Enhanced flushing of sediment deposits in the backwater reach of reservoirs

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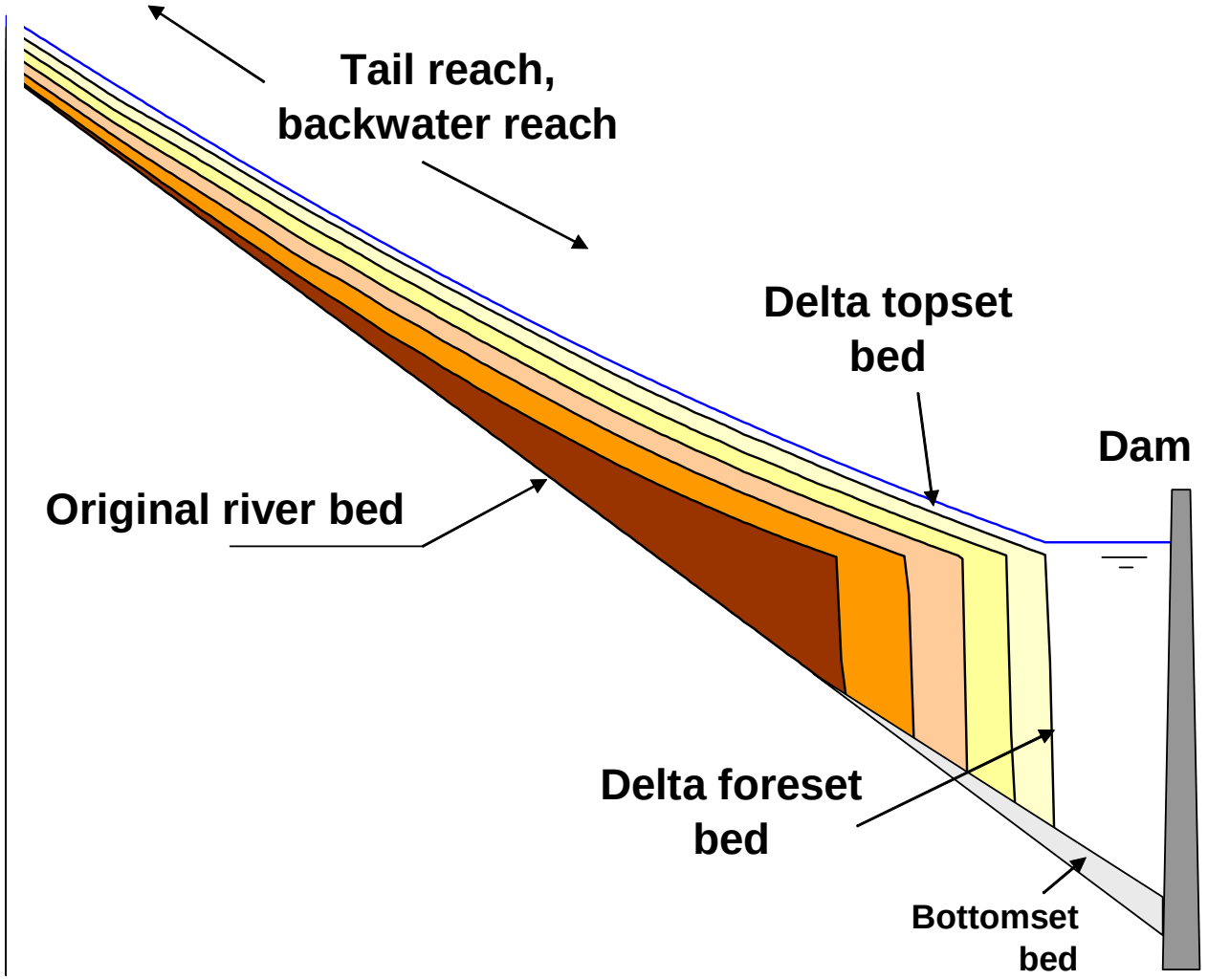
RCEM 2005, ILLINOIS

