The Hydraulics Research Station
محطة البحوث الهايدرولكية

SEDIMENT CONTROL AND MANAGEMENT IN THE DIVERSION AND MAIN CANAL OF GASH AGRICULTURAL SCHEME, SUDAN

Presented By

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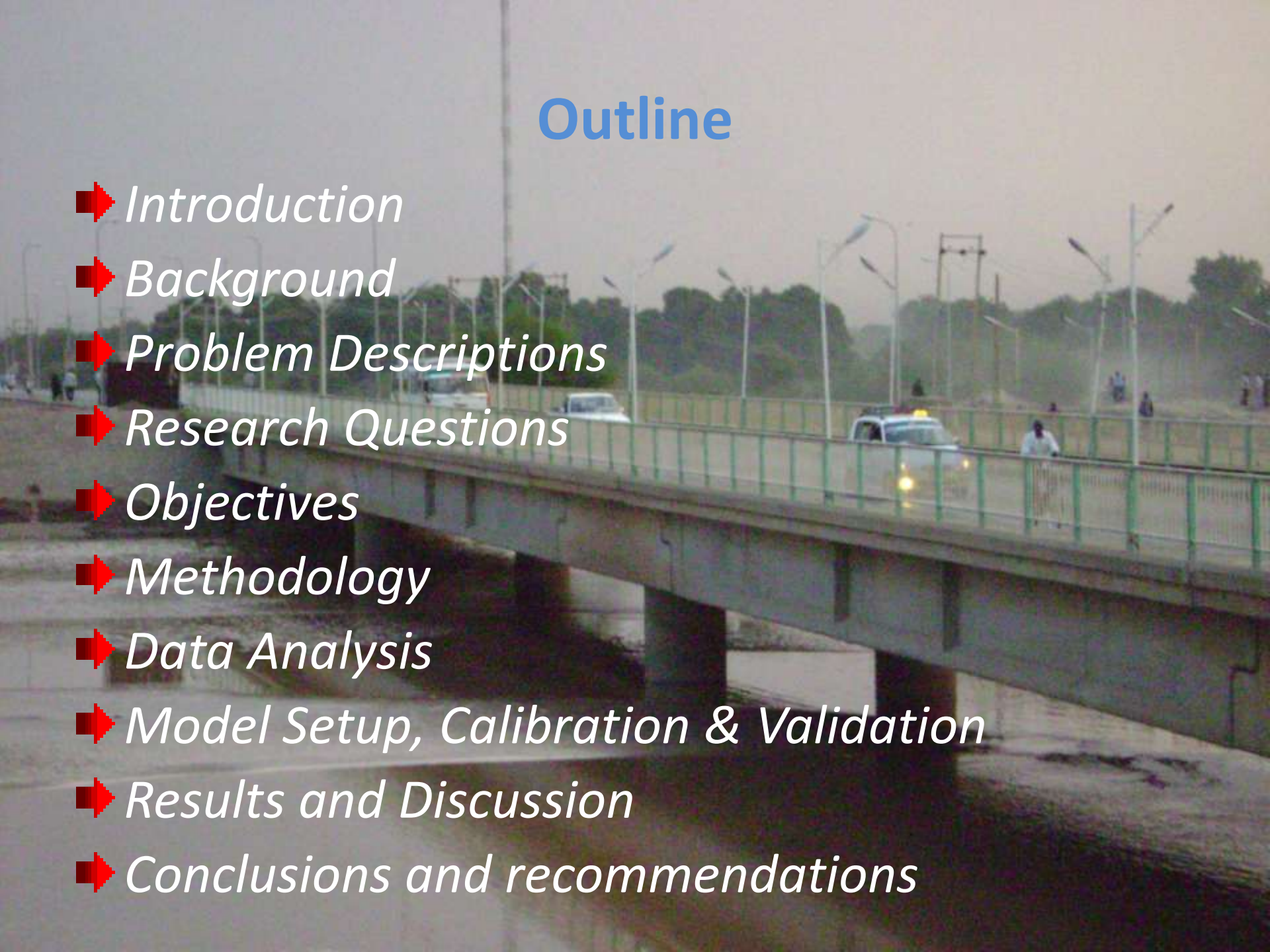


Outline

- *Introduction*
- *Background*
- *Problem Descriptions*
- *Research Questions*
- *Objectives*
- *Methodology*
- *Data Analysis*
- *Model Setup, Calibration & Validation*
- *Results and Discussion*
- *Conclusions and recommendations*

Introduction

- Sedimentation causes several problems:
  - *Change in flow condition and Direction*
  - *Unsatisfactory water distribution*
  - *Block intakes and channels*
  - *Raise irrigable areas – making them out of command*
- These problems are more severe in spate irrigation
  - *0.02% in perennial - 10% in spate floods*
- Control at the intake, flushing, good design and proper O&M could minimize sedimentation

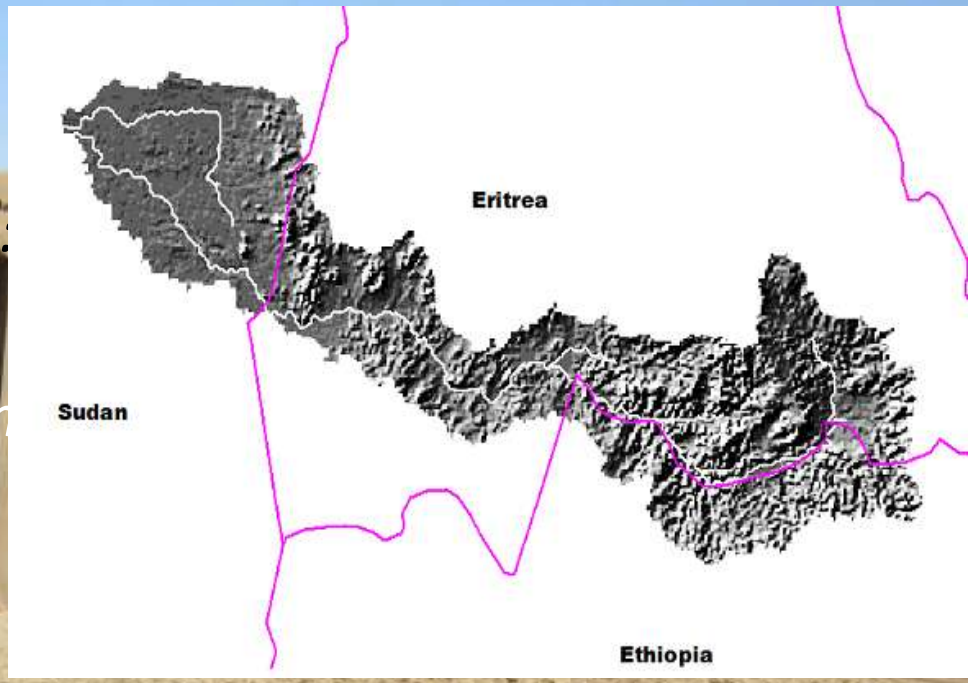
Background

- Sudan
  - *located in the North Eastern part of Africa*
  - *cultivable land: 86 M ha.*
  - *less than 20% utilized*

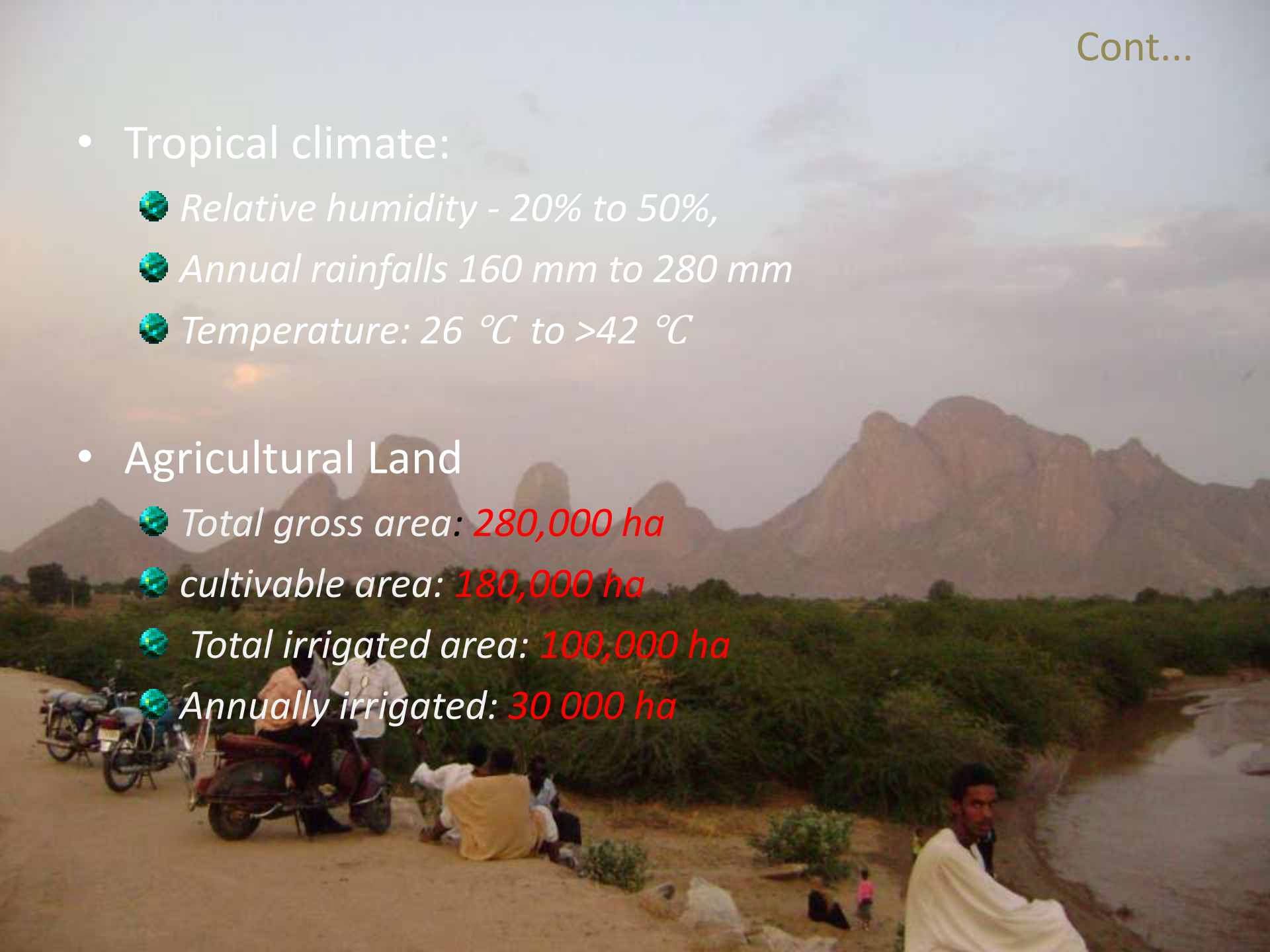
    at present
  - *Agricultural is major route to food security*

➢ The study particularly focused on GAS

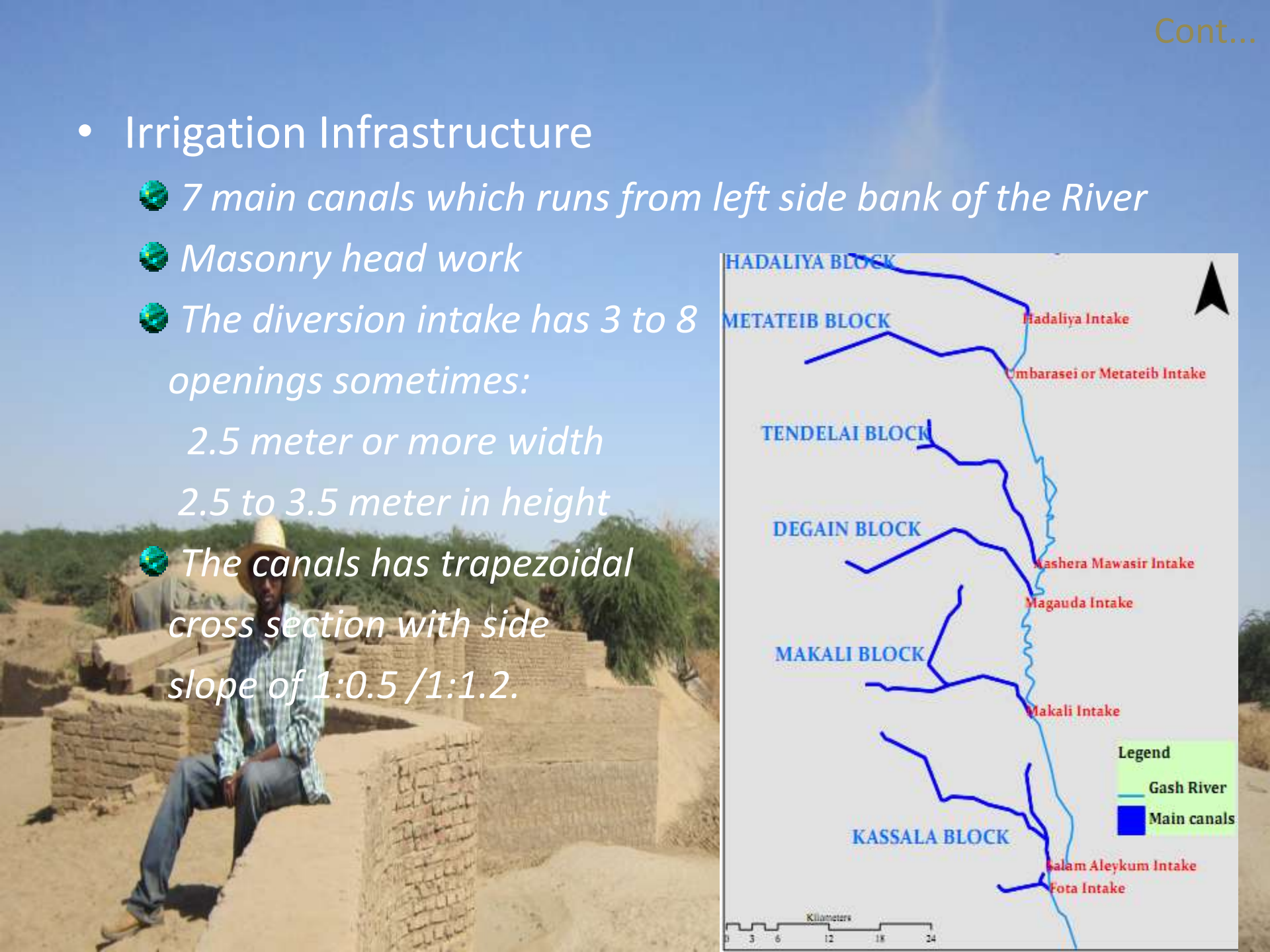
- The Gash agricultural scheme (GAS)
  - *Located in Eastern Sudan*
  - *spate irrigation over a century old*
  - *a major breadbasket for Eastern region of Sudan*
  - *Catchment: 21 000 Km2*
  - *Intermittent flow: 3 months: June to September.*
  - *High sediment concentration above 40,000 ppm*



