GWIBEO	GWI BE1	Calow	Cklow		
1 Y40D	0.73	1744	1	0.1	10	0	0	10000		

- Next, click on the Timeseries tab. This is where the rainfall and evaporation data are selected.
- For Rainfall, browse to the TS folder provided and select the time series file called "NOAA\_Rain\_Y40D.dfs0".
- Similarly, for evaporation, browse to the same TS folder and select the "Y40D\_Evap.dfs0" file. You should now have a screen similar to the one below:

🔒 MIKE Zero - [Incomati_demo_RR.rr11 - Modified]										
🔵 <u>F</u> ile <u>E</u> dit <u>G</u> rid <u>V</u>	<u>(</u> iew <u>P</u> arame	ters <u>L</u> ayers	<u>B</u> asin Wor	rk Area	<u>W</u> indow	<u>H</u> elp				
Catchments NAM UH	M SMAP U	rban FEH	DRiFt Tim	meseries						
Hydrological Timeseries	for Selected Ca	tchment								
Data type	Weighted timeseries					File name	Item	Browse		
Rainfall		C:\BRUCE-DHI\BREA\3_GIS\LOWER_INCOMATI\IPO_TRAINING\MIKE_11_RR\TS\NOAA_RAIN_Y40D.DFS0 NOAA_RAIN_Y40D								
Evaporation		C:\BRUCE-DI	HI\BREA\3_0	GIS\LOW	ER_INCON	MATI\IPO_TRAINING\MIKE_11_RR\TS\Y40D_EVAP.DFS0	Y40D			
(Observed discharg										

Click on Save, and close the RR window by clicking on the small 'X' button (top right).

Now that the rainfall-runoff file has been configured, it needs to be linked up to the network file in MIKE 11. This is done by following these steps:

• Within the simulation editor, click on Edit for the network file to open.

• Now within the network editor, you'll notice that there is now an additional river branch (called 'Mazimechopes'), as you can see in the screenshot below.



- Open up the tabular view, either by clicking on the View menu and selecting 'Tabular View...', or by pressing Ctrl+T on the keyboard.
- Expand the Network menu and select Branches. Here you see a summary of the branches included in the model, where the names, upstream and downstream chainage numbers are shown (see shown below). This information is important for linking the rainfall-runoff to the branch.

📸 MIKE Zero - [Incomati_demo_RR.nwk11:2	2]			and the second second	and the second	-					- 0
File Edit View Network Layers Settings Window Help											
D 🚅 🖬   🌡 🖻 🛍   🚳 📍 🌾											
Overview	Definitio	ns						_			
Network	Branch	Name Topo ID	Upetr Ch	Downetr Ch E	ow Direction M:	winnum dv Brand	h Tvne				
Points (1160)	Incom	ti Topo 2	0	206374			dar -	1			
Branches (2)	incom	au Topo ?	U	2003/4		negu	Jiar 🔹	J			
Junctions (0)	Conner	tione									
Structures	Connec	Branch Name	Chainage			Edit Link Char	nnel Parameters				
	Upstre	am									
Runoff/groundwater links	-										
	Downs	tream									
	Overvie	w									
		Name	Topo ID	Upstr. Ch.	Downstr. Ch.	Flow Direction	Maximum dx	Branch Type	Upstr.Conn. Name	Upstr.Conn. Ch.	Downstr. Cor Name
	1	Incomati	Topo?	0	206374	Positive	10000	Regular			
	2	Mazimechopes	Topo?	0	65311	Positive	10000	Regular			Incomati

- Now expand the Runoff/groundwater links menu, and select 'Rainfall-runoff links'. This is where the name of the catchment in the rainfall-runoff file is defined, and with which branch it is linked.
- Specify the name and area of the catchment the same as what was specified in the rainfall-runoff file, namely 'Y40D' and 4536 (km2) respectively. Then specify the name of the branch as 'Mazimechopes', with US. and DS. Chainage of 0 and 65311 respectively (see screenshot below).

📸 MIKE Zero - [Incomati_demo_RR.nwk11:2 - Modified]										
File Edit View Network Layers	Settings W	/indow He	elp							
🗅 🚅 🖬   🐰 🖻 🛍   🍜 🤋 😢										
Overview  Wetwork  Points (1160)  Branches (2)  Alignment Lines (0)  Unctions (0)  Cructures  Cruct	Catchment I Name Area Overview	Definitions Y40D 4536		Connection to Bra Branch name Upstream Chaina; Downstream Chai	inches M ige 0 inage 65	azimecho 5311				
MIKE SHE links (0)		Name	e	Area	Branch	Name	US. Chainage	DS. Chainage		
Rainfall-runoff links (1) ⊕ Grid points	1	Y40D		4536	Mazime	chopes	0	65311		

Now save and close the Tabular View, so that the network view is visible. You'll
now notice a thick green line symbolizing the Mazimechopes branch, meaning
it now has a catchment link to it (see screenshot below).


- Insert a boundary condition for chainage ) on the Mazimechopes branch, and specify a constant discharge of 0 m3/s.
- Now close the close the network file (small X), and within the simulation editor, specify the location of the result file and set the storing frequency to 1 day.
- Now click on the Start tab. Notice now that there is an additional model present under the Validation status window for the RR parameters (see screenshot below).

📸 MIKE Zero - [Incomati_demo_RR.sim11]	
<u>File Edit View Window Help</u>	
D 🗃 🖬   X 🖻 💼   🚭 🤋 📢	
Models Input Simulation Results Start	
Validation status Run Parameters HD parameters RR parameters	Validate MIKE 11 Classic MIKE 1D
Validation messages	

 Now run the simulation (MIKE 11 Classic). Examine the results in MIKE View. Note the discharge time series just after the confluence (blue line) compare to before the confluence (black line), where the effect of the rainfall from the catchment contributing to this branch can be seen (see screenshot below).



## 2.3 EXERCISE 1

- 1 Using the existing MIKE 11 setup provided (BlueNile.sim11), run the model and examine the results in MIKE View.
- 2 Run the "BlueNile.sim" model and compare the results in MIKE View with the results from "BlueNile.sim11" (especially just downstream of the confluence).
- 3 For the "Incomati\_demo.sim11" model, edit the HD parameter file by adjusting the Global Mannings M number from 13 to 50. Save the HD file, and rerun the simulation (remember to change the name of the result file).Now compare the discharge time series at a same location downstream from the first run (Mannings M = 13) to this run (Mannings M = 50). What do you notice?
- 4 Replace the upstream boundary file with the one called "Roseres\_Dam\_Release\_reduced.dfs0". Save and close the boundary file, and rerun the simulation.
- 5 Repeat the above step, but change the Global Mannings M number back to 13. Compare the result to the previous simulation in MIKE View.

## 3. How to Register/Setup MIKE 11 in MIKE Operation Workbench

## 3.1 INTRODUCTION

The purpose of this chapter is to learn how to import, or register, a MIKE 11 model setup into MIKE Operations. This process is important, as the model needs to be within MIKE Operations framework before any further steps can be taken. Now that you have learnt how to create and run a simple MIKE 11 model, the next step will be to register this model within the MIKE OPERATIONS Workbench application.