Enhanced flushing of sediment deposits in the backwater reach of reservoirs

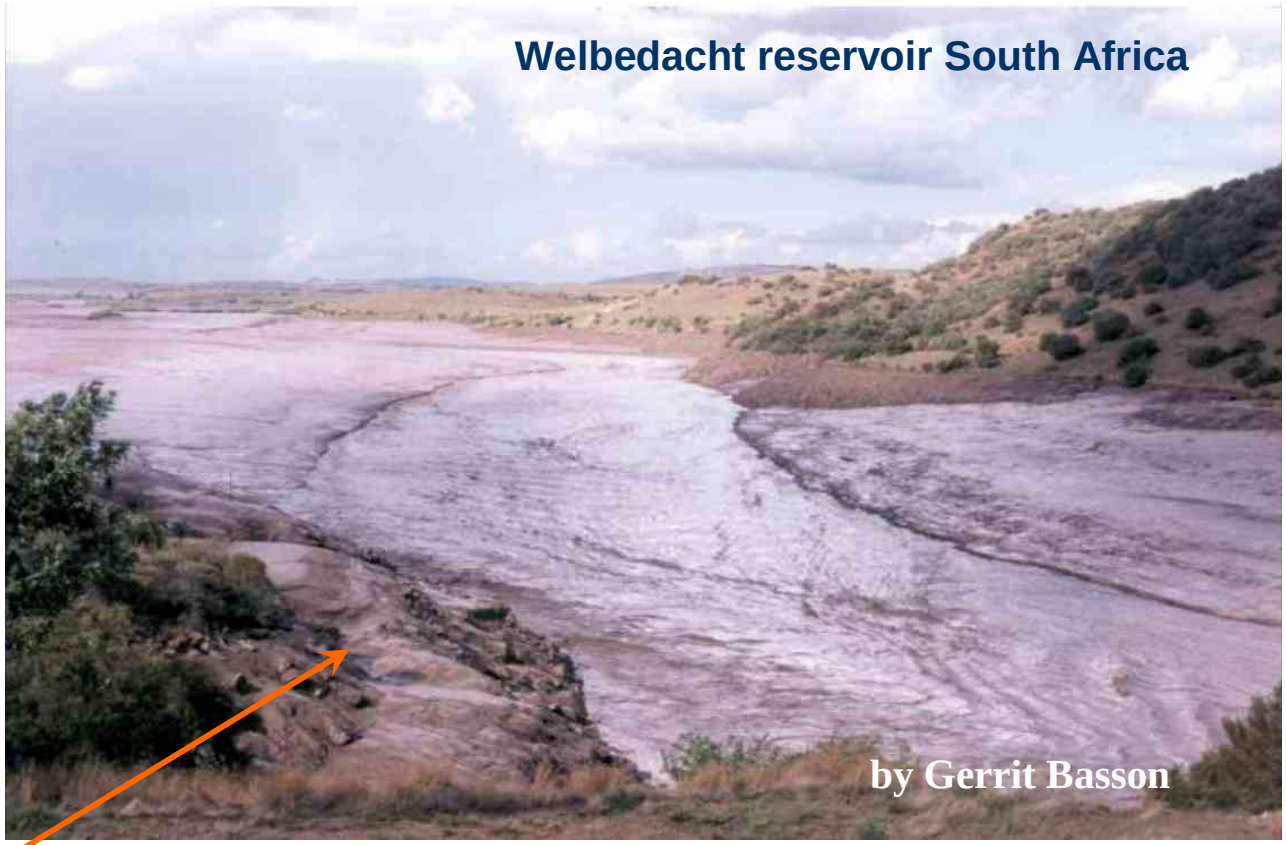
- Reservoir sedimentation and backwater deposits
- Flushing, and enhanced flushing
- Sakuma Reservoir Japan
- Discussion

Processes

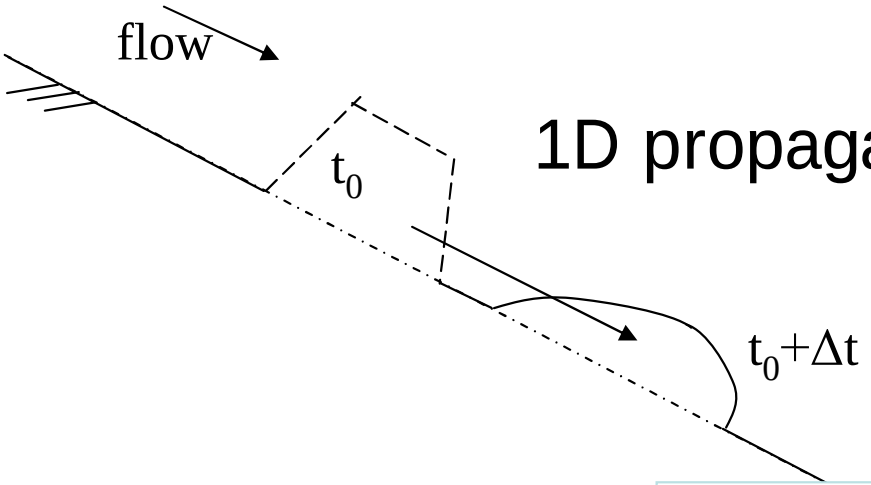

Tail reach,
backwater reach
Delta topset
bed
Dam
Original river bed
Delta foreset
bed
Bottomset
bed

Flushing

- Use floods to erode deposits
- Only a channel is eroded
- Use mechanical support to push the higher deposits into the channel