- Tropical climate:
  - *Relative humidity - 20% to 50%,*
  - *Annual rainfalls 160 mm to 280 mm*
  - *Temperature: 26 ℃ to >42 ℃*
- Agricultural Land
  - *Total gross area: 280,000 ha*
  - *cultivable area: 180,000 ha*
  - *Total irrigated area: 100,000 ha*
  - *Annually irrigated: 30 000 ha*

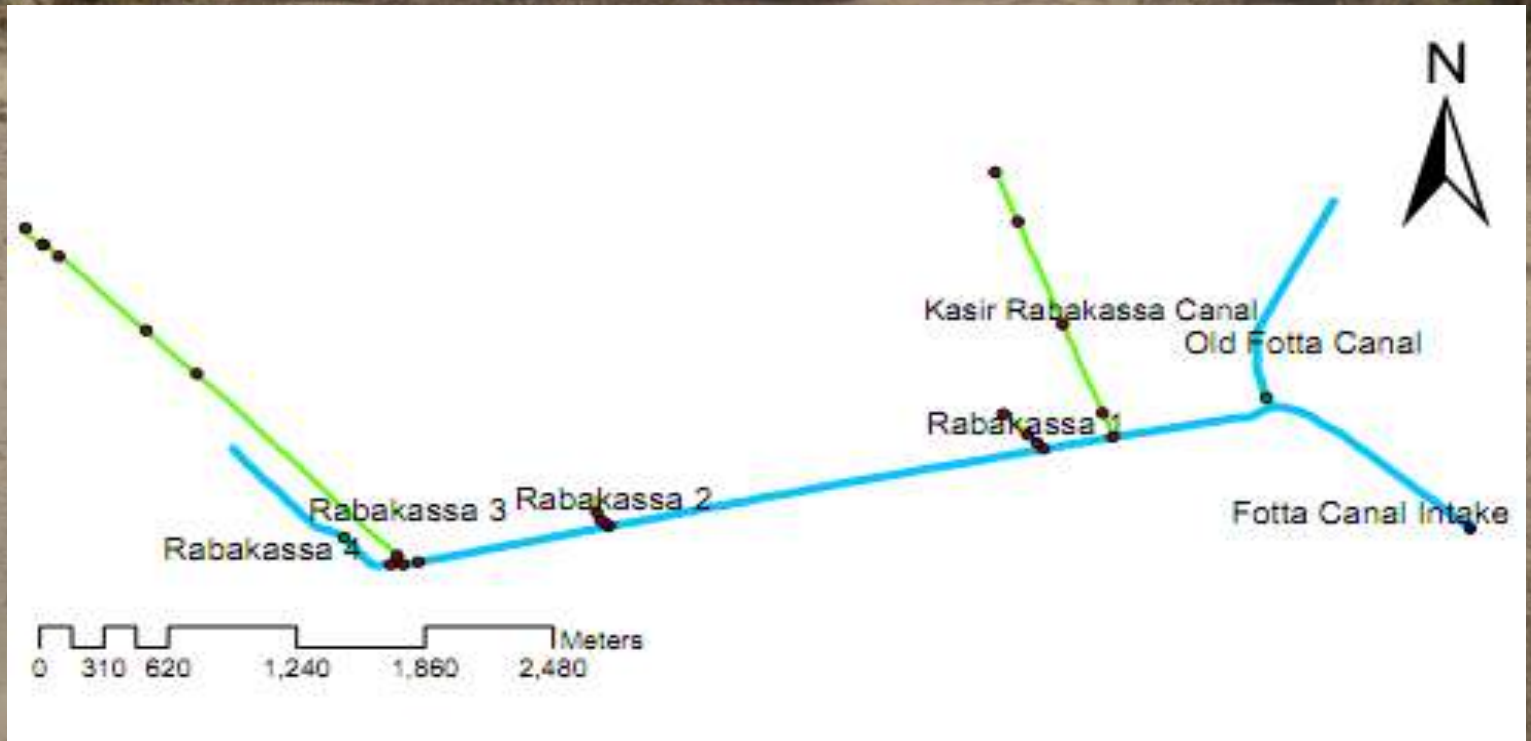


- Irrigation Infrastructure
  - *7 main canals which runs from left side bank of the River*
  - *Masonry head work*
  - *The diversion intake has 3 to 8 openings sometimes:*
    - *2.5 meter or more width*
    - *2.5 to 3.5 meter in height*
  - *The canals has trapezoidal cross section with side slope of 1:0.5 /1:1.2.*



Cont…

- Specific Study area
  - Fotta Diversion Intake
  - Fotta Main Canal



Problem Descriptions

- Sedimentation is a major problem in Gash:
  - *5.5 – 13 million tons of sediment annually deposited in the River course:*
    - *River bed rising and creating flood on Kassala city – 2003 and 2007 devastating floods occurred*
    - *Fotta canal intake completely blocked, >1.8 m sediment deposit*
    - *Fotta canal discharge abstraction reduced by a max 70%*
    - *Irrigable land in Fotta scheme reduce by more than 50%*



Research Questions

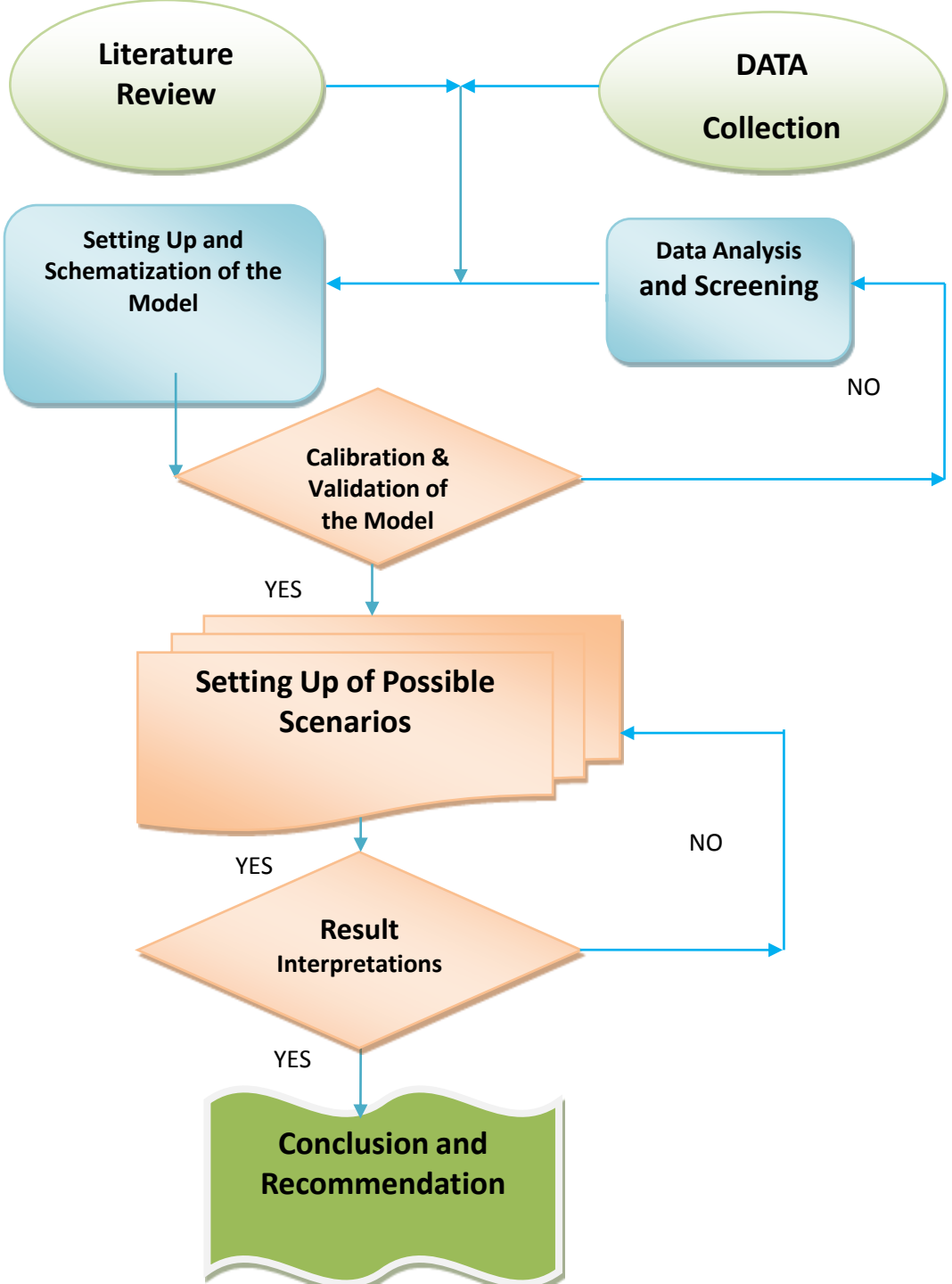
- *How much* sediment is being annually *deposited* at the diversion intake and the main canal network
- How much is the *magnitude of impact* on the main canal conveyance capacity (discharge)?
- How effective is the existing operation and maintenance for sediment control?
- What sediment minimization measures could be recommended?

Objectives

- Overall Objectives

  To quantatively assess the sedimentation problem at the Fotta Diversion Intake and Main Canal and recommend alternative remedial measures.

Methodology

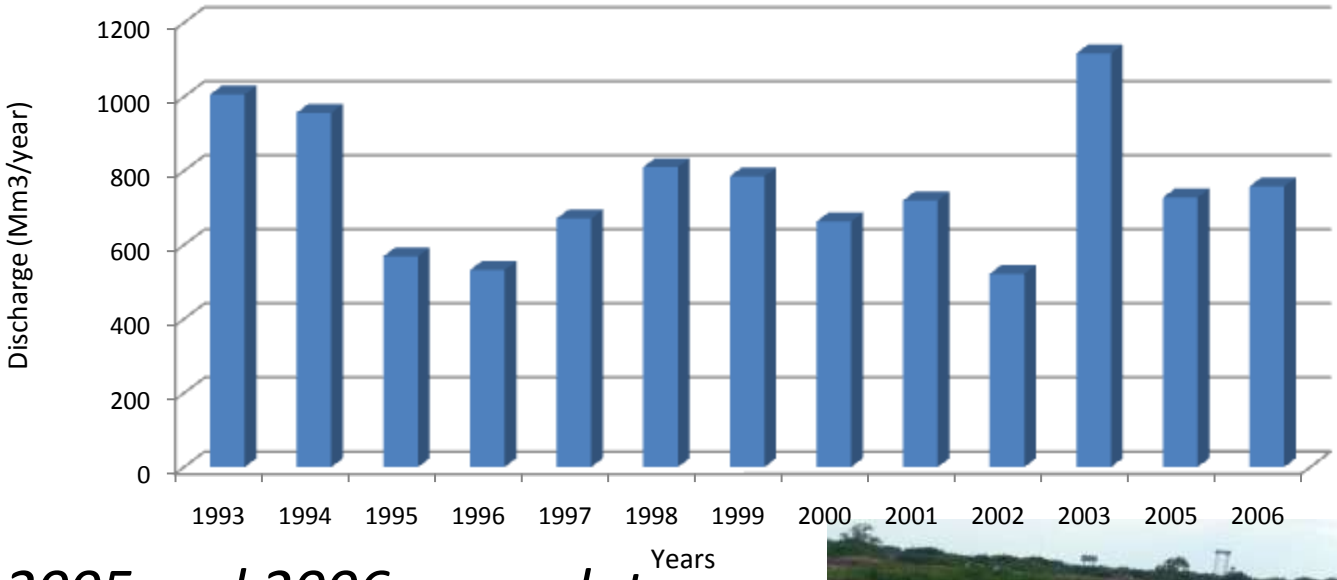


- Model selection
  - *Many models exist: DUFLOW, SETRIC, SOBEK, SIC, SHARC, HECRAS, Delft3D...etc*
  - *Out of this SHARC and Delft3D are selected*