## 3.2 STEP-BY-STEP: HOW TO REGISTER A SIMPLE MIKE 11 MODEL IN MIKE WORKBENCH

- Create a "BlueNile" database using a "Database Manager Utility" (Start > All Programs > MIKE OPERATIONS 2019/2020 (version may differ) > Database Manager Utility
- Open MIKE OPERATIONS Workbench from the Start menu (Start > All Programs > MIKE OPERATIONS 2019/2020 (version may differ) > MIKE OPERATIONS Workbench (see screenshot below).

MI	KE OPERATIONS 2016.4
	Database Manager Utility
3	MIKE OPERATIONS Documentation
3	MIKE OPERATIONS Workbench Doc
w	MIKE OPERATIONS Workbench
0	MIKE OPERATIONS
	Programmer's Documentation

3. Select the desired connection name from the dropdown list, then enter the appropriate login credentials and click on Login (it is assumed that a connection has been created beforehand. If not, this will be done for you). See the example screenshot below.

M	Use this dial	Connection Name:			
	Region20	BlueNile_Training			H
	Region30	Database Type:			1
c	Region40 Region50	PostgreSQL ~			
	Sava	Server:			
2	Test	localhost	0		1
	Training	Port:			1
V	TSA Umgeni	5432			1
Б	WRI_RT	Database:		~	1
C	Add	BlueNile_Training ~			1
		OK Cancel			
				Close	

🕋 MIKE Workbe	ench Login		×
MIKE V	Vorkbench		
Connection:	BlueNile_Training	~	Setup
User Name:	admin		
Password:	•••••		
Workspace:	workspace1	~	
🗹 Always use	the same user name and password		
Always login	with the above settings		
		Login	Cancel

4. Once the MIKE Operations Workbench application has opened, click on the 'View' menu at the top left corner of the screen and select 'Explorers...'. Once the Explorer Configuration window opens, select "Scenarios" (See screenshot below).



5. Under the Scenarios tab, you'll notice two folders that have already been created, namely 'Comparison Configuration' and 'Model Setups'. Right-click on the 'Model Setups' folder and select Create group, then give the new folder a name, for example 'BlueNile. Now right-click on the newly created folder and create another one, for example 'BlueNileEWFFS' (See screenshot below).



6. Now right click on the second group you created (i.e. 'BlueNileEWFFS'), and select 'Register model', where a Model Register Wizard window should appear. Click on the Select Model Type dropdown and select 'MIKE11' (See screenshot below). Then click Next.

Model Register Wizard - Welcome Page		= X
Model register wizard.		
This wizard helps to register a model and link its time serie	es with existing or new features.	
Select Model Type	MIKE 11	
	Cancel	< Back Next >

7. Take note of the tips that appear in the resulting MIKE 11 model register wizard window (see screenshot below). Click Next.

HIKE11 Wizard - Welcome Page
MIKE 11 model register wizard.
To register a MIKE 11 model setup you shall have prepared the following:
* a model setup in a folder structure where all files are located * the model setup must have result files to allow registration of outputs
The wizard will then in the following steps guide you through:
* selection of the model setup * verification of the model setup * preparation of input to the registration process
Click Next to start the process.
Cancel < Back Next >

8. Provide a suitable name for your model, then browse to the location of the sim11 file on your PC, which you created in chapter 2 (See screenshot below). Click Next.

🖷 MIKE11 Wizard - Inp	but Page X
MIKE 11 model re Please provide below	egister wizard. vinput for registering the model.
Input Parameters	
Model Name	BlueNileFFS
Model file path	C:\DHI\01_current\00437_ENTRO FEWS\WIP\Training\BlueNile\BlueNile.sim11
Engine	MIKE 11 (Based on initial condition and result files defined in sim11 file)
	Cancel < Back Next >

9. Depending on the size of the MIKE 11 model configuration, it may take a while for it to be imported into MIKE Operations. The next screen will show a summary of what files have been registered (See screenshot below).

🖷 MIKE11 Wizard - Overview Page	x
C:\DHI\01_current\00437_ENTRO FEWS\WIP\Training\BlueNile\BlueNile.sim11	
Prepare for Registration	
Cancel < Back Next > Finish	

10. The model is now ready to be registered. Click on 'Prepare for Registration'. Once done, there should be a message above the status bar saying 'Preparation for registration Complete'. Now click Finish (See screenshot below).

MIKE11 Wizard - Overview Page	x
C:\DHI\01_current\00437_ENTRO FEWS\WIP\Training\BlueNile\BlueNile.sim11	
Preparation for registration Complete	
Prepare for Registration	
Cancel < Back Next > Finish	

11. Once the Finish button has been clicked, a Time Series link page will be displayed (See screenshot below). This page will also include a summary of the objects within the MIKE11 file that you're registering. Click next.

Model Register Wizard - Time series Link Page		= x
Model register wizard.		
Link adapter time series with database time series.		
BlueNileFFS	8∎ 2↓ 🖻	
🕀 💼 Initial Condition	✓ General P	roperties
🗄 💼 Model Objects	Description	n .
🗄 📲 Other Output Data	End Date	2019/07/30
	Model typ	e MIKE 11
	Name	BlueNileFFS
	Projection	PROJCS["WGS_1984_
	Start Date	2019/06/30
	Time of Fo	1 2019/07/30
	News	
	Name	
	Cancel	< Back Next >

12. On the next Model Register Wizard page, there is an option to create a scenario for the MIKE11 model being registered. Leave the settings as the defaults (i.e. as in the screenshot below). Click Finish.

Model register wizard. Specification helps to assign group and create d	lefault scenario with model.	
Assign Group Model Setup Group	asterNile/BlueNileEWFFS	
Scenario O Do Not Create Scena © Create Default Scena Name of Scenario Description	rio rio Base scenario Default scenario of BlueNileFFS model	
O Use Template Scenar	io	
Scenario		

13. Once the model registration is complete, a message will pop up in the bottom right-hand corner, indicating that the model registration is complete (See screenshot below). Additionally, the MIKE11 model will appear as a scenario under the folder tree within the Scenario tab in MIKE Operations (See second screenshot below).

Scenario exploi	rer	X
The second	Model registration complete.	



14. If you open the model by right-clicking on the name of the folder (in this case, "BlueNile\_test") and selecting Open (or double-clicking on it), an overview of the model setup will appear (See example in screenshot below).



## 3.3 STEP BY STEP: HOW TO SETUP SCENARIOS FOR THE REGISTERED MODEL

It may be necessary to create several scenarios of the registered models, in this case MIKE 11. The simplest way to do this is as follows:

1. From the previous guide on how to register the MIKE 11, right-click on the model in the Scenario tab and select "Clone" (See screenshot below).



2. You will notice that a new scenario appears below the initially registered model, called "Clone of...". Here you can rename the scenario to something more appropriate.

## 3.4 STEP-BY-STEP: HOW TO RUN SCENARIOS IN MIKE WORKBENCH

Now that you have learnt how to register a model, as well as cloning an already-registered model, the next step is learning how to run a simulation from within MIKE Workbench.