Downstream propagation



1D propagation

n=power of transport law (n>3)

s_0=transport

$$c_b = \frac{n s_0}{h_0\left(1 - Fr_0^2\right)}$$

h_0=depth

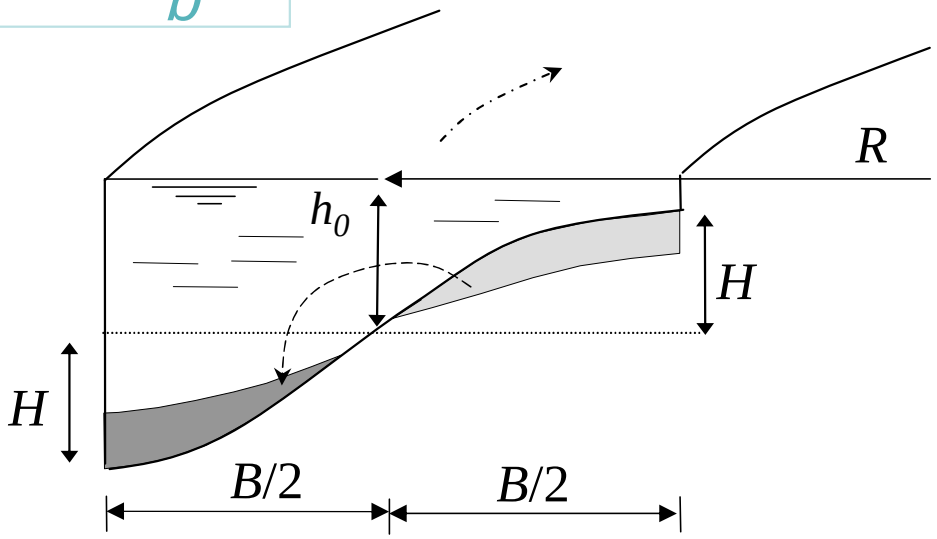
Fr_0=Froude number < 1

$$c_r << c_b$$

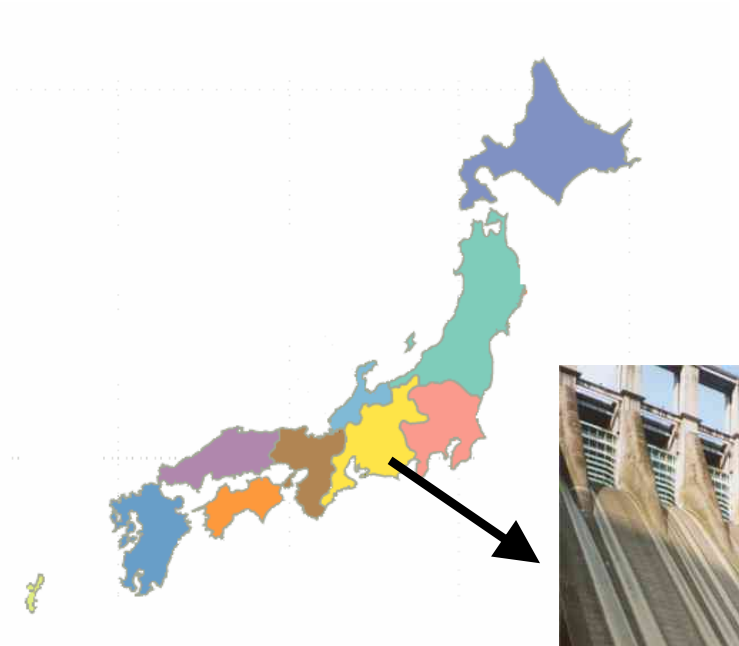
2D propagation

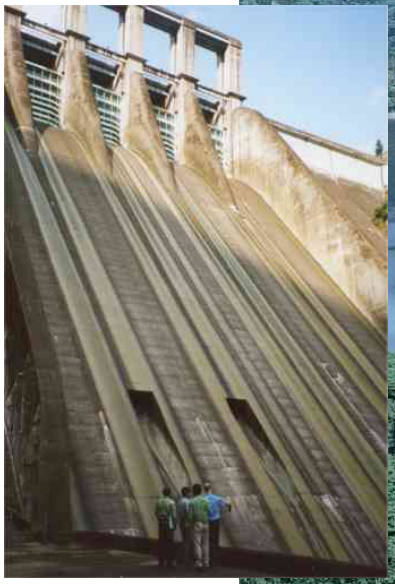
$$c_r = \frac{s_0}{h_o}\frac{k'^2 - \left(\frac{n-3}{2}\right)}{k'^2 + 1}$$