- Selection Criteria
  - *Freely availability and its user friendly*
  - *Availability of data*
  - *Capability to model sediment transport*

Data Analysis

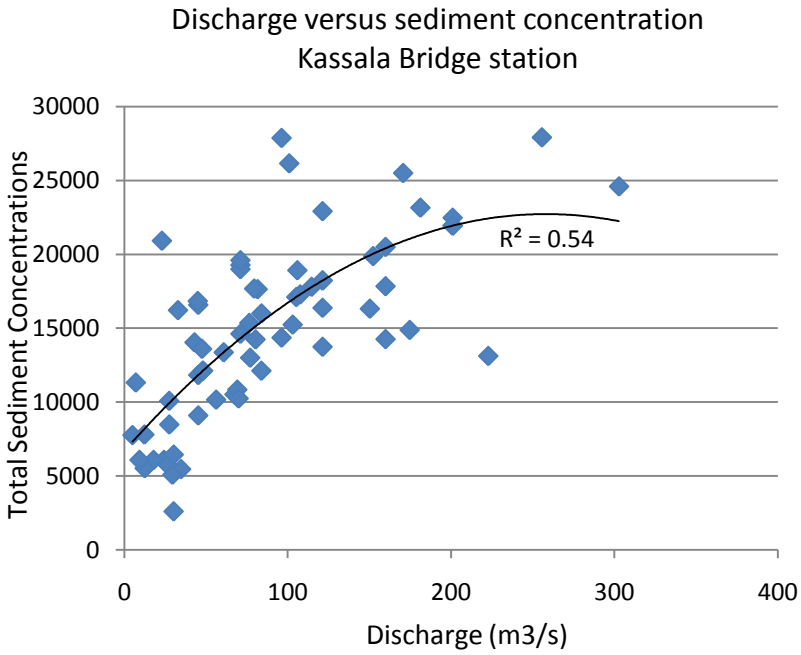
- Hydrologic Data analysis
  - *The historical flow of the River Gash at the Kassala Bridge*

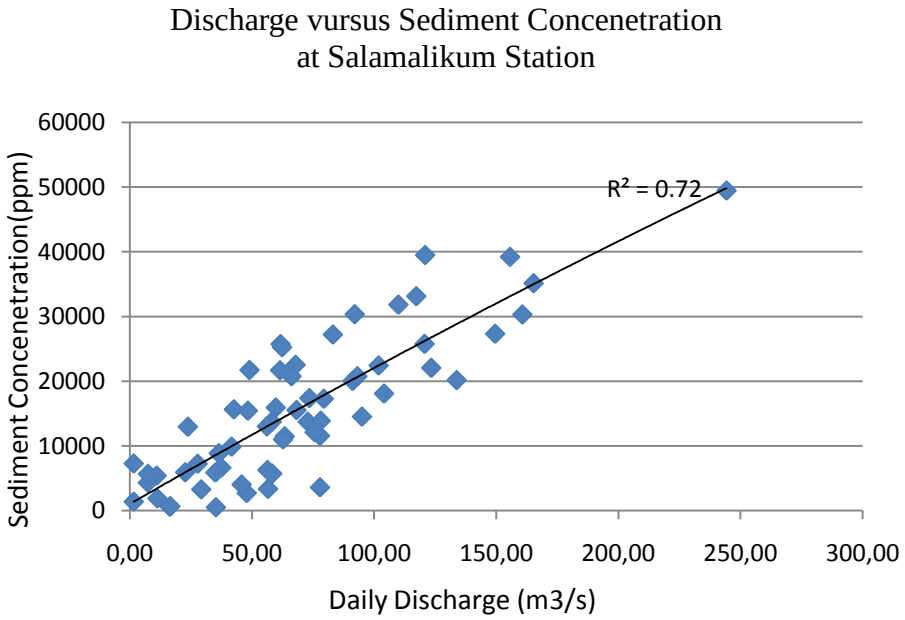


  - *2005 and 2006 years data were selected: For Calibration and validation. (more or less complete data base)*

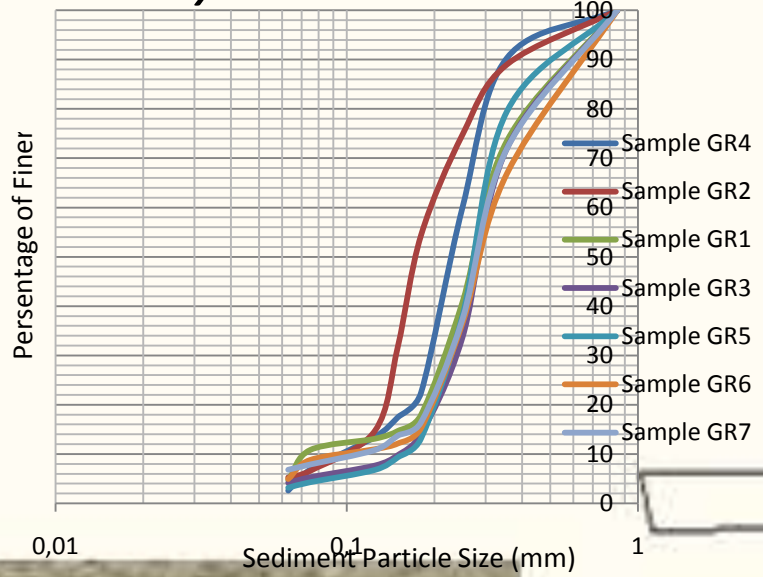
- Sediment Data analysis

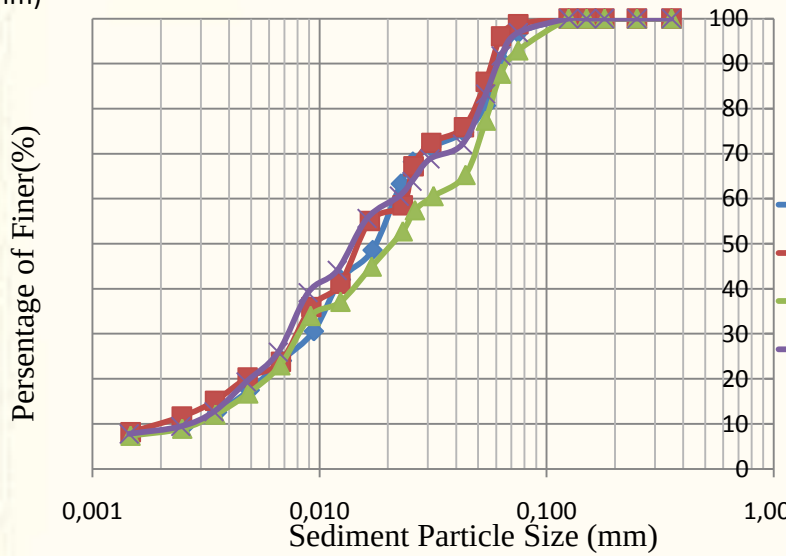
  - *Since the sediment data has missing values, a trained line is used with the available measured data to fill the missing values*



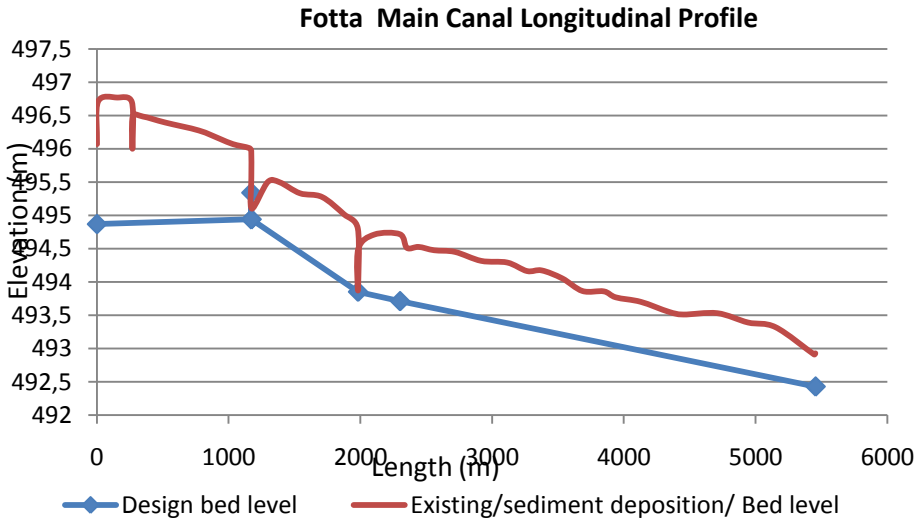


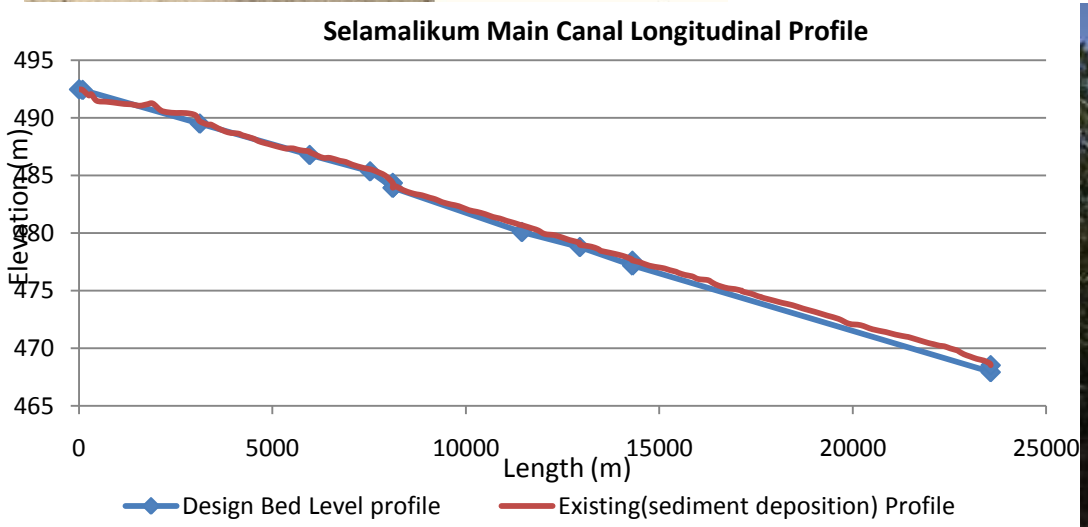
- *Sediment sample is collected from three different site and sieve analysis was done in the HRS Laboratory ;*