- 1. Open the model that was initially registered (if it is not open already). The top screen shows the geographical layout of the network file for the MIKE11 model, and below it is a summary of data within the model.
- 2. Double click on the folder called "Calculation point". Inside this folder are all the q (discharge) and H (water level) points within the MIKE 11 model. For each one of these points, there is an output time series.
- 3. Select all of these model objects, then right-click and select "Include all output time series" > "Scenario of BlueNile\_test" (See screenshot below).

Connection View Settings Help					
renarios	P ×         # Start Page         BlueNileFFS		* ( ) X	Tools Explorer	D 4
Real Models and Scenarios	BlueNileFFS - Boundary • 🕨 🕲 🔍 🔍 🖓	l 🔍 📐 · 🔡 🗄		Search toolbox	
Comparison Configuration	BlueNileFFS - Boundary		1	Tools	
Model Setups	BlueNileFFS - Calculation point     BlueNileFES - Cross particip		Λ		
BlueNileEWFFS	- BlueNileFFS - Branch		4	Other Tools	
E BlueNileFFS			nu L	B- Data tools	
Scenario of BlueNileFFS	2017-11		1	Eco System Service	
				🔋 🚞 Gauges	
				🕀 📷 Statistics	
				Stored Sequence	
				Properties	0
				BLUE NILE REACH: EDDEIM-KARTOUM	
				21 21	
	200 km				
	BlueNieFFS > Calculation point >	Genue by Search Test	10		
		side by			
	Name	Туре			
	BLUE NILE REACHEDDEIM-KARTOUM - 722548.5625 - QPoint	Model Object			
	BLUE NILE KEACHEDDEIM-KAKTOUM - 722602.5 - HPoint	Model Object			
	BLUE NILE REACHEDDEIM-KARTOUM - 722032.0025 - CPOINT	Model Object			
	BLUE NILE REACH-EDDEIM-KARTO Include all parameter	s +			
	BLUE NILE REACH-EDDEIM-KARTO Include all input time	series			
	BLUE NILE REACH:EDDEIM-KART	Scenario of BlueNileFFS			
	BLUE NILE REACH:EDDEIM-KART	tout time series			
	BLUE NILE REACHEDDEIM-KARTO	object +			
	THE AVERAGE AND THE AVERAGE A VERICITY AND A VERICI		~		
	BLUE NILE REACHEDDEIM-KARTGerne rearrance in one				
) Do 🔢 Gi 💁 Jo 🗫 Op < Sc 🕃 Scr 🛅 Sp 🍀 S	BEBLUE NILE REACHREDDEIM-KARIG		>		

- 4. Go back to the <u>BlueNile\_Test</u> folder, and double-click on the "Boundary" folder. Include the time series here as input time series to the same model (similar to the step done above).
- 5. Before the model is run, click on the Time series tab at the bottom of the left panel, and expand the "Model and Scenarios" folder as much as possible. You should see the boundary files as input data here (similar to the screenshot below).



6. Now right-click on the model that was registered (not the cloned model), and select Run Simulation > Foreground (see screenshot below). This will run the MIKE 11 model (as we did in chapter 2), but instead of running it within the simulation editor, it is now run within MIKE Workbench.

Connection View Settings Help						
icenarios	4 ×	A Start Page Scenario of BlueNilel	FFS	+ 4 ⇒ 5	Tools Explorer	04
Real Models and Scenarios	-	BlueNileFFS - Boundary	🛛 ଷ୍ ପ୍ ରୁ ରୁ ରୁ 📐 🛚 🔡 🔛		Search toolbox	
Comparison Configuration		BlueNileFFS - Boundary		1	FeatureLayer Tools	\$
EasterNile		BlueNileFFS - Calculation point BlueNileFFS - Cross section     BlueNileFFS - Branch		h.	Geo Processing     Output Tools     Raster Interpolation	
Scenario of BlueN	Open			1	B Soll Erosion	
	Add optimizer				Temporal Tools	
	Check out				Other Tools	3
	Run simulation	Foreground			😥 🚞 Data tools	
	Clone	Background on job://localhost	_		Eco System Service	
	Copy full path		1		Statistics	
	Delete Del		<b>N</b>		Stored Sequence	
	Delete as background		(		Properties	
	Rename F2				BlueNIeFFS - Calculation point	- Feature Layer
	Stop all gupping simulations				82 2 I   E	
	Auto-approve simulations				<ul> <li>Appearance</li> <li>Display Attribute</li> </ul>	Name
	Define land Manada	-			✓ Layer Style	Point Layer Style
	Denne input Hierarchy	200 km			Color	RoyalBlue Point Laver Style
		Scenario of RiveNileEES		Sauch Zard	Outer Line Color	Blue
			1.4700	Jese of Feet	Outer Line Thickness Outer Line Type	Solid
		Name	Count	Type	Size	4
		Calculation point	839	Model Object Group	Symbol Type Style Type	Circle
		BlueNile	1	Other Output Data	> Text Style	Text Style
		BlueNile-SIMSTAT	1	Other Output Data	Transparency Minc	0
		<ul> <li>MZAdapter</li> </ul>	1	Other Output Data	Current map scale	1:9 244 649
					Label visibility range	[-]
					Name	BlueNileFFS - Calculation poin
	The Marshall and				Outer Line Color The color of the outer line.	
Do 🔢 GI 🙄 Jo 🐜 Op 🕰 Sc I	💱 Scr 🌐 Sp 🐺 Sy 🛃 Ti	<		2		

7. While the model is running, a small screen like the one in the left screenshot below will appear. Once the model has finished running, a small window at the bottom right-hand corner will appear showing that the simulation has been completed.

S MIKE 11dbd283d484\BlueNile.sim11	×	
Computational status:       13306 of 172800         Computational speed:       469650 points/sec         Estimated time left:       9.50 minutes		Scenario explorer 🛛 🗙
Suspend Cancel		Simulation Simulation of Scenario of Incomati_test at 2017-03-08 09:23:19 complete.

8. After the model has finished running, you'll notice a new record appears below the scenario model name, called "Simulation of..." and the name of the scenario, with the date it was run (see example below).