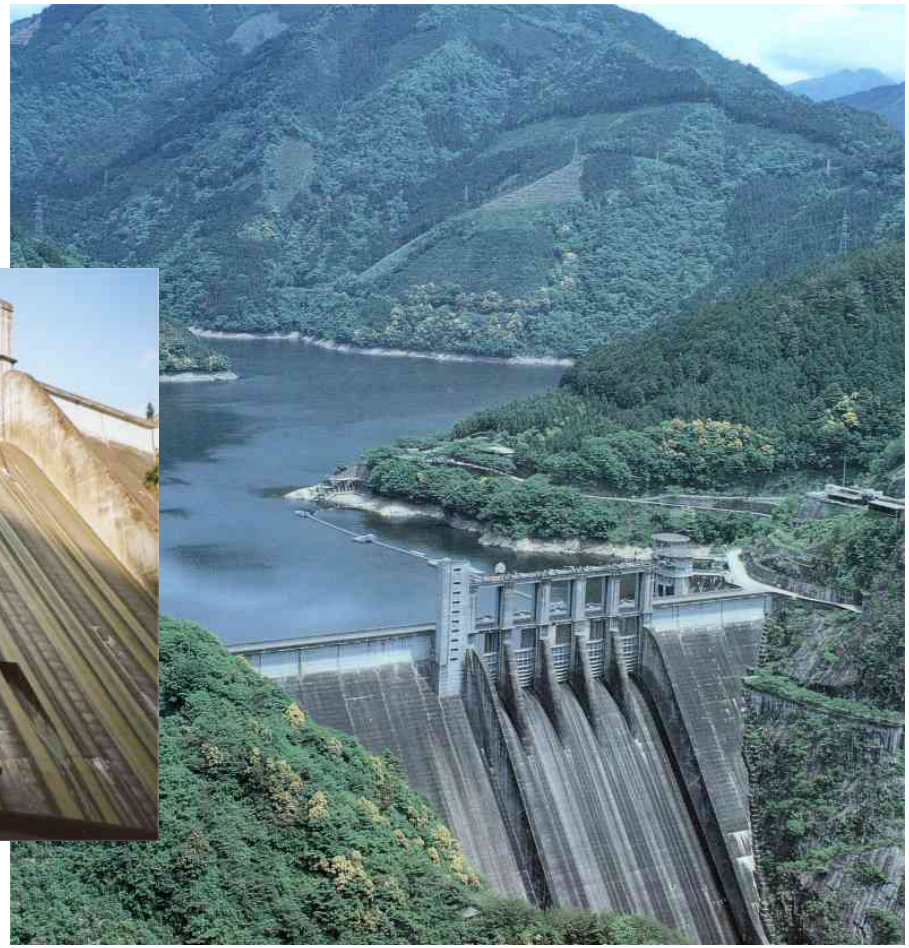
k =wave number of bed disturbance



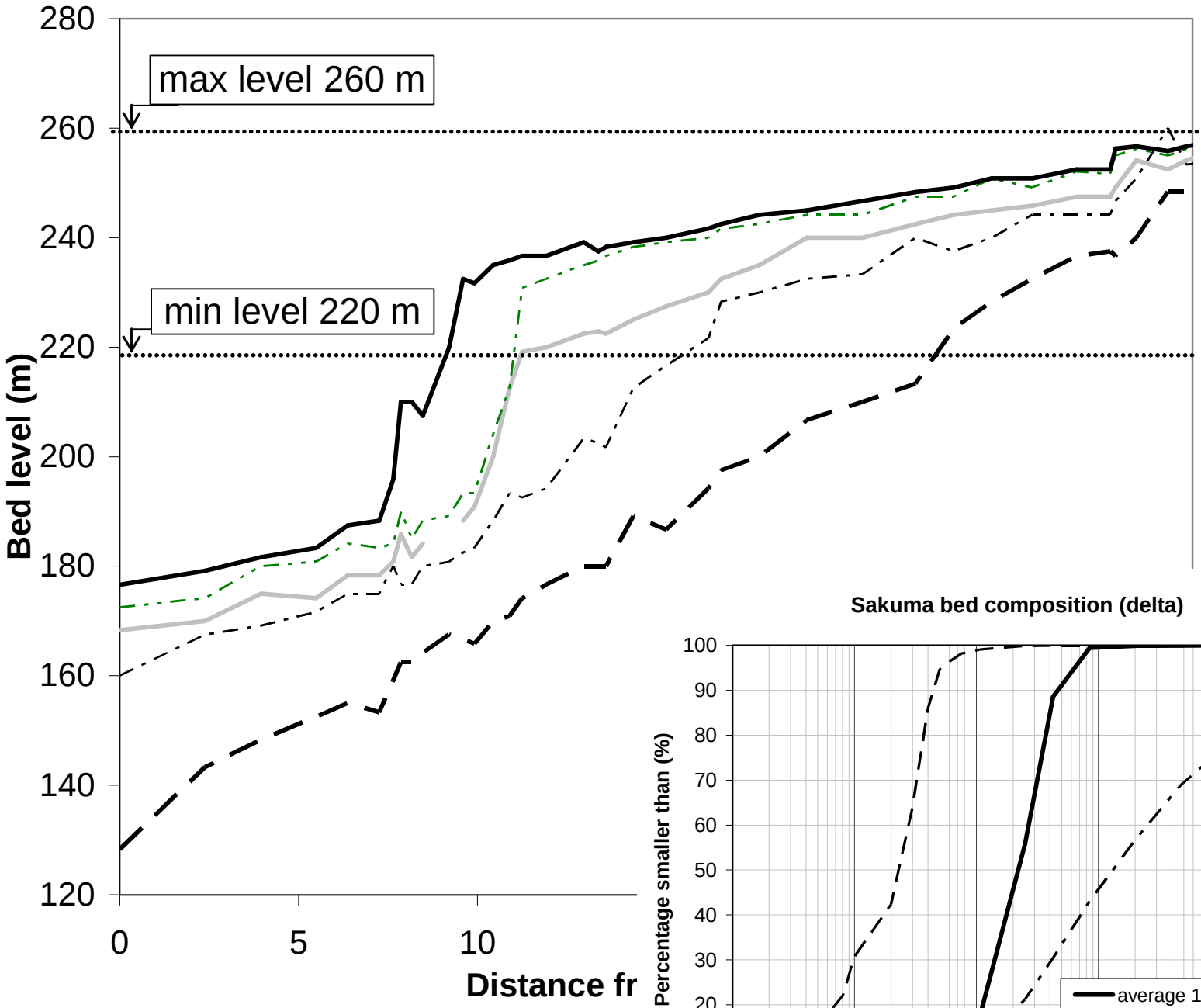
Sakuma reservoir Japan