- Topography Survey and structure size measurement

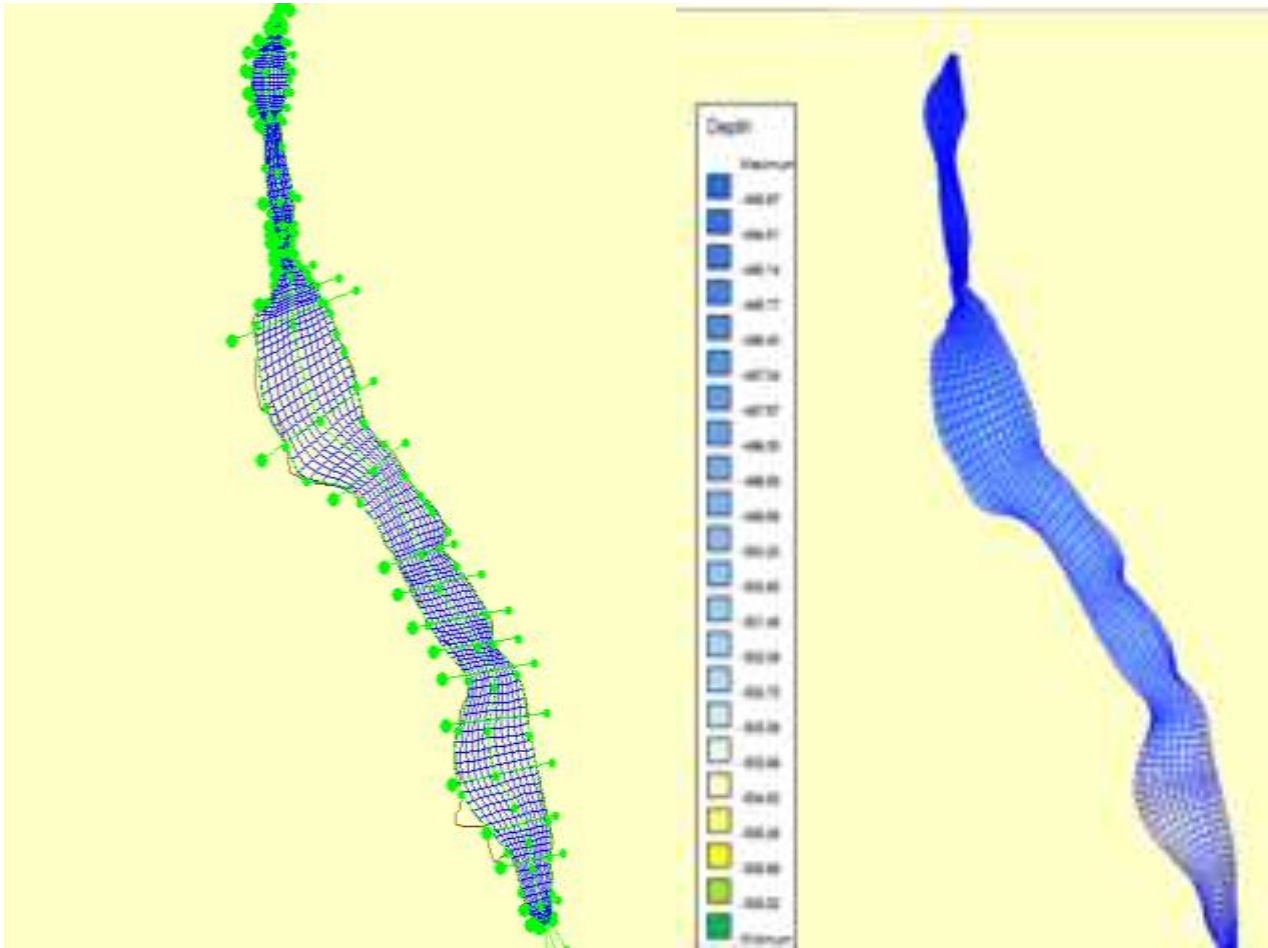




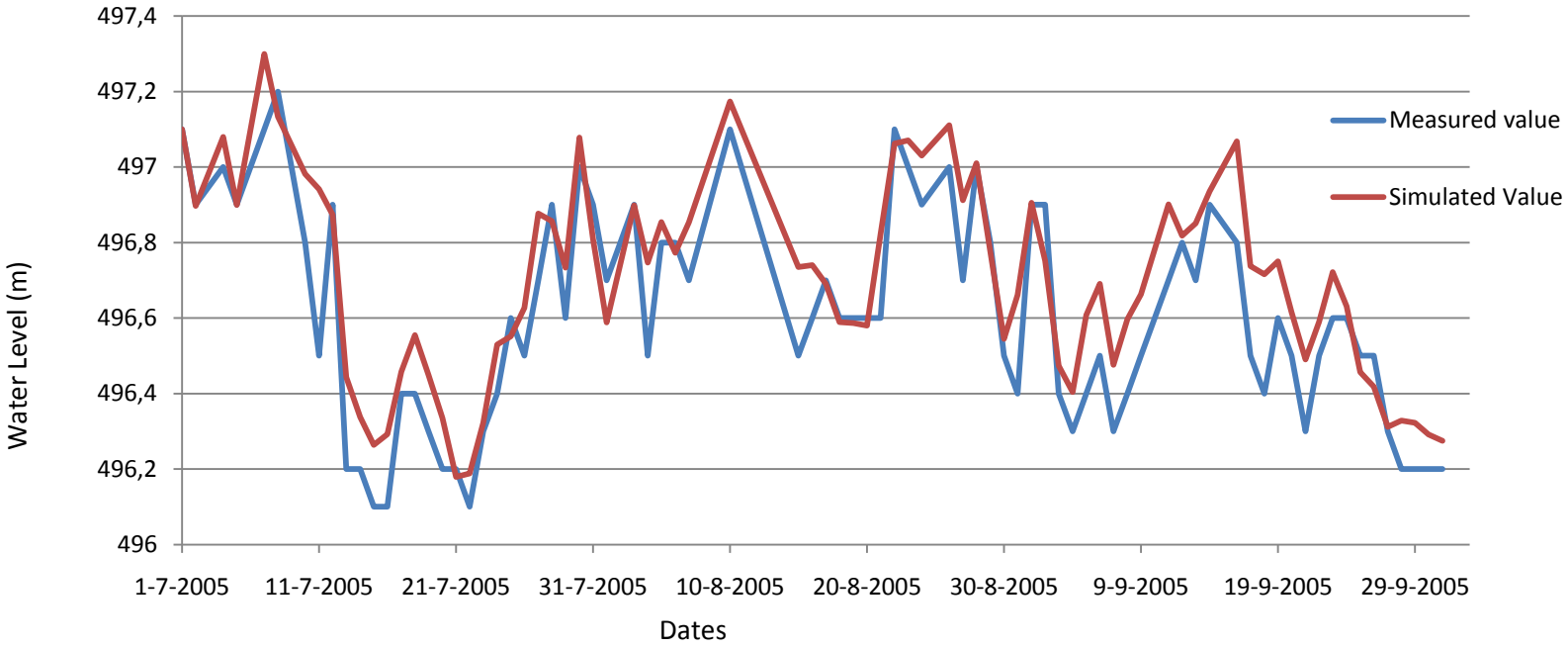
- Operation and Maintenance Program
  - *2 phase rotation*
  - *1 phase has a duration of 25 to 30 days*
  - *Irrigation schedule /irrigated missgas per each phase*
  - *Annually the canal maintained and specially at Fotta there is stand by Excavator to clean sediment*

Model Setup, Calibration & Validation

- Delft3D Model Setup
  - *Area selection , Grid and Bathymetry generation*

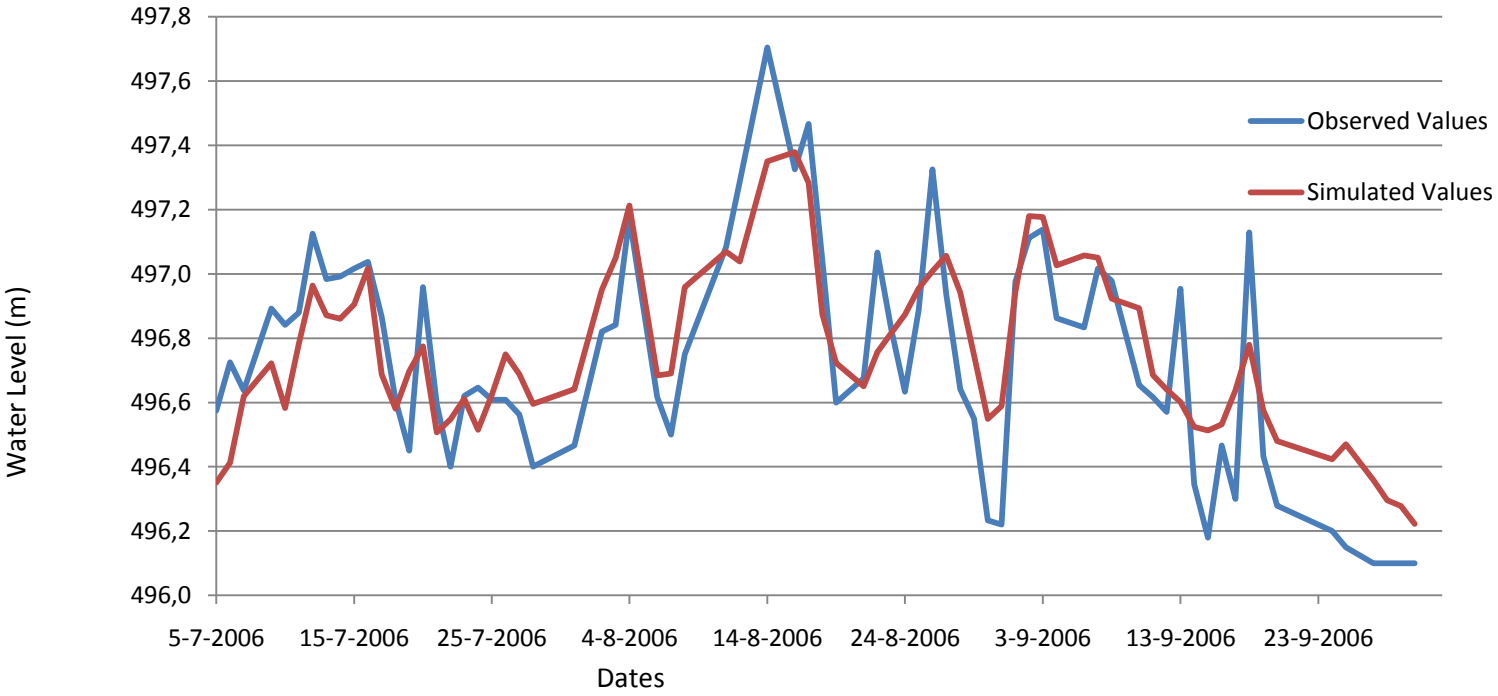


- Delft3D Model Calibration /2005-hydrodynamic /



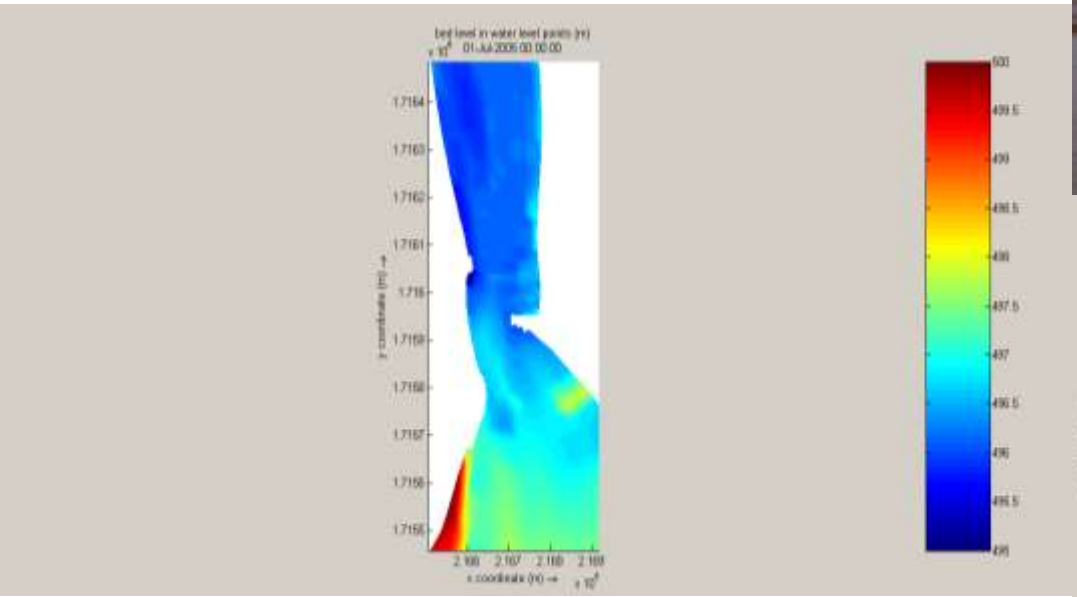
- *R^2 is equal to 73.10% and correlation factor equal to 85.50%*
- *Adjusting some observed and simulation value for some days* then R^2 becomes 85% and correlation factor changes to 92%

- Delft3D Model Validation /2006-hydrodynamic /



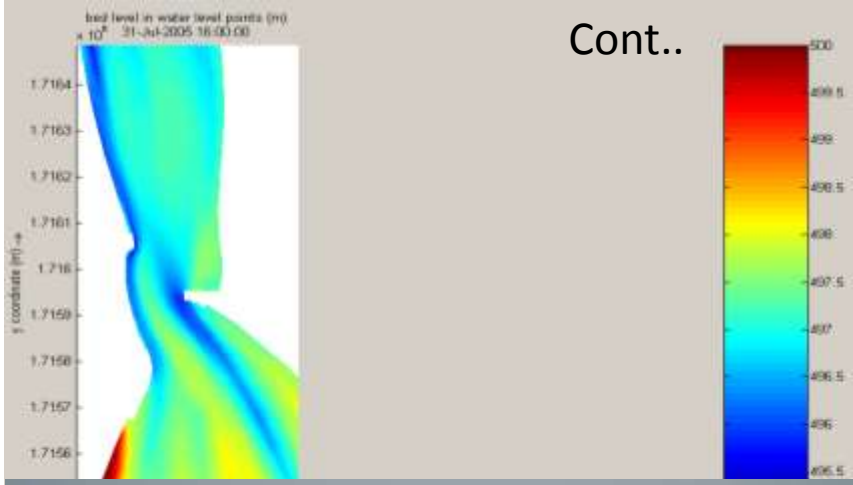
- *Adjusting some observed and simulation value for some days t*hen R^2 becomes 72% and correlation factor = 85%