9. Now go back to the Time series tab, and look for the new folder called "Simulations". Expand this folder as much as possible, until you see all the q and H output time series created from the model. Select one of the Qpoint time series and right-click then add to new chart (see screenshot below)



## 3.5 **Exercise 2**

- 1. Change source of time series at the upstream boundary within MIKE Operations Workbench and run different scenarios for SDF2, SDF5, SDF10 and SDF20 (different flood return periods). To do this for SDF2, perform these steps:
  - Create a scenario (clone) of the model setup that was imported, and rename it (i.e. '2yr Scenario of BlueNile\_Test').
- ction View Settings H 2 Start Page Scenario of Blue
  BlueNileFFS - Boundary
  BlueNileFFS - Boundary
  BlueNileFFS - Calculation poin
  BlueNileFFS - Calculation poin
  BlueNileFFS - Calculation poin
  BlueNileFFFS - Calculation
  BlueNileFFS - Calculatio
  BlueNileFS - Calculatio
  BlueNileFFS - Calculation
  BlueNileFFS - Ca eNileFFS 🖉 Chart1 • ኲ 한 원 원 요 요 요 요 . ▼ 4 0 × Tools Explo D # X eFFS - Gro eFFS - Bra n4 imulation of Scenar es\_Dam\_Rele ase dfs0 - 1 - Bo to Input Tim 21 21 📰 ral P seres Dam Release.dfs0 - 1 - F Model Object Name Blue Nile Rea h:Edde Roseres Dam Release.dfs0 - 1 - F 1098753.3023 (36.6762 9.82 100 m No change Blue Nile Re ach:Edd Type SubType String Oper String Inflow ..\TS\Roseres\_Dam\_Rele MIKE11BoundaryPointL String MIKE11Bo 🖹 Doc... 🇱 GIS 🗞 Job 🗫 Op... ⊄ Sce... 🕃 Scri... 🛅 Spr... 🏟 Syst... 🗠 Tin - ÷ 🍓 💶 📵 📕 🐮 🖩 🎼 🖬 🔁 🌣 🙋 🛄 🗁 🚥 🚱 🗞 🌚 💁 🦓 w RR 🔨 📹 💪 🌈 ENG
- Now open this scenario (see screenshot below)

- At the bottom window, where the summary of the boundary and calculation point counts are shown for the scenario, double-click on the Boundary folder.
- o Then double-click on the upstream boundary, namely 'Blue Nile Reach:Eddeim-Kartoum - 0 – OpenSource'.
- Now select the current time series that has been specified as the upstream condition, namely 'Roseres\_Dam\_Release.dfs0 - 1 – Roseres' (see screenshot below).

Scenario of BlueNileFFS > Boundary > Blue Nile Reach:Eddeim-Kartoum - 0 - OpenSource > Search Text				Q,
Name	Туре	Value		^
屋 Roseres_Dam_Release.dfs0 - 1 - Roseres	Input Timeseries Definition	Timeseries: Roseres_Dam_Release	.dfs0 - 1 - Roseres	~

 Once this time series has been selected, the properties window (bottom-right corner) will show the properties of that boundary. The Source shows that the current boundary condition is a Timeseries type, with the name of the time series file. Click on the name of the timeseries, then click on the browse button (see screenshot below)

Pr	operties		04	×
Sce	nario Input Timeseries - Roseres_Dam_R	elease.dfs0 - 1 - Roseres		-
•	2↓ 🖻			
~	General Properties			
	Description	Roseres_Dam_Release.dfs0 - 1 - Roseres		
	Model Object Name	Blue Nile Reach:Eddeim-Kartoum - 0 - Op	enSo	ourc
	Name	Roseres_Dam_Release.dfs0 - 1 - Roseres		
	Source	Timeseries		
>	Timeseries Interval	Scenario		
>	Timeseries Variation	No change		
~	Source			
	Timeseries	Roseres_Dam_Release.dfs0 - 1 - Roseres		
Tir	neseries			
Ge	neral Change log entries			

• When the 'Timeseries Selector' window appears, type "Roseres" in the search box, then press Enter on the keyboard. [This searches for time series in the database with this name]. When the resulting time series appears, select it, then click on the Select button (see screenshot below). You'll notice that there is a timeseries called "Roseres" that appears as well. This one will be used in the same exercise later on.

🖷 Timeseries Selector	- 🗆 X
Roseres	↓
Name	Parent Group
Roseres_Dam_Release.dfs0 - 1 - Roseres	Models and Scenarios/BlueNileFFS/Mod
Roseres_Dam_Release.dfs0 - 1 - Roseres	Models and Scenarios/BlueNileFFS/Simu
Roseres_Dam_Release	Input Data
	Select Cancel

- You'll now notice that the name of the time series in the Properties window changes to "Roseres". Now the upstream boundary condition has been changed.
- Chang the simulations time for the new scenario

i Pr	operties		0 <b>4</b> X
See.	apris Class of Secondia of PhysNilsEES		
SCe	nano - Cione of Scenano of Bidenilerrs		•
•	2↓ 🖻		
	Checkout user		^
	Generate change log	False	
	Generate Input time series	Variations	
	Store simulation content	True	
	Store simulation input time series	Variations	
	Time series Interval	FullTimeseries	
~	Script		
	Post-processing script		
	Pre-processing script		
~	Simulation times		
	End Time	2019/08/30 00:00:00	$\sim$
	Start Time	2019/07/30 00:00:00	
	Time of forecast	2019/08/30 00:00:00	
			~
En	d Time		
Th	e simulation end time.		
Ge	neral Change log entries Metadat	a	

- Now run the scenario (right-click > Run simulation > Foreground. A message should appear at the bottom-right corner saying that the simulation is complete.
- Now compare the simulation discharge result from the first scenario against a new the scenario

# 4. How to setup a configuration in MIKE Operation

## 4.1 INTRODUCTION

The MIKE Operation platform is a platform that is designed to integrate operation and planning tools or models with near-real time, forecasted and historical observed data and the platform produce reports from model results and raw and processed data that will assist managers and technical personnel to make the required decisions or planning. The platform is for establishing customised outputs – generally referred to as decision support systems or information management systems - based on standardised functionality.

The configuration of MIKE OPERATIONS requires relations between GIS feature layers, time series and their thresholds in order to present the results. All information is saved in spreadsheets in MIKE WORKBENCH. Spreadsheets are maintained in MIKE WORKBENCH but can also be changed in the platform.

The configuration consists of Feature Types. Feature Types are configured from the Application Menu of MIKE OPERATIONS.

## 4.2 STEP-BY-STEP: HOW TO SETUP THE MIKE OPERATION

1 Open MIKE OPERATIONS from the Start menu (see screenshot below).



2 Login using the same connection name as the one you were using in Workbench (i.e. Training). Once the application has opened, you should see a home page, without any data to be seen (example shown below).

()				
🖸 🛛 🕄 🔹		DHI MIKE OPERATIONS - workspace 1 (Data & Maps)		- @ ×
Home Publish View				^
Cobservation				
Type -				
Comguration Observat				
Select Groups	<b>(</b> )			
Data 9 Mana	0			
	<b>₽</b>		Time of Forecast	
	500 km		💽 G ———————————————————————————————————	
	- 1 mi			
1			_	
	ĸ	□ # ×	legend	□ # ×
	۲	□ # ×	Egend	- # ×
	K.	□ # ×	Egend	□ # ×
	۲.	□ # X	The Legend	□ # ×
	k	□ # X	E Legend	□ # ×
	k	□ # X	lig Legend	□ # ×
	Le la	□ # X	To Legend	□ # X
		□ # X	Estegend	□ # X
		□ # X	Image:	- # ×
Data & Maps		□ # X	Egend Eg ▲ 16 E E Q.	- # X
Data & Maps		a of Envarante /// 1. Semulation (9. nr. // ).	Implement           Implement <t< td=""><td>- # X</td></t<>	- # X

- 3 Click on the General settings button to the left of 'Home' ().Click the "New" button to create a new configuration.
- 4 Specify a name (e.g. "BlueNile\_Training") and click OK (leave the Copy from empty) - See screenshot below.