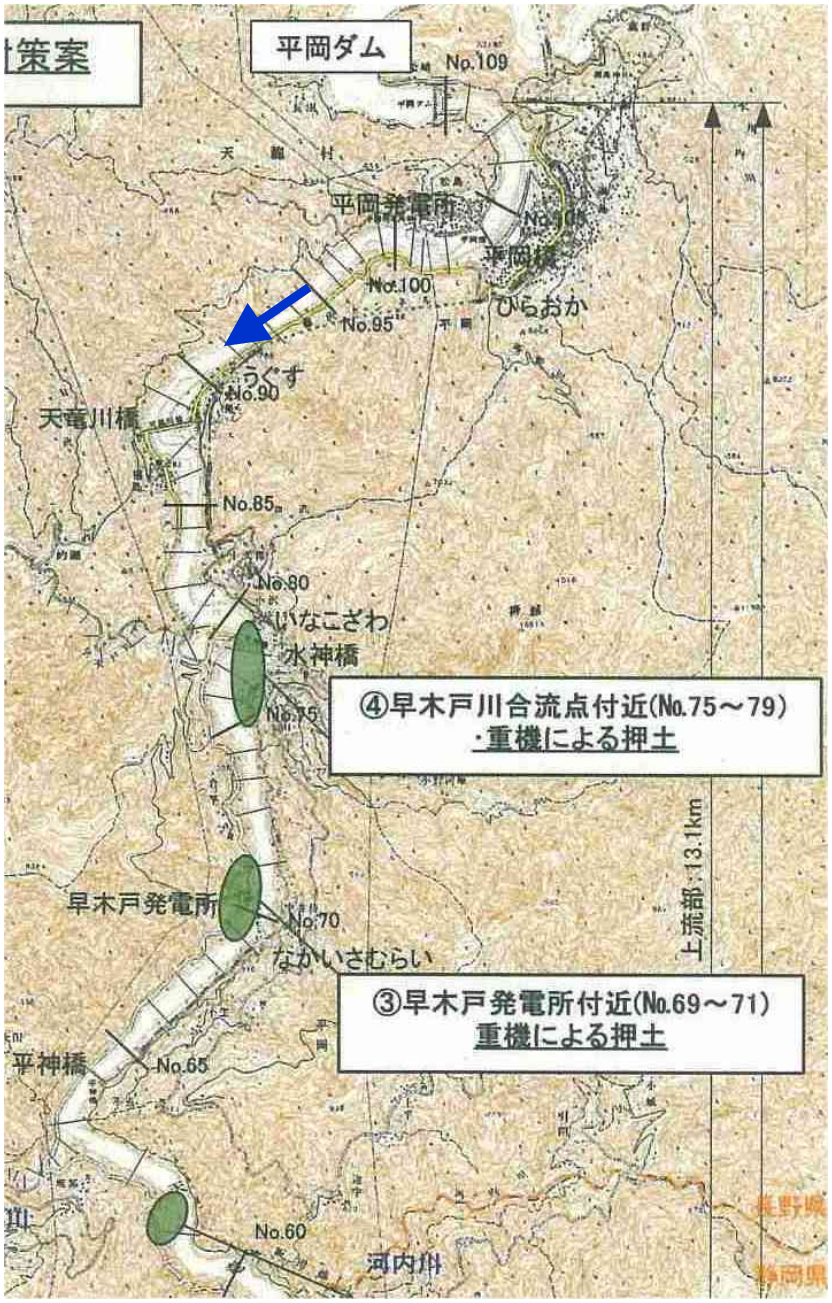




since 1956
dam 155 m
max 350 MW
V_0=327 Mm^3
V_{lost}=117 Mm^3
$L_{backwater}$=
20 to 30 km
Q_{design}=
7700 m^3/s