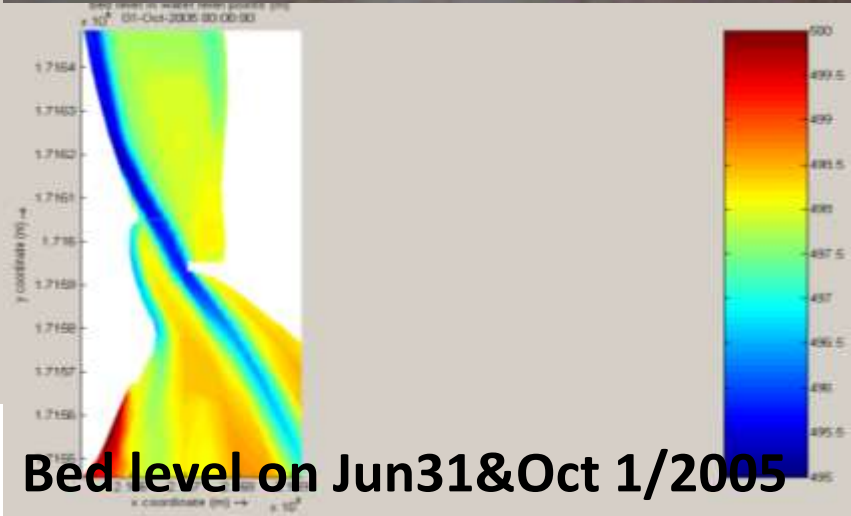
Using Hydrodynamic calibrated and Validated model the morphology of the Gash River at the Fotta intake was analyzed/qualitatively/



Initial bed level

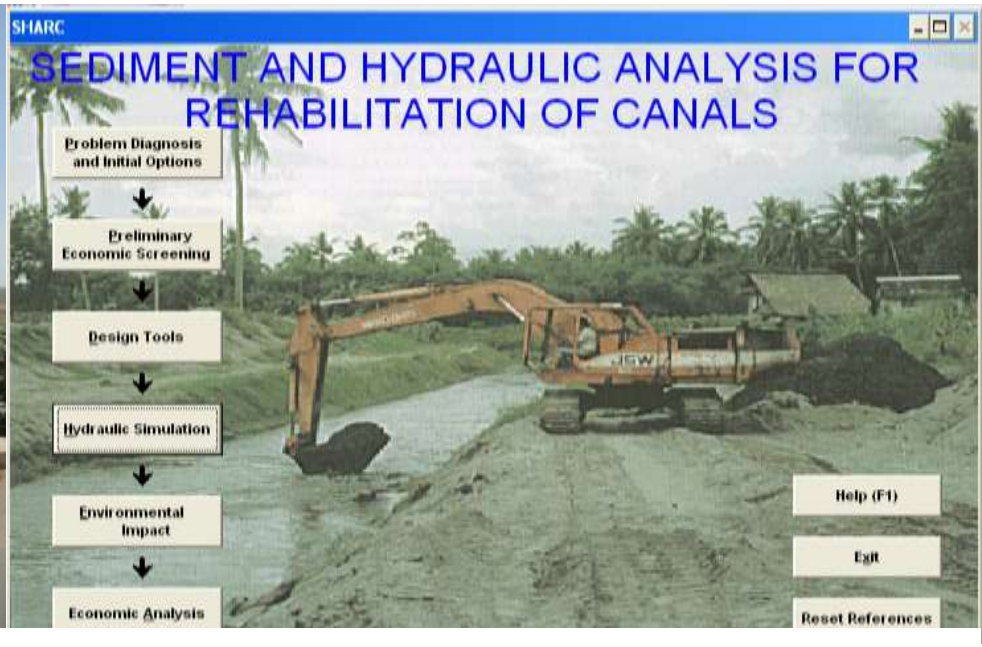
Cont..

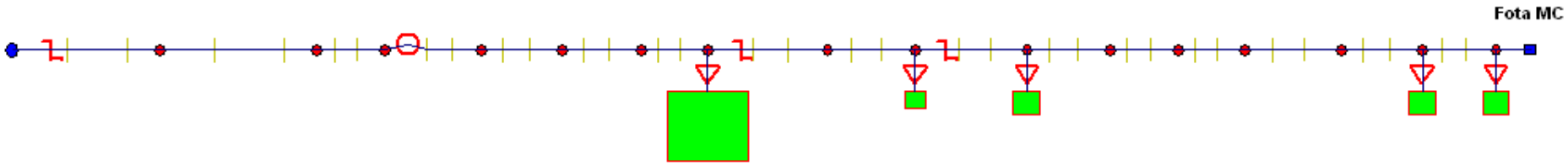




Bed level on Jun31&Oct 1/2005

- SHARC Model Setup
  - *The 6 km Fotta main canal Schematized in SHARC model system*

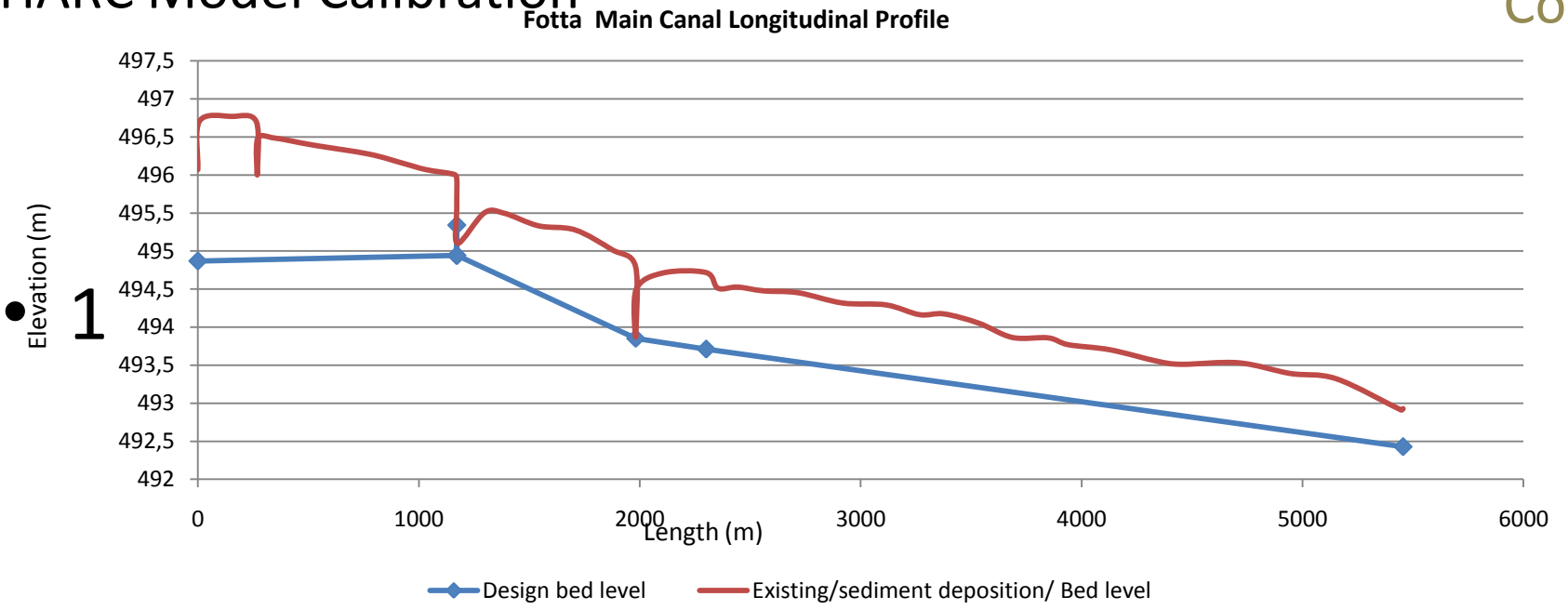


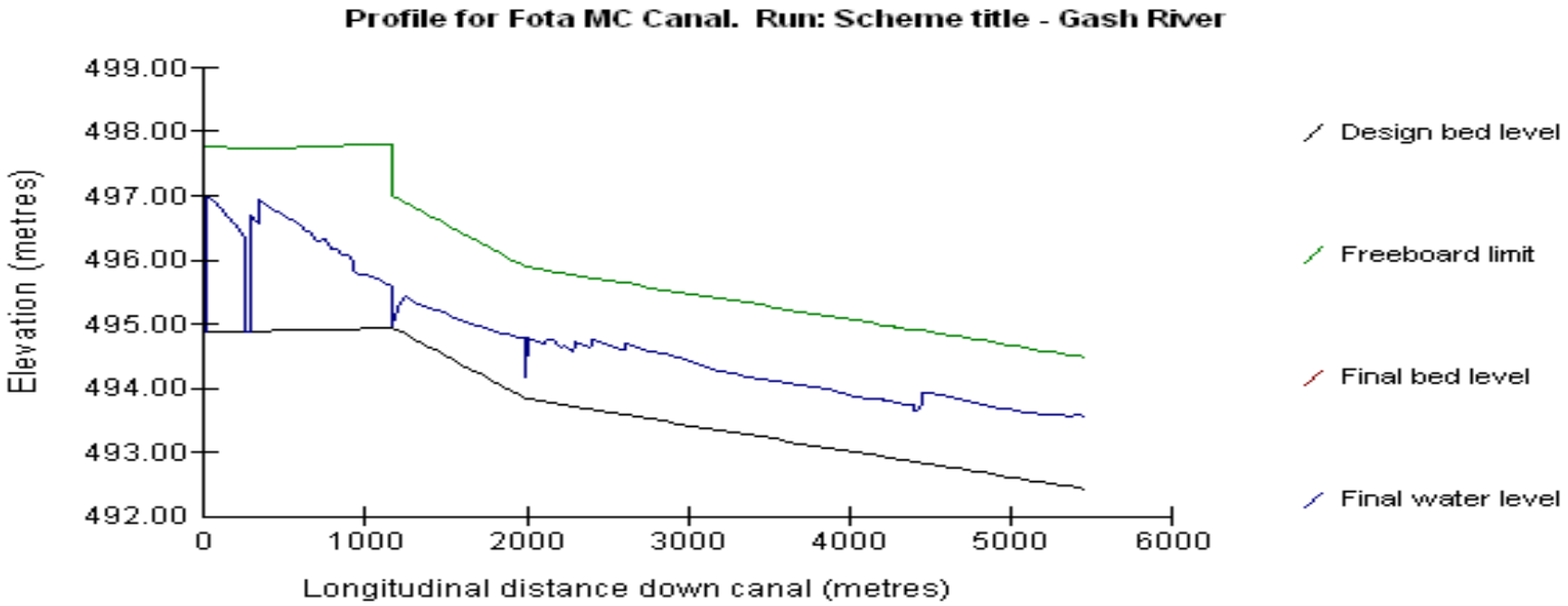


SHARC Model Calibration

Cont...