📮 Save 📑 New	🔠 Create Spre	adsheet	🛗 Ob	servatio	n Periods
Summary Views	📑 Messages	🙀 Lang	guages	🔂 No	tifications
🔒 Create Configurati	on	—		×	
Configuration Name	BlueNile				
Copy from				-	
	OK		Cancel		

5 Now add the data from the Workbench database. This is done under the General box. Select the "BlueNile" as the Model Setup and "Base scenario" as the Forecast Scenario (see screenshots below).

General			
Name	(fiuetile		
Description			
Model Setup	/Group of Buehle/Buehle	H	
Porecast Scenario	Group of Bluetille     Bluetille	-	
Users	Loop the	1	
Index			
Layout			
🗲 Default Skin			
< Scenario Skin			
🖹 Background Map Type			
d Source Coordinate System			
Vens			
Use Tree Navigation			
Zoom to selection	×		
Canada			
General			
Name	Diuetile		
Description			
Forecast Scenario	Aroup in bueve, bueve	i	
Lisers	Bese scenario	h	
Index			
Layout		ł	
🗲 Default Skin			
Scenario Skin	×		
Background Map Type	T GET GHT T	4	
Source Coordinate System	WGS 04 / Pseudo-Mercetor	긬	
U VIENS		*1	

6 Now we will change the layout to suit us. Leave the Default skin as it is (Office 2013 Light Grey), but change the Scenario Skin to 'Sharp' (see screenshot below).

Layout		
🗲 Default Skin	Office 2013 Light Gray	~
< Scenario Skin	Sharp	<
Background Map Type	Pumpkin	^
Source Coordinate System	Seven     Seven	
Views	<ul> <li>Sharp</li> </ul>	
Use Tree Navigation	Sharp Plus	
Zoom to selection	Springtime	
	🏠 Stardust	V

7 Change the Source Coordinate System to the same as what was used for the MIKE 11 model, namely WGS 84 UTM 36S. Leave the Views as is (see screenshot below).

🛕 Source Coordinate System	WGS 84 / UTM zone 36S	
Views		V

#### Feature Types

Feature types are the central point of the MIKE OPERATIONS configuration. Feature Types contain information about layers to display and specifies relations between Feature Classes, observation time series and model input and output. When creating a Feature Type, a new tab item is displayed in the application menu, for each active feature type. Here all point features, multiline features and polygon features can be configured; specifying thresholds, time series and model object references. From MIKE Workbench, it is also possible to edit the entire feature type spreadsheets. This will make more sense once a feature type has been created.

1 In the Feature Type list, click the 'New' button. This will create a new line in the list of feature types (see screenshot below).

	Feature Types							
		Copy 🕂 New 🗙 Delete ᡝ N	Move up 🛯 🖞 Move down					
I Layer Type Name		Name	Themes	Group Name	Time Series	Thresholds	Details	
	9	Dynamic Feature Layer	New1			🛃 Time Series	1 Thresholds	Details

- 2 Click the 'Details' button to enter the details form of the Feature Type. The details form shows all properties of the Feature Type. The 'Active' checkbox is automatically checked. The Active checkbox is used to enable or disable the feature type. Disabling the feature type will hide the feature type all over MIKE OPERATIONS.
- 3 Give the feature type an Id and Name (see example screenshot below). We will be using the BlueNile Basin shapefile for this feature type. Id is used as a reference in spreadsheets. The name is used as display name in MIKE OPERATIONS. Description is optional and can contain more lines of text. The description field will be shown in tool tips.

诸 Identification		Layer Type			
🔑 Id 🛛 💶		Layer Type	Dynamic Feature Layer	-	
Name Catchment Ra	ainfall	Visibility	Always	-	
Description		SIS	SIS		
Active 2	v	Feature Class Path	/Hydrology/Catchment/BlueNile_subcatc		
		🔑 Id Attribute Name	name	-	
Layout		Raster Path			
Ribbon Page Name		Traces-X Path			
Group Name	MIKE 11 Forecast	Traces-Y Path			
Ribbon Item Type	Gallery Check Item 👻	Layer File Path			
Resource Image Name	catchment -	Vector Scale Factor		1000	
Document Image Path		Nap Label Type	None	*	
Theme	Hydrology; Hydraulic 🗸	Layer Transparency		-1	
Show on Web	<ul> <li>Image: A start of the start of</li></ul>	🔩 Scenario Mode			
		Period Interval Unit	All time steps	-	
Spreadsheets		Period Interval		0.00	
🖬 Spreadsheet Path 🛛 /R	eal time configurations/BlueNile/FT1 🛛 … 📸	]			

#### Layer Types

The Layer Type, defines the type of layer on the map.

#### Static Feature Layer

Static Feature layers are fixed feature layers placed in the GIS Manager of MIKE Workbench.

The colours of the static feature layers are determined by the default symbology of the layer specified in MIKE Workbench.

#### **Static Raster Layer**

Static Raster layers are fixed raster's layers placed in the GIS Manager of MIKE Workbench.

The colours of the static raster layers are determined by the default symbology of the layer specified in MIKE Workbench.

#### Dynamic Feature Layer

Dynamic Feature layers are layers where colours are determined by thresholds setup on each feature of the feature class specified.

Feature Types of this type must have a spreadsheet specified, where information of the feature types features can be stored.

Layer Type		
Layer Type	Static Feature Layer	~
Visibility	Static Feature Layer	
visionicy	Static Raster Layer	
	Dynamic Feature Layer	

**Static Feature Layers** 

4 Select the Static Feature Layer from the Layer Type dropdown (as seen above). Leave the Visibility as the default (i.e. Always).

#### Layout

5 Under the 'Layout' section, fill in the following (example screenshot shown below)

Ribbon Page Name: Overlays

Group Name: Catchments

Ribbon Item Type: Gallery Check Item

Resource Image Name: Catchment\_32 (under the System folder)

Document Image Path: leave blank

Theme: leave blank

Overlays	
Primary Catchment	
Gallery Check Item	~
Catchment_32	~
	•••
	~
	Overlays Primary Catchment Gallery Check Item Catchment_32

## GIS

Feature Class Path is the path to the feature class in the GIS Manager of MIKE Workbench. MIKE OPERATIONS supports feature types containing points, without specifying the feature class. This is because point features contain coordinates in the spreadsheet. For polygon and line feature types, the Feature Class is mandatory.

6 Click on the browse button in the Feature Class Path, and select Catchments > BlueNile catchment boundary (as seen in the screenshot below).

SIS GIS			
Feature Class Path	/Hydrology/Catchment/BlueNile_subcatc		
🔑 Id Attribute Name	name	*	
🔛 Raster Path			
Traces-X Path			
Traces-Y Path			
📠 Layer File Path			
Vector Scale Factor		1000	
🚫 Map Label Type	None	*	
Layer Transparency		-1	
< Scenario Mode			
Period Interval Unit	All time steps	*	
Period Interval		0.00	

7 Now click OK to close the Feature Type Setup window. Once back in the General Settings page, click on Save near the top left corner (). Now click on the new tab called Overlays (which was defined as the ribbon page name). You should see the BlueNile Basin in the map view (see screenshot below).