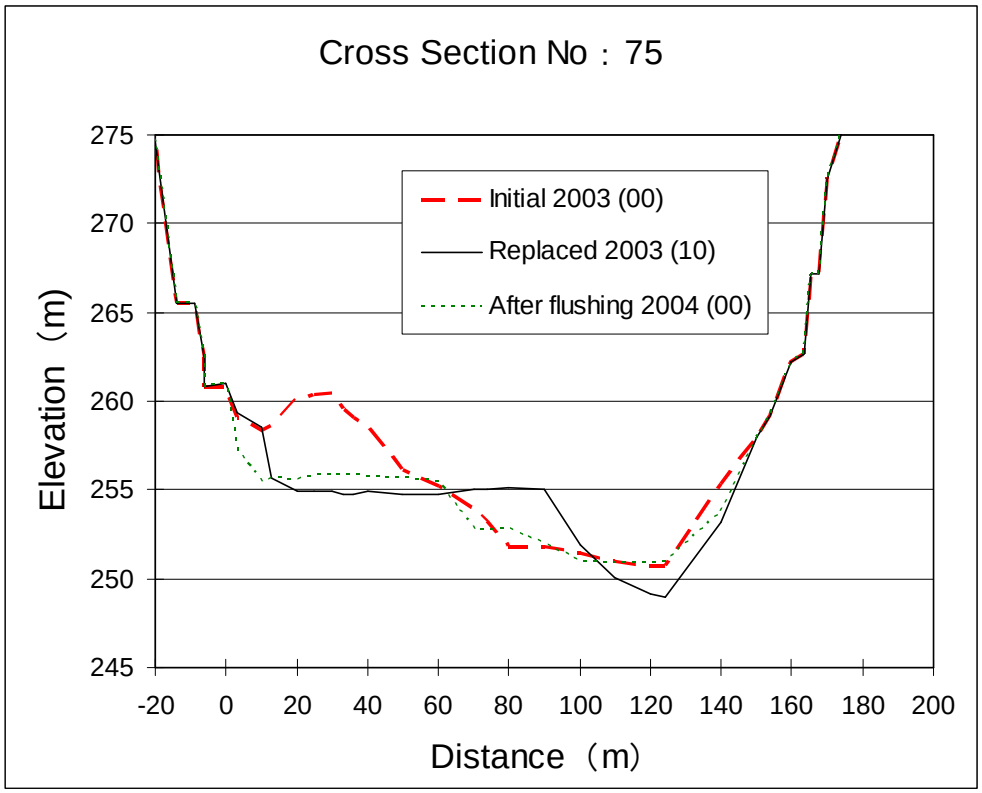

max level 260 m
min level 220 m
Bed level (m)
280
260
240
220
200
180
160
140
120
0
5
10
Distance fr