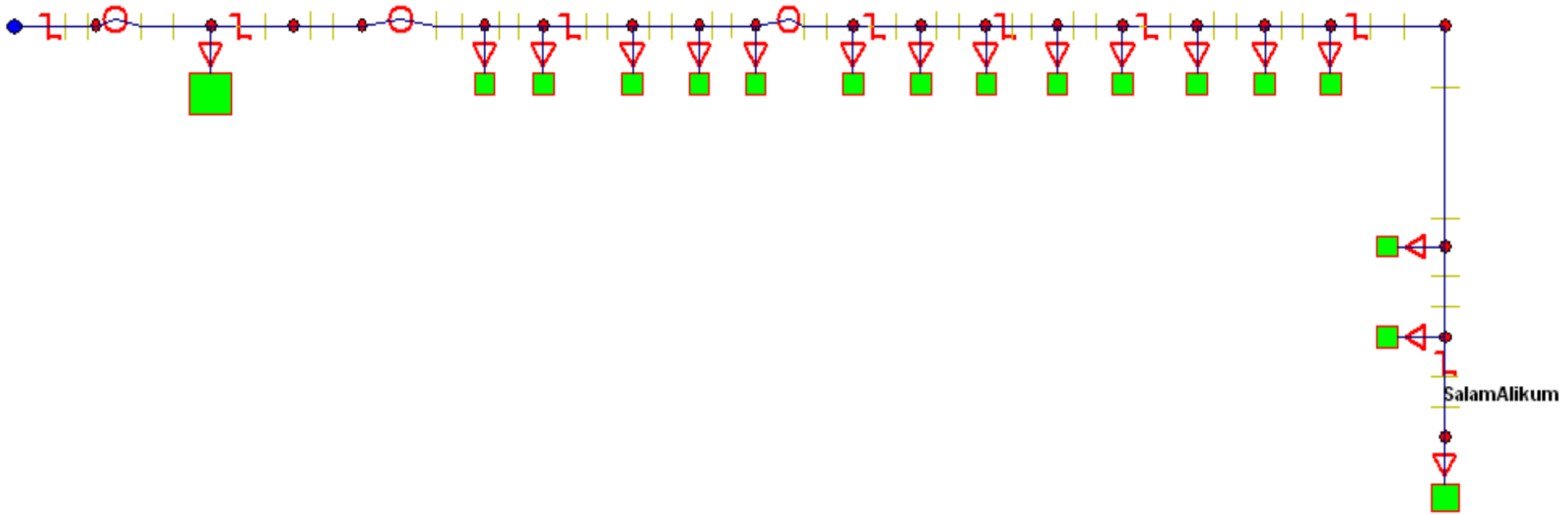
- 1





- Additional Reference for SHARC Model

  - *24km Salamalikum main canal Schematized to used as a reference*



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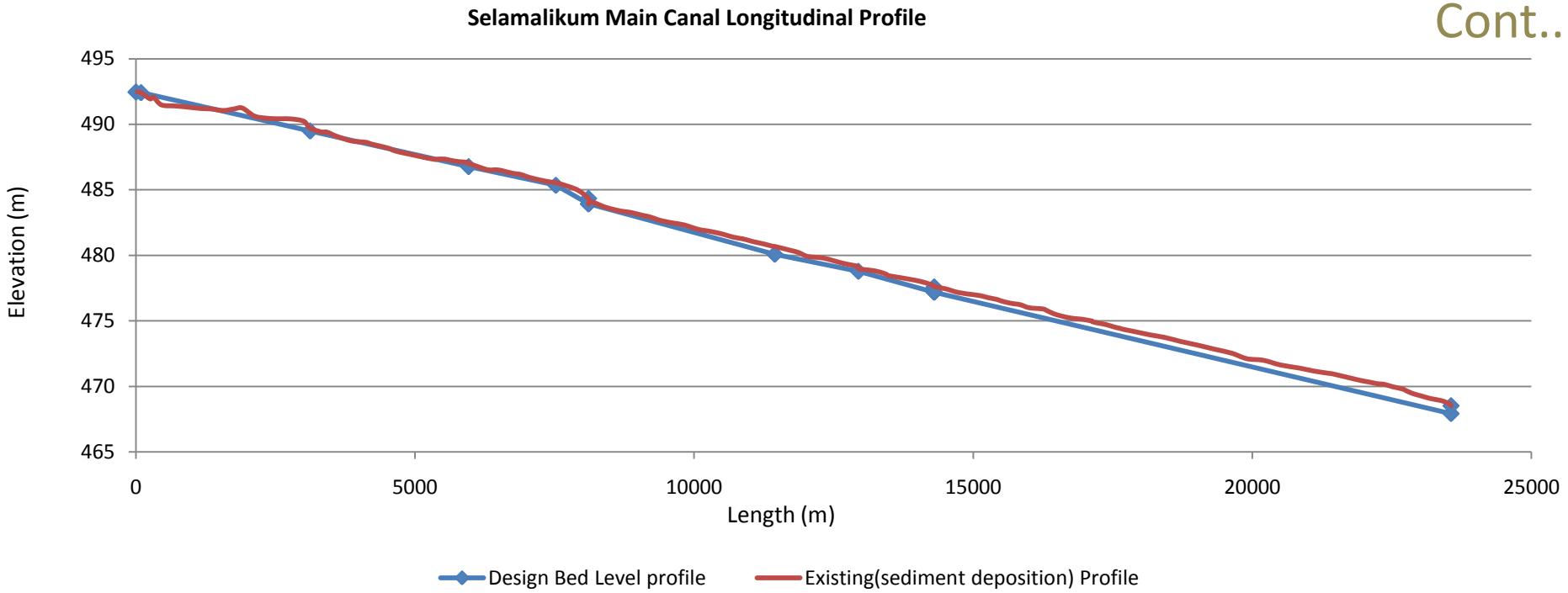
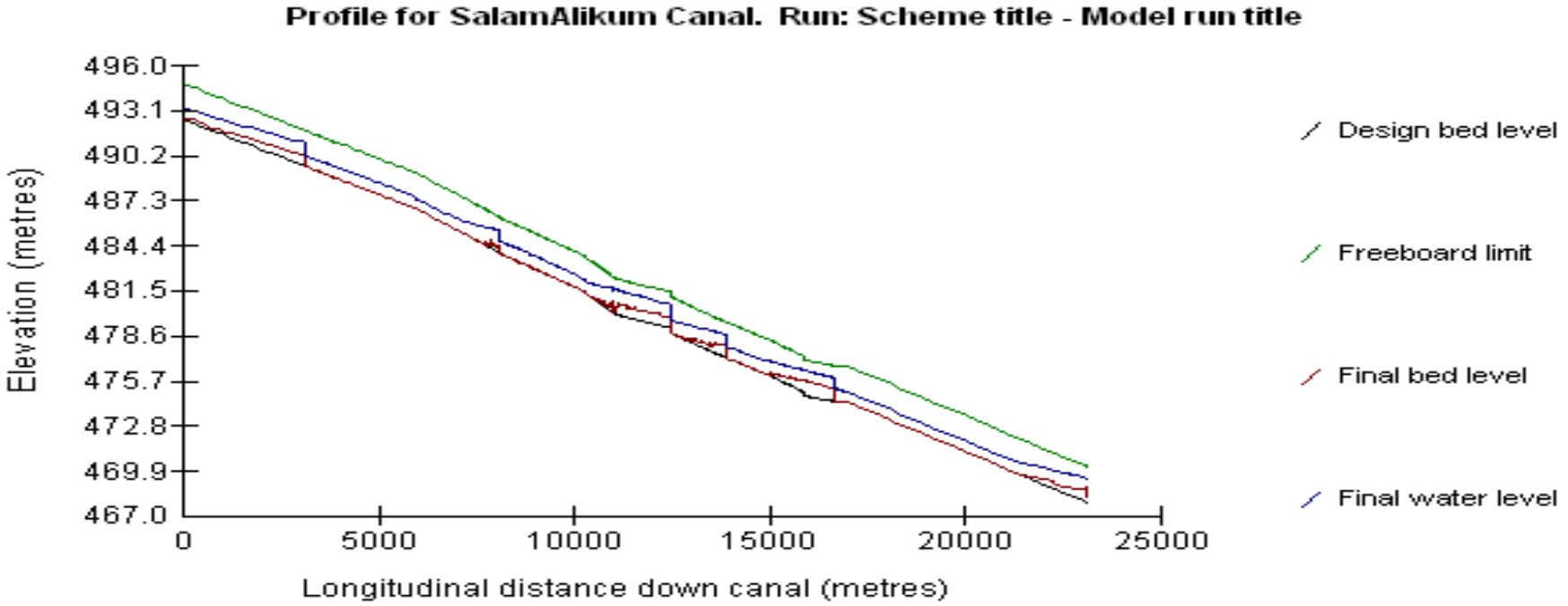
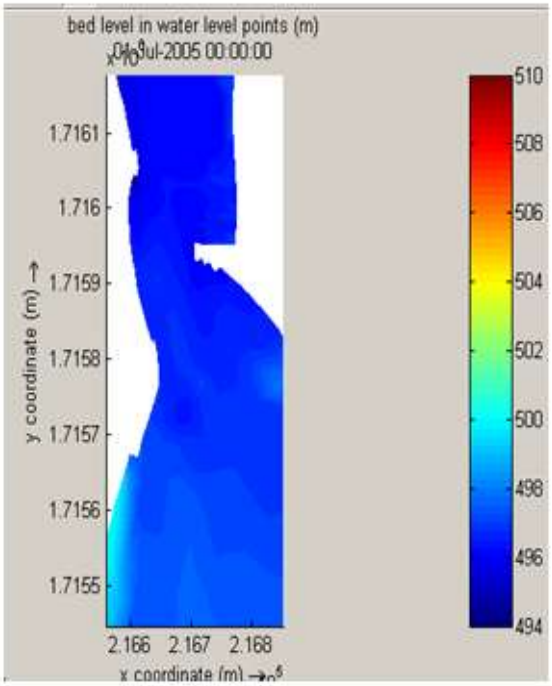

Selamalikum Main Canal Longitudinal Profile
Elevation (m)
495
490
485
480
475
470
465
0
5000
10000
15000
20000
25000
Length (m)
Design Bed Level profile
Existing(sediment deposition) Profile

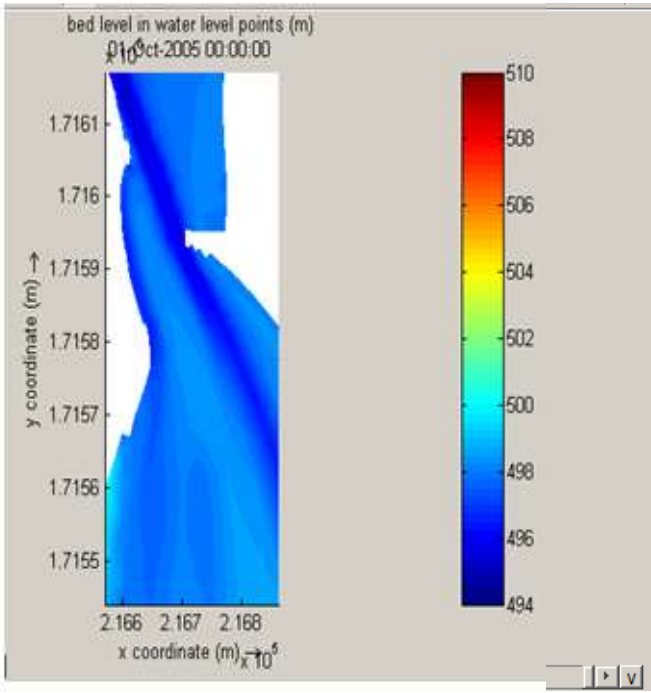

Profile for SalamAlikum Canal. Run: Scheme title - Model run title
Elevation (metres)
496.0
493.1
490.2
487.3
484.4
481.5
478.6
475.7
472.8
469.9
467.0
0
5000
10000
15000
20000
25000
Longitudinal distance down canal (metres)
Design bed level
Freeboard limit
Final bed level
Final water level

Results and Discussion Based on Scenarios

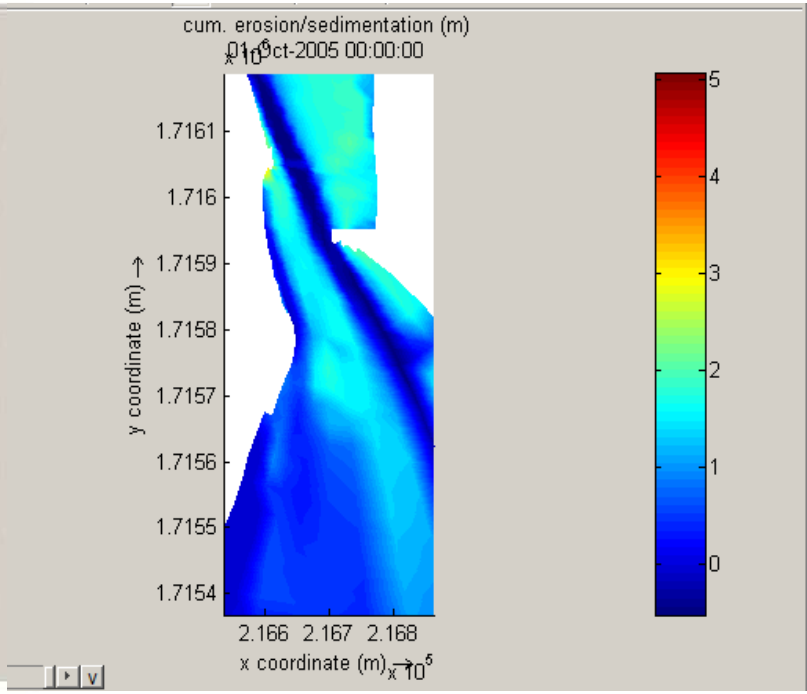
- Using Delft3D
  - *Scenario I, Existing Condition*