Now that you have learnt how to add a static feature layer, we will add a dynamic layer next.

## Dynamic Feature Layers

- 1 Within the General Settings page, add a new feature type, and click on Details.
- 2 Provide an Id, Name and description (optional).
- 3 Leave the Active checkbox ticked, and ensure the layer type is Dynamic Feature Class, Always visible (see screenshot below).

Feature Ty	/pe Setup	(New2)			
- 🔓 Identifi	Contraction				
🔎 Id	Gauging Sta	ations			
Name	Discharge				
Description	Gauging sta available.	ations where some discharge time series will be	< >		
Active 🖌					
Layer T	ype				
Layer T	ype	Dynamic Feature Layer	~		
Visibility		Always	$\sim$		

- 4 Click the Create spreadsheet button ().
- 5 Untick the 'Create Empty Spreadsheet' checkbox.
- 6 Click on the Feature Class browse button, and under the Stations folder, select Real time gauges (see screenshot below)

Create Spreadshe	et _ 🗆 🗙
Create Empty Spread	Asheet  Catchments  Catchments  Models and Scenarios  Rivers  Stations  Real time gauges  Reservoirs

- 7 For the Id Attribute and Name Attribute, select "name" for both of them
- 8 For Spreadsheet Name, click on the browse button and select the folder called "Real time configurations", then double-click the spreadsheet with the same name (see screenshot below).

💼 Spreadsheet Name		
	Real time configurations	Ì
	Incomati_Training	I
	Real time configurations	

9 Now in the space next to Spreadsheet name, after the second backslash sign, delete the words 'Real time configuration', and replace them with 'Discharge' (see screenshot below). Click OK to close the Create Spreadsheet window.

Create Spreadsheet –				
Create Empty Spreadsheet				
E Feature Class	/Stations/Real time gauges	••••		
🔎 Id Attribute	station_co	••••		
Name Attribute	station_co	••••		
💼 Spreadsheet Name	/Real time configurations/Discharge	••••		
	OK Cancel			

10 Within the Feature Type Setup window, under the Layout section, fill in the fields as seen in the screenshot below.

Layout		
Ribbon Page Name	Forecasting	
Group Name	Discharge	
Ribbon Item Type	Gallery Check Item	~
Resource Image Name	River_32	~
Document Image Path		
Theme		~

11 For the Feature Class Path in the GIS section, browse for Real time gauges under the Stations folder. For Id Attribute name, select 'name. For Map Label Type, select 'Name'.

For dynamic feature layers, the layer transparency can be specified. The transparency can take values in the range 0 to 100. Where 0 is not transparent and 100 is completely transparent. The default value is -1. This means that for polygon layers the layer transparency is set to 60. For line and point layers, the layer transparency is set to 0. For static layers, the layer transparency can be set using the default symbology of the layer.

12 Set the Layer Transparency to 0. Click OK (to close the Feature Type Setup window).

The details for the Dynamic Feature Type have now been specified. Now we need to configure the Time Series for this feature type.

#### Time series

1 Click the 'Time Series' button of the feature type to configure the time series of the feature type. (Click twice - first select then open).

2 Click the 'New' button twice to add two time series row:

Name the first one "Observed", having a "Time Series" Time Series Type and a "Line" as the chart type. Name the second one "Simulated", having a "Model Output Time Series" type, and a "Line" as the chart type (see screenshot below).

ţļ	Time Series Setup (Discharge) – $\Box$ ×					
	🖺 Copy 🕂 New 🗙 Del	ete ᡝ Move up 👈 Move d	own 🗸			
	Name	Time Series Type	Chart Type	Details		
	Observed	Time Series	🗠 Line	┃ Details		
	Simulated	Model Output Time Series	-~~ Line	Letails		
				Cancel		

3 Click on Details, and make the ld the same as the name (i.e. Observed). Do the same for the Simulated one. For the Simulated time series, change the line colour to red and the line style to Dash (see screenshot below). Leave all other details as they are.

Chart Style		
Chart Type	-~~ Line	~
Color	240, 0, 0	~
Line Style	Dash	~

- 4 Click OK to close the Time Series Setup window. Now click Save () to save the edits for the Dynamic Feature Layer.
- 5 Under the General Settings icon at the top-left corner, the 'Discharge' icon is now visible, which is the Dynamic Feature Layer that was just added. Click on it. You should now see a screen similar to the screenshot below.

<b>1</b>	5				DHI MIVE OPED ATIONS - workposes ( Data & Mane)			- ×
	Users Dahlah M	Condens Constant			Diff Hate OFERRITORS - Workspaces (Data a Haps)			
	General Settings	Bave Bar Copy + New X	Delete	Co Identifi	ication	Ľ	Observed	
		† <b>i</b> ¶ Tools <b>*</b>		DI 🍳	X1H014	Time	e Series	
		Name	Value	Name	X1H014	Lab	el	
27	Discharge	X1H014			^			
		X3H023		Description			Cimulated	
		X3H021		Description		0.498	Sindicted	
?	Help	X3H015			×	Mod	el Object	
		X3H008		Active		Vari	able	
_		X2H097						
×	Exit	X2H072		Details		Labe		
		X2H070		Docume	nts			
		X2H059					Custom data	
		X2H046		Tr Groups	~			
		X2H036		🔂 'Go to' Ti	hemes v		ShowAll	
		X2H022		🐔 'Go to' Fi	ilter Groups			
		X2H016		Ewod Decour	rea Image Name			
		X2H015		Fixed Resour	rce intage Name			
		X2H014						
		X2H013		Thresh	nolds			
		X2H006		Cinulator	d Observed			
		X2H005		- Theorem	d Observed Mehre			
		X1H053		I Inres	shold Value			
		X1H036						
		X1H033						
		X1H017						
		X1H003						
		X1H001						
		E43						
		KOB007						
		KOB003						

This is where the time series associations will be made with the stations. For this example, we will only link up an observed and simulated time series for one station. Under

the Name column on the left, click on the Id and Name under Identification should now also show.

6 Now on the top right, click the browse button under the Observed category. Navigate through the folders to the Input one (input boundary condition at chainage 0 from MIKE 11) If there is an observed data.



The upstream boundary condition specified in the MIKE 11 model configuration (from chapter 2) is observed time series data from the Roseres\_Dam. Thus, this is the observed time series we specify in MIKE Operations. Although the simulated time series will not differ that much, the point of this exercise it to demonstrate how to link up observed and simulated time series data for the same station in MIKE Operations.

Next, we will link up the simulated time series data from the MIKE 11 at the q-point closest to station Roseres\_Dam.

7 Click on the browse button under the Simulated category, and search for chainage number that is closest to the Roseres\_Dam. You'll notice that two result files appear, but the QPoint one on top is the one we're looking for (see screenshot below). Double click on it.