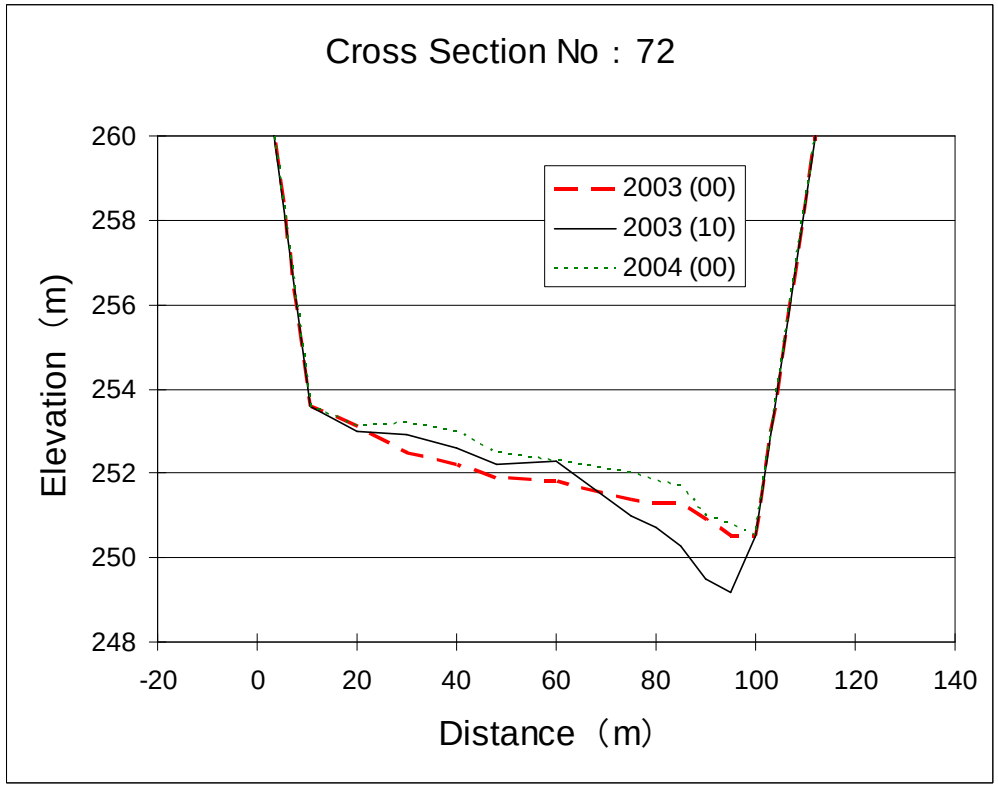
Sakuma bed composition (delta)
Percentage smaller than (%)
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Grain size (mm)
average 10.4 - 23.8 km
average 24.8 - 32.9 km
Very fine (bottomset)


平岡ダム
No.109
平岡発電所
No.105
平岡橋
No.100
No.95
ひらおか
うぐす
No.90
天竜川橋
No.85
No.80
いなこざわ
水神橋
No.75
④早木戸川合流点付近(No.75～79)
・重機による押土
上流部:13.1km
早木戸発電所
No.70
なかいさむらい
③早木戸発電所付近(No.69～71)
重機による押土
平神橋
No.65
No.60
河内川

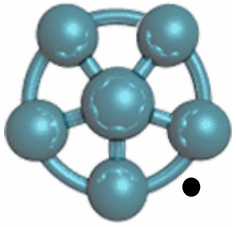
x 10^4
1.8
1.78
1.76
1.74
1.72
1.7
1.68
1.66
1.64
distance (m) →
3600
3800
4000
4200
4400
distance (m) →
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10


CAT
WAQA KENYA!

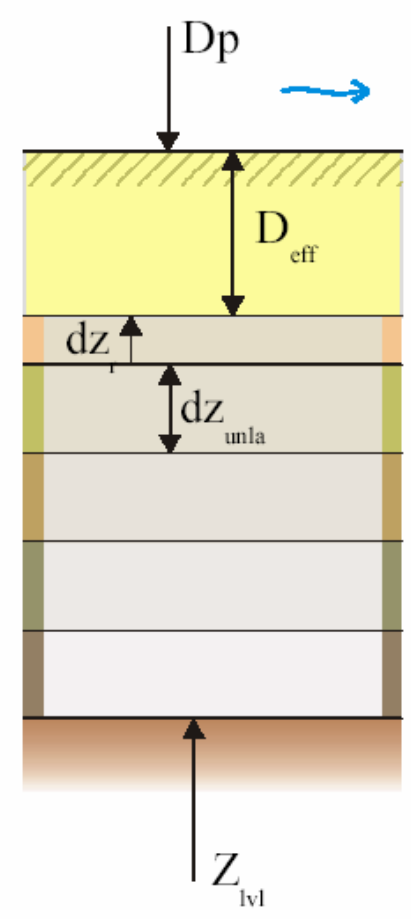

Cross Section No : 75
Initial 2003 (00)
Replaced 2003 (10)
After flushing 2004 (00)
Elevation (m)
275
270
265
260
255
250
245
-20
0
20
40
60
80
100
120
140
160
180
200
Distance (m)

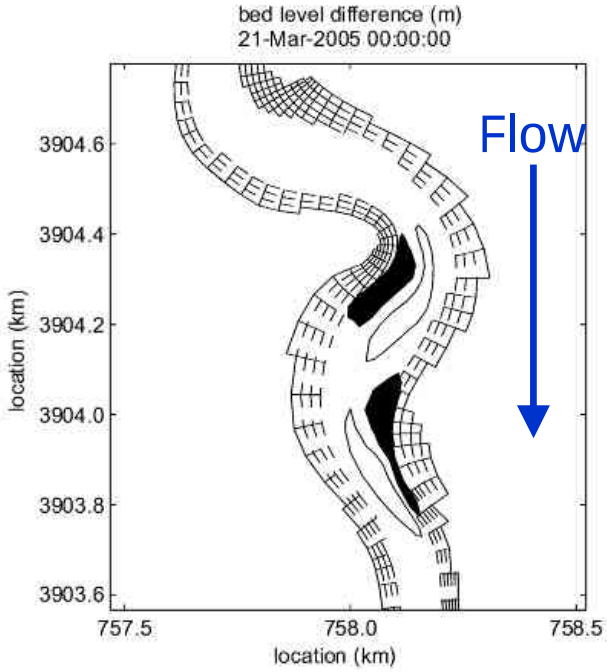

Cross Section No : 72
2003 (00)
2003 (10)
2004 (00)
Elevation (m)
260
258
256
254
252
250
248
-20
0
20
40
60
80
100
120
140
Distance (m)