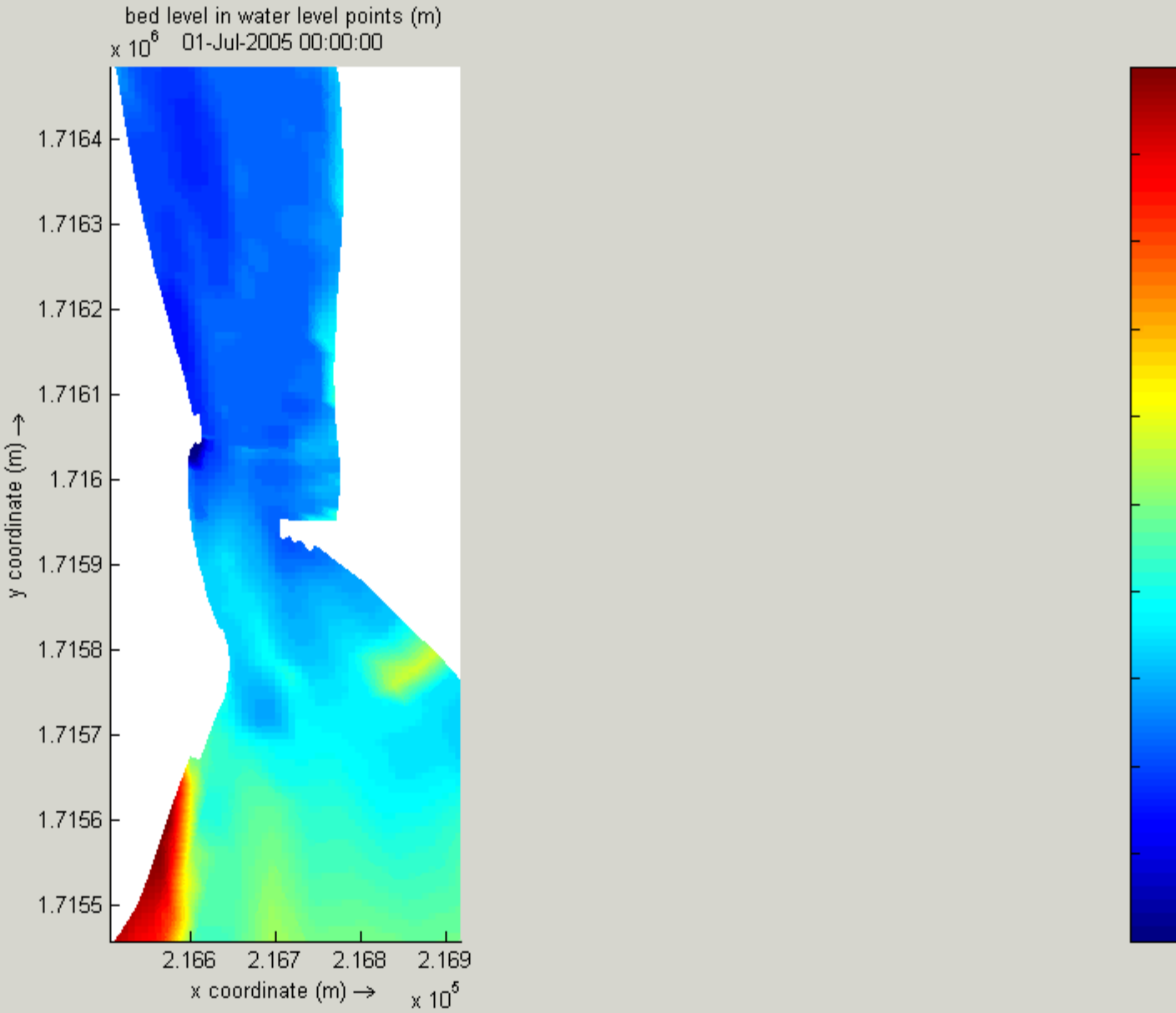


Bed Level initial/1July2005

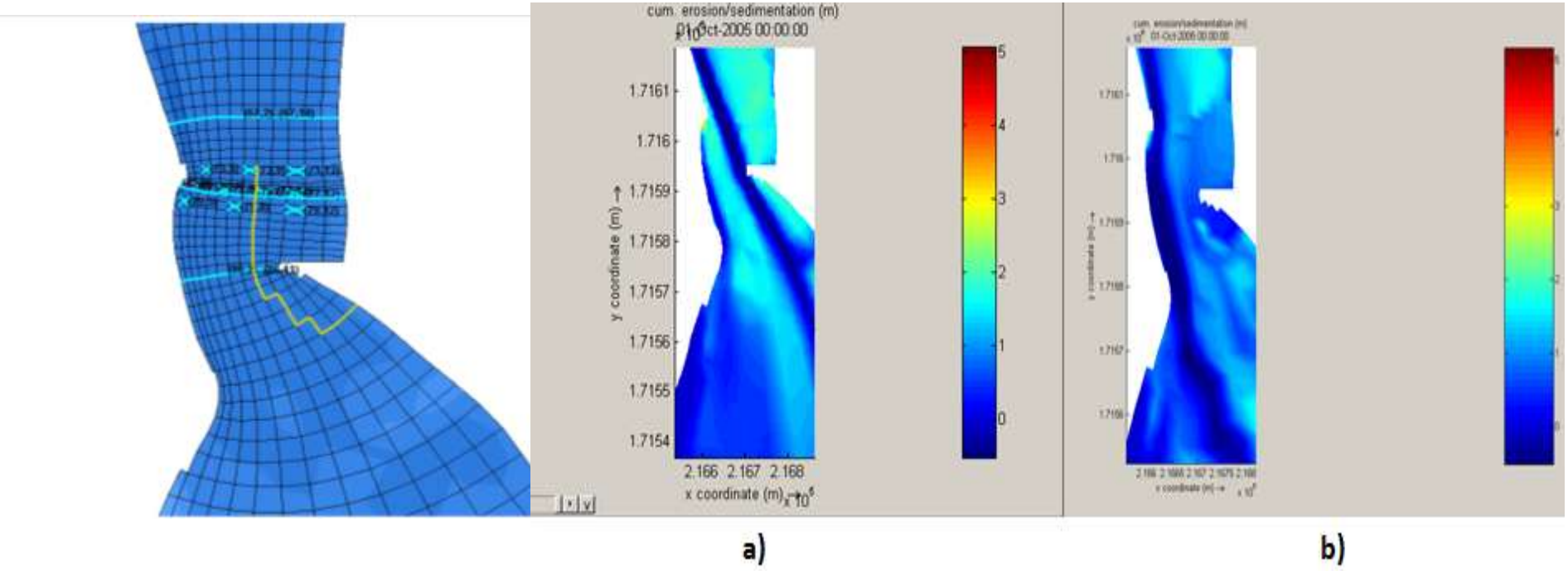


Bed level final/1October2005




bed level in water level points (m)
x 10^6 01-Jul-2005 00:00:00
1.7164
1.7163
1.7162
1.7161
1.716
1.7159
1.7158
1.7157
1.7156
1.7155
y coordinate (m) →
2.166
2.167
2.168
2.169
x coordinate (m) →
x 10^5

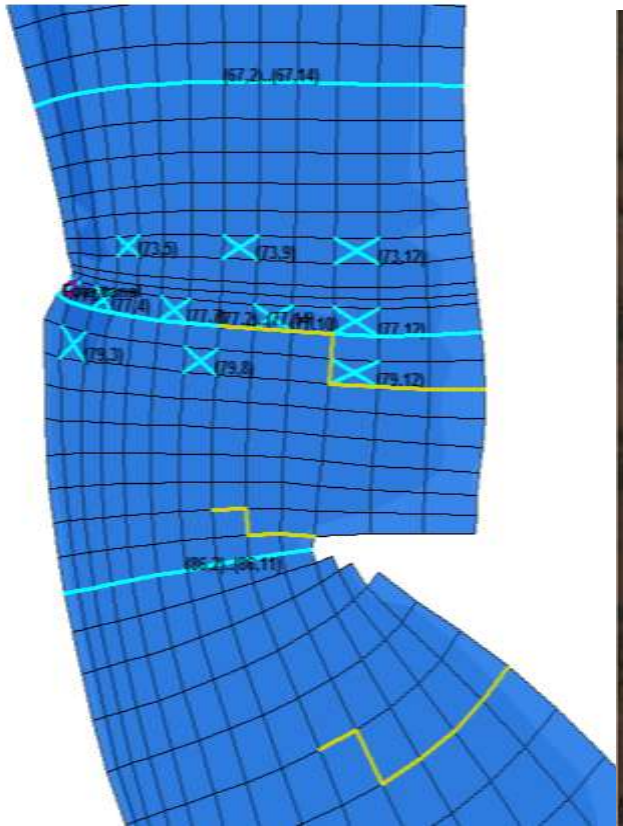
- Using Delft3D
  - *Scenario II,* Constructing one long guiding wall(270m)

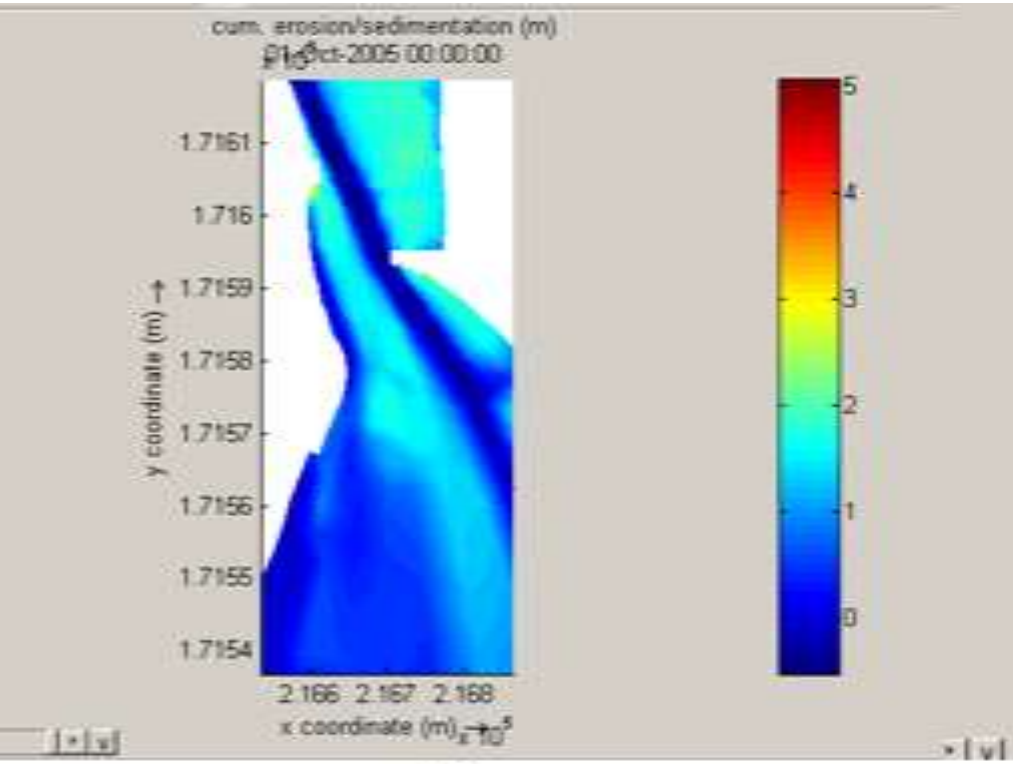


a) Existing condition:
b) guide wall intervention

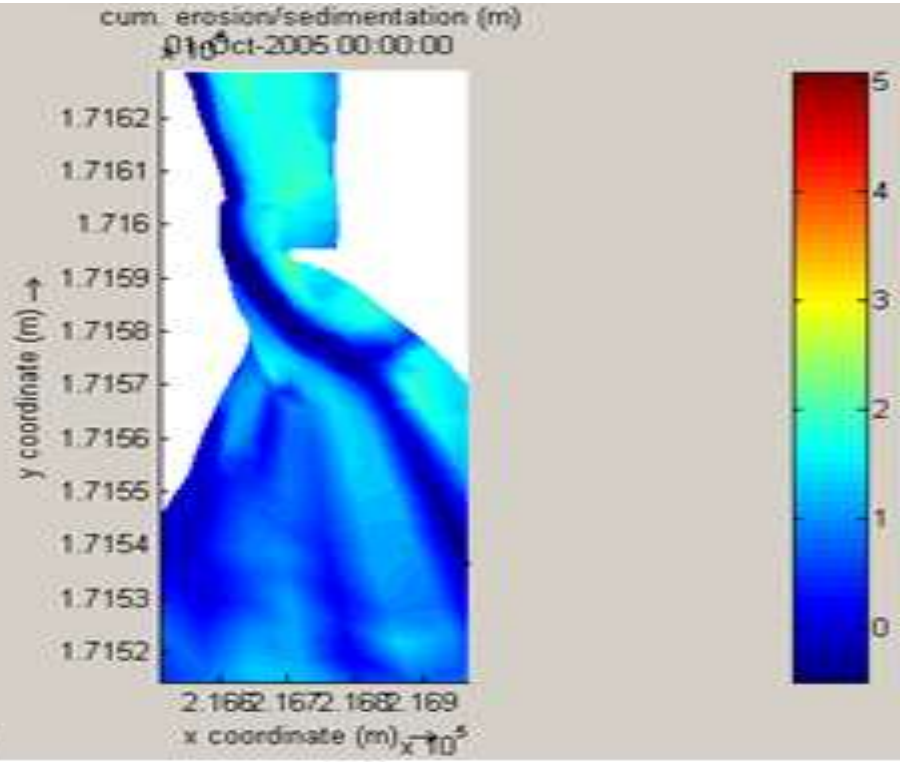
Black – Existing
Red – Senario II

- Using Delft3D
  - *Scenario III,* Modifying the *intake(removing the right side wall of the intake which is extended in to the river side and increasing the sill* height of the intake by 1.2 m) and constructing groyens/spur s(100m, 50m, 120m)



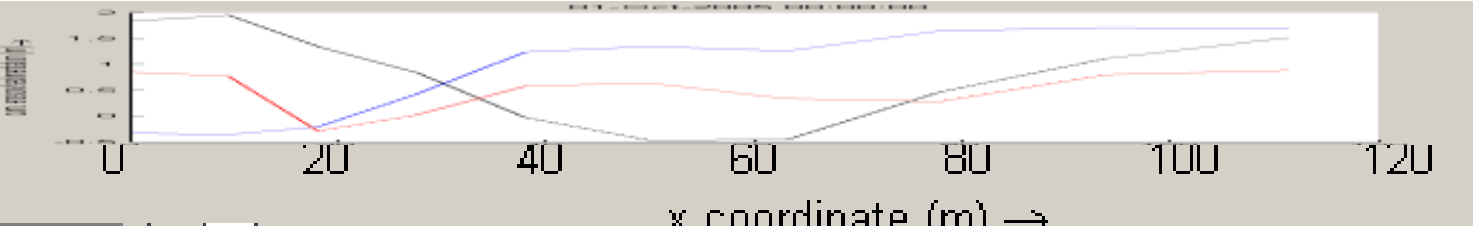


a)