Simulate	d		*	
Model Object	RUENTIE DEACHEDDETM KADTOLIM - 521929 6975 - Obeint			
Model Object	BLOE NILE REACH: EDDELM-RAR TOUM - 521050.0075 - QPOINT			
Variable	Discharge, BLUE NILE REACH:EDDEIM-KARTOUM 0.000-722945.254; Chainage: 521839;	•••		
Label	Forecasted		Ļ	ļ
			Ŧ	

- 8 Click on the browse button for Variable, and double-click the only one available.
- 9 Provide a suitable label "downstream of Roseres\_Dam simulated"
- 10 Click Save.

Simulate	ed and a second s		*
Model Object	BLUE NILE REACH:EDDEIM-KARTOUM - 521838.6875 - QPoint		
Variable	bischarge, BLUE NILE REACH:EDDEIM-KARTOUM 0.000-722945.254; Chainage: 521839;	•••	
Label	Forecasted		_

## Thresholds

The thresholds function is an easy way to colour-code time series values in MIKE Operations. In this case, we will define thresholds for the discharge values.

- 1 In the General Settings view, click on Thresholds for the Discharge dynamic feature layer.
- 2 Once the Discharge Thresholds window is open, click on New. Here you will need to specify a name (Very Low), and a colour (Red) and the size of the symbol (12). Leave the symbol as a circle. See an example in the screenshot below.

٨	1 Discharge									
Threshold Definitions										
		Image	Name	Themes	Color	Symbol	Size	Document Image Path	Resource Ima	Alert
	I	•	Very Low			Circle	12			

3 Repeat this for four more thresholds: Low, Medium, High, Very High. See the colours for each in the screenshot below. Click Apply then OK when done, then Save within the General Settings.

	L Discharge								
т	Threshold Definitions								
	Image	Name	Themes	Color	Symbol	Size	D		
	•	Very Low			Circle	12	!		
	•	Low			Circle	12	!		
	0	Medium			Circle	12	!		
		High			Circle	12	!		
	0	Very High			Circle	12			

- 4 Now to assign discharge values to each threshold: click on the Discharge icon below General Settings (left of window). Click on the E43 station from the list. Now specify the following values for each discharge (for both Simulated and Observed):
  - Very Low: 50
  - Low: 100
  - Medium: 250

- High: 500
- Very High: 900

See the screenshot below for an idea of how the threshold values should look.

6 ?				DHI MIKE OPERATION	45 - workspace 1 (Data & Maps)		– a x	
11 Home Publish	View							~
Mil General Suttons	Save 🔯 Copy	+ New X Delete	Co Ident	ification		Simulated		
111 occurrences	tit Tools -			DS-Roseries		Model Object	BLIE NILE REACH-EDDEIM-KARTOUM - 521838-6875 - OPoint	
CEEP Catchment Rainfall	Name	Simulated (Now) [m	Name	DS-Roseries		Variable	herbarne BLUE NILE DEACH-EDDEIM, KADTOLIM 0.000, 722045-254: Chainane: 521839:	
	Kemlin	875.34				variable	paciarge, blue nile Reschiebbethmarrioon 0.000-722913-234, Granage: 522039,	
O Distanta	OF-Netdan     OF-Rearries     OF-Rearries	Label	Forecasted					
Local lenge	DS-Roseries	1011.80	Description			P. custom		
	Ethio-Sud-Border	151.74				V custom	Gald	
About	W-Hadad	1 229.13	Active	v		: E ShowA	All	
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			- Had	a rentered				
			- High	1				
			Very	High	P4			

5 Click Save once all the threshold values have been assigned.

#### Period

The default period in MIKE Operations is 'Relative to Now' (see screenshot below). This time period does not coincide with the start and end period from the MIKE11 simulation. The next step will be to create an observation period that is in line with the time series from the MIKE11 setup.

🚍 Save 🕞 New 🕌 Cr	eate Spreadsheet	bservation Periods	Mail Setup	🛛 Groups 🖞 🕮 Units
Summary Views 🚞 Me	essages 🙀 Languages		Chart Panels	
HI Observation Periods			- 0	×
: 🚍 Save 🖺 Copy 🕂 Ne	ew 🗙 Delete ț Move	up 🕕 Move down 🕇	La Tools ▼	
Name	Group	Observation Period Type	Details	
EOF		Entire Forecast Period	뷰 Details	<b>_</b>
				-
				0 ‡
		OK	Cancel	

- 1 Under General Settings, click on Observation Periods ().
- 2 You will notice that the only one there is the default, "RelativeToNow". Click on 'New', and call the newly added period "MIKE11\_Demo". Under the Observation Period Type, specify "Relative to ToF" from the menu dropdown.

Observation Periods			- 🗆 🗙
📮 Save 🖺 Copy 🖣	- New 🗙 Delete ᡝ M	ove up 🛝 Move down	†‡† Tools ▼
Name	Group	Observation Period Type	Details
RelativeToNow		Relative to Now	

- 3 Click on Details for the MIKE11\_Demo. Make the ld the same as the name, then click on the Period tab.
- 4 From the Relative to ToF, specify the Relative Period as 90 days Before (see screenshot below). Click OK.

G Observation Period Type	Relative Period	
	Days Hour	s Minutes
<ul> <li>Entire Forecast Period</li> </ul>	Before 90 0 0	0 0
<ul> <li>Relative to Now</li> <li>Relative to Date</li> <li>Fixed Dates</li> </ul>	Fixed Dates         From         0001/01/01 12:00:00 AM         ✓         Relative to Date         Period Length         Month	To 0001/01/01 12:00:00 AM V

- 5 In the Observation Periods window, click Save first, then OK. Then click on Save within the General Settings page (you may have to refresh MIKE Operations as well).
- 6 Now click on the Home tab, and change the Observation period from 'Relative to Now', to the one we just created under the Event category, namely "MIKE11\_Demo", and click on the date next to the ToF to the right (see screenshot below). The date on the map view will now change to what we specified for this observation period.

	) 🕄 👘	Ŧ			DHI MIKE OPERATIONS - workspace
一帮	Home	Publish	View	Overlays	Forecasting
E In	E Incomati_Training V		RelativeT	oNow	
Configuration Select Groups (No group)			Relative to Nov	MIKE11_Demo	
			MIKE11_Demo	<b>F</b> ToF: 2014/03/31 12:00:00 PM, Run at: 2017/03/09 03:21:47 PM	

- 7 Click on the Forecasting tab and click on the 'Discharge' icon.
- 8 Now click on the station called Rosiers dam on the left of the screen. You should see the observed and simulated time series for this station (blue solid line and red dashed lines respectively), as you can see in the screenshot below. The station in the map view becomes highlighted with a blue circle around. You can now see the thresholds within the chart view, along with how the dot for the station in the map changes, depending on the discharge value.



## 4.3 **Exercise 3**

- 1 Add the 'Rivers' shapefile as a static layer into MIKE OPERATIONS.
- 2 Link the Observed time series for stations in MIKE OPERATIONS.
- 3 Add a dynamic feature class, using the shapefile called "BlueNile Dummy Gauges". Then link the simulated discharge time series for these locations. Furthermore, create discharge thresholds (similar to the one earlier, or create your own).

## 5. EASTER NILE EWFFS

## 5.1 INTRODUCTION

The fundamental purpose of the BlueNile Early Warning Flood Forecasting System (EWFFS) is to predict floods using near real-time and forecasted data to low-lying areas, which are susceptible to flood risk within the BlueNile basin. This chapter will guide you through the actual BlueNile Basin model and MIKE Operations configuration (rather than the one you created earlier) and how this has been configured.

## 5.2 MIKE 11 BLUENILE SETUP

As explained in chapter 2, the core of MIKE 11 is the hydrodynamic (HD) module, used to convey water within the river channels. However, in MIKE 11, it is possible to include additional modules to the HD for particular simulations. One of these is the MIKE 11 Rainfall-Runoff module, which coupled with the HD module forms the basis of the hydrological model. This section will explain how the MIKE 11 was configured for the BlueNile EWFFS.

## 5.2.1 Forecast Model

A combined hydrological - hydrodynamic MIKE11 model has been developed for the BlueNile Basin. This includes a NAM model for the entire basin, which is used to estimate the runoff to the BlueNile floodplain. This section provides an overview of the models and data used.

In the operational real-time flood forecasting setup, the following editors are run:

- Hydrodynamic (HD)
- Rainfall-Runoff (RR)
- Data Assimilation (DA);

with the HD calculations based on hydrodynamic flow conditions.

## Hydrodynamic (HD)

As explained in chapter 1, the fundamental components of the MIKE 11 setup are the network, cross-section, boundary condition and HD parameter files. These were all included in detail within the BlueNile EWFFS configuration. The figure below shows the network layout of all the rivers in the MIKE 11-NAM model for the BlueNile EWFFS. The blue boxes in this figure represent the boundary positions in the model, including all the upstream points of each river branch, and the outlet boundary at bottom of the BlueNile River.


Cross-sections in the cross section file were derived from various datasets: surveyed crosssections, 24 meter AIRBUS DEM. The surveyed cross-section covers the downstream od BlueNile river beyond the border of Ethiopia and Sudan. The upstream of the BlueNile River crosssections are derviced from 24 meter AIRBUS DEM..

The simulated streamflow from the NAM Rainfall-runoff model were used as boundary files for all the upstream ends of the branches that required boundary files.

For the hydrodynamic parameter file, the main parameter specified was bed resistance. A uniform Manning's M value of 15 was used for the river bed, where M is a reciprocal of n.

#### Rainfall-Runoff (RR)

A Rainfall-runoff hydrological model is one of the primary components of a EWFFS, to predict or forecast flows based on real-time or forecasted rainfall data. Rainfall-runoff models are setup to simulate the streamflow of catchments, by conceptualising the physical aspects of the catchment (e.g. soil profile, topography, land cover/use). The NAM rainfall-runoff model was chosen for this study, for its suitability to flood forecasting systems.

NAM is the Danish abbreviation of "Nedbør-Afstrømnings-Model" which translates into English as "Rainfall-Runoff Model". NAM simulates the terrestrial phase of the hydrological cycle. The NAM model can be applied independently or it can be used to generate boundary contributions to a river network model (as for the BlueNile EWFFS). In this way, it is possible to model an individual catchment as well as a group of sub-catchments contributing to a larger basin with a more complex river network. The NAM Rainfall-runoff model has a hot-start capability, which is a fundamental requirement for near real-time systems. Hot-start is the ability of the model to save the state variables from previous simulations to be used in simulations in the near future.

The NAM model requires the following input data:

- Model parameters which describe the hydrological characteristics of the catchment
- Boundary conditions (e.g. catchments)
- Meteorological data
- o Rainfall
- Potential evaporation
- Streamflow data for calibration and verification purposes

The meteorological data are input into the model as continuous time series. The temporal resolution (i.e. the time-step) of the data is very important. This is especially important for precipitation data, which must have a sufficiently fine temporal resolution, in order to obtain accurate results. For this reason daily precipitation data is the minimum temporal resolution that should be used. With evapotranspiration data, if daily data is not available, it is sufficient to utilize daily averages based on monthly values.

Sub-catchments that were delineated from the 24 meters AIRBUS DEM for the BlueNile River basin were used for the NAM Rainfall-runoff modelling of this project. The catchment spatial scale was sufficient for the purpose of the project. Furthermore, the required meteorological data, specifically evaporation, is available per sub-catchment. Parameters are required for each sub-catchment included in the model. Initial model parameters are estimated based on soil and land use characteristics of the catchment. The parameters are then further refined during a manual calibration process.

#### Data Assimilation (DA)

Data assimilation is a technique for combining any measurements of the state of the system with the model dynamics, in order to improve the knowledge of the system. The data assimilation module in MIKE 11 can be used for assimilation of water level and discharge measurements in the hydrodynamic model. Furthermore, the data assimilation module can be used for uncertainty assessment and estimation of model prediction uncertainties.

### 5.3 BLUENILE MIKE 11 SETUP ON MIKE OPERATION WORKBENCH

The Rainfall-runoff and hydrodynamic model, in this case the BlueNile Basin MIKE 11 NAM Rainfall-runoff setup, was registered and imported to the central database and set up to run from the platform. Here, the input time series is updated regularly using the real-time and forecasted data. The BlueNile MIKE 11 NAM Rainfall-runoff model was configured to run every 6 hours. Once the model run/simulation has been completed, results are summarised to be analysed on the MIKE Operation User Interface and the BlueNile basin web portal. If simulated or observed streamflow values exceed the pre-defined threshold values, warning triggers are sent to the appropriate bodies by SMS or Email.

The MIKE 11 NAM Rainfall-runoff model that was registered and imported into the MIKE Operation platform through a "Scenario Manger", is shown below. Scenarios are defined in the platform, where all the input time series that are expected to be updated by the near realtime and forecasted information, are linked to appropriate timeserie/s in the model. In some cases, where the input timeseries are required to be built from more than one source (for example, combining observed and forecast rainfall into one timeseries), a hierarchy tool in the "Scenario manager" is used to build the input timeseries.



# 5.4 BLUENILE EWFFS ON MIKE OPERATION UI

A simplified user interface which enables everyday users to configure specific elements within the model and to maintain the system has been developed. This is the "MIKE Operation Real-Time User Interface". It is quick and easy to teach potential users to operate the system effectively and thus ensures that system operators can effectively run and maintain the system. It is designed to display real-time data, model time series input and model simulation results linked to spatial features. An example of how the BlueNile EWFFS looks in MIKE Operations is shown below.



## 5.5 BLUENILE EWFFS WEBSITE

The BlueNile Web portal is a replica of the BlueNile basin EWFFS desktop user interface. The web portal displays all information that is included in the desktop user interface. An example of how the EWFFS website looks can be found at the following url: <u>http://bluenileffs.ekodata.co.za</u>. A screenshot from this website is provided below.