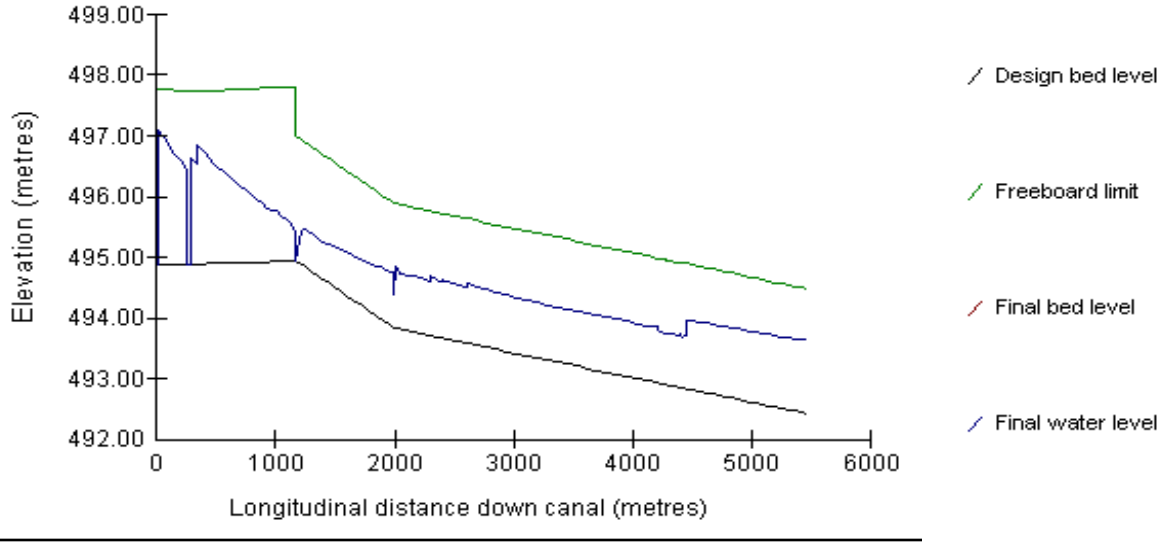
b)

a) Existing condition
b) Scenario III



Black – Scenario I
Red –Scenario II
Blue – Scenario III

- Using SHARC Model system /Fotta Main Canal
  - *Scenario I, Existing Condition*



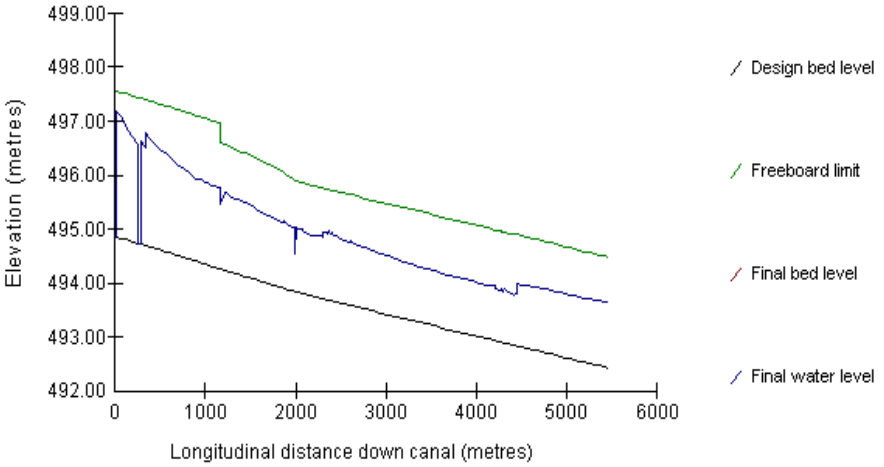
Total water volume

Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	8.21	Mm3
Ratio supplied to requested is	22	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	22	%

The total sediment deposited in the canal *=0.0359 Million* m^3

Scenario II, Improving the slope

the 1st 2 reaches only (0.05%)

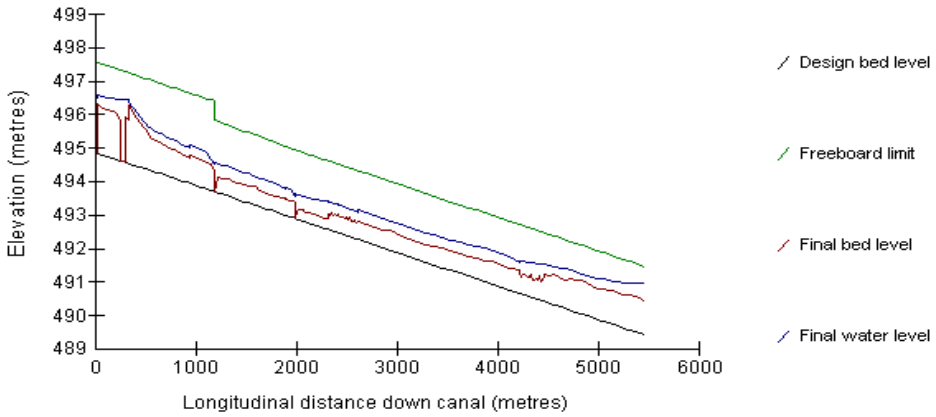


Total water volume		
Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	17.86	Mm3
Ratio supplied to requested is	48	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	48	%

The total sediment deposited in the canal

= 0.047 Million m³

the whole reach (0.1%)



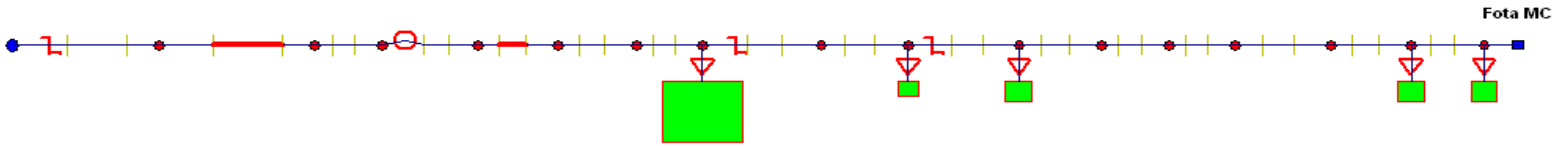
Total water volume		
Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	35.86	Mm3
Ratio supplied to requested is	96	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	96	%

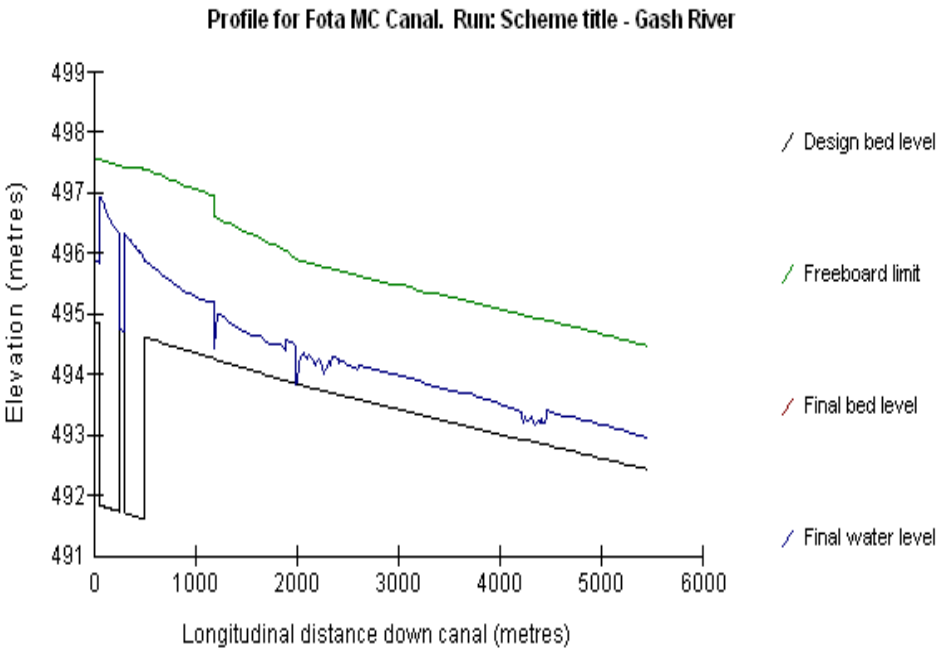
The total sediment deposited in the canal

=0.024 Million m³

Scenario III, Settling Basin Intervention

*Two settling basin with different size (200*30*3m and 200*25*3m)*

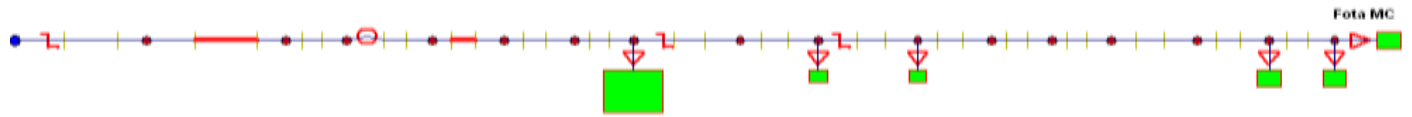


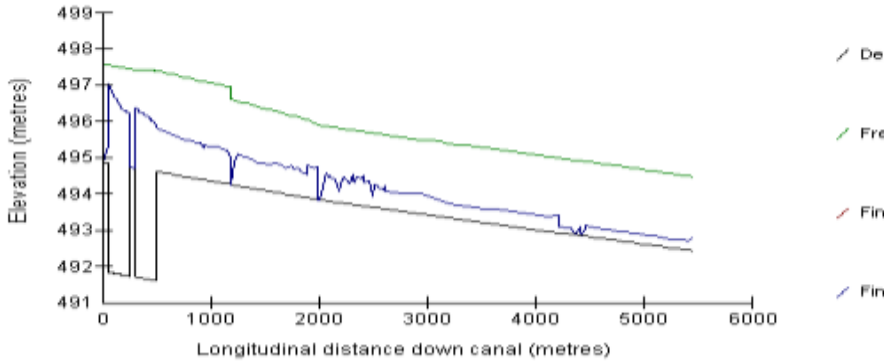


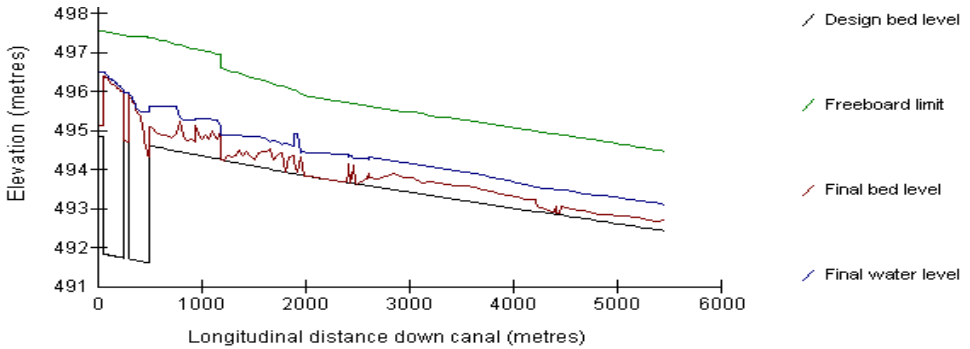
Total water volume		
Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	25.37	Mm3
Ratio supplied to requested is	68	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	68	%

The total sediment deposited in the canal *=0.0185 Million m^3*

- *Scenario IV, Operation & Maintenance Intervention*
  - *Settling basin maintenance (two or three/year)*
  - *¼ of the total missa 5 irrga*







Total water volume		
Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	33.22	Mm3
Ratio supplied to requested is	89	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	89	%

The total sediment deposited in the canal =0. 0.0174 Million m^3

Total water volume		
Volume requested (all turnouts)	37.56	Mm3
Volume usefully supplied is	34.83	Mm3
Ratio supplied to requested is	93	%
Volume lost to seepage	0.00	Mm3
Total seepage rate from input	0.00	m3/s
Ratio supplied to requested at the intake	93	%

The total sediment deposited in the canal = 0.0075 Million m^3

Conclusions and Recommendations

Conclusions

- *There is more than 1.8m depth of sediment deposition at the diversion intake as well as in the canal which reduce the Fotta canal water abstraction by 78%*
- *By the intervention of guiding wall, sediment deposition reduced to 0.8 m depth at intake (scenario II)*
- *By spurs combination with intake modification there is no sediment deposition at the intake (scenario III)*
- *By improving the slope of the canal by 0.1% → up to 96%*
- *Modifying the 1st two reaches slope by 0.05%→ up to 48%*
- *By the intervention of settling basin with proper operation & maintenance it is possible to increase the conveyance capacity by up to 89 - 93%*

Recommendation

- *Scenario III, Removing the right side wall of intake which is extended into the river and bed level of the intake and constructing groyens/spur*(100m, 50m, 120m)
  - *Spurs is common practice in the area*
  - *Provide good sediment deposition reduction*
  - *Availability of construction materials*
- *Scenario IV case 1, Settling Basin intervention with improved O&M (one desilting in b/n irrigation phase & last missga always operating)*
  - *It will be practically impossible increasing the whole slope*
  - *Settling basin desilting more than once with in the irrigation time may be impractical*
- *Two* parallel *settling basin may be important to avoid interruption of irrigation during maintenance*
- *Improving their data base system../ could further improve the reliability of the model results/*

Acknowledgement

I would like to acknowledge,

- My Supervisor (Prof. Bart Schultz, PhD, MSc,)
- My mentors (F.X. Suryadi, PhD, MSc, Abraham M. Haile, PhD, MSc, and Y. Mohamed, PhD, MSc,)
- GRTU, HRS, GAS, IFAD &Ministry of Irrigation and Water Resources

- Special thanks for Mr. Ali Dastgheib, MSc (Lecturer in port development),


THANK YOU !!