2D morphological modelling



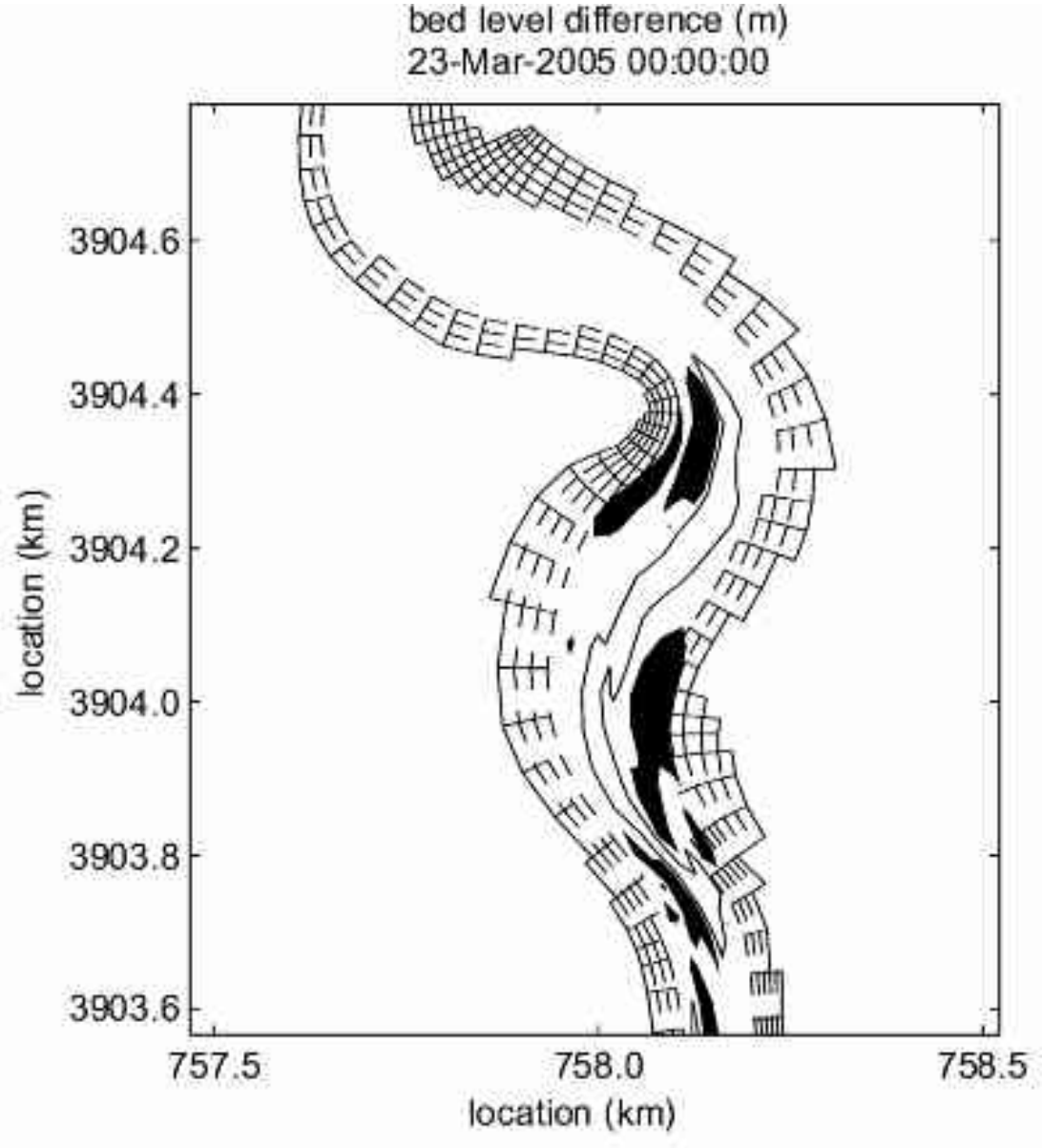
- Delft3D modelling system
- 2D flow with parametrised 3D helical flow
- Curvi-linear grid
- Layer concept with under layers
- 11 size fractions
- Ashida and Michiue transport (2D by S. Egashira)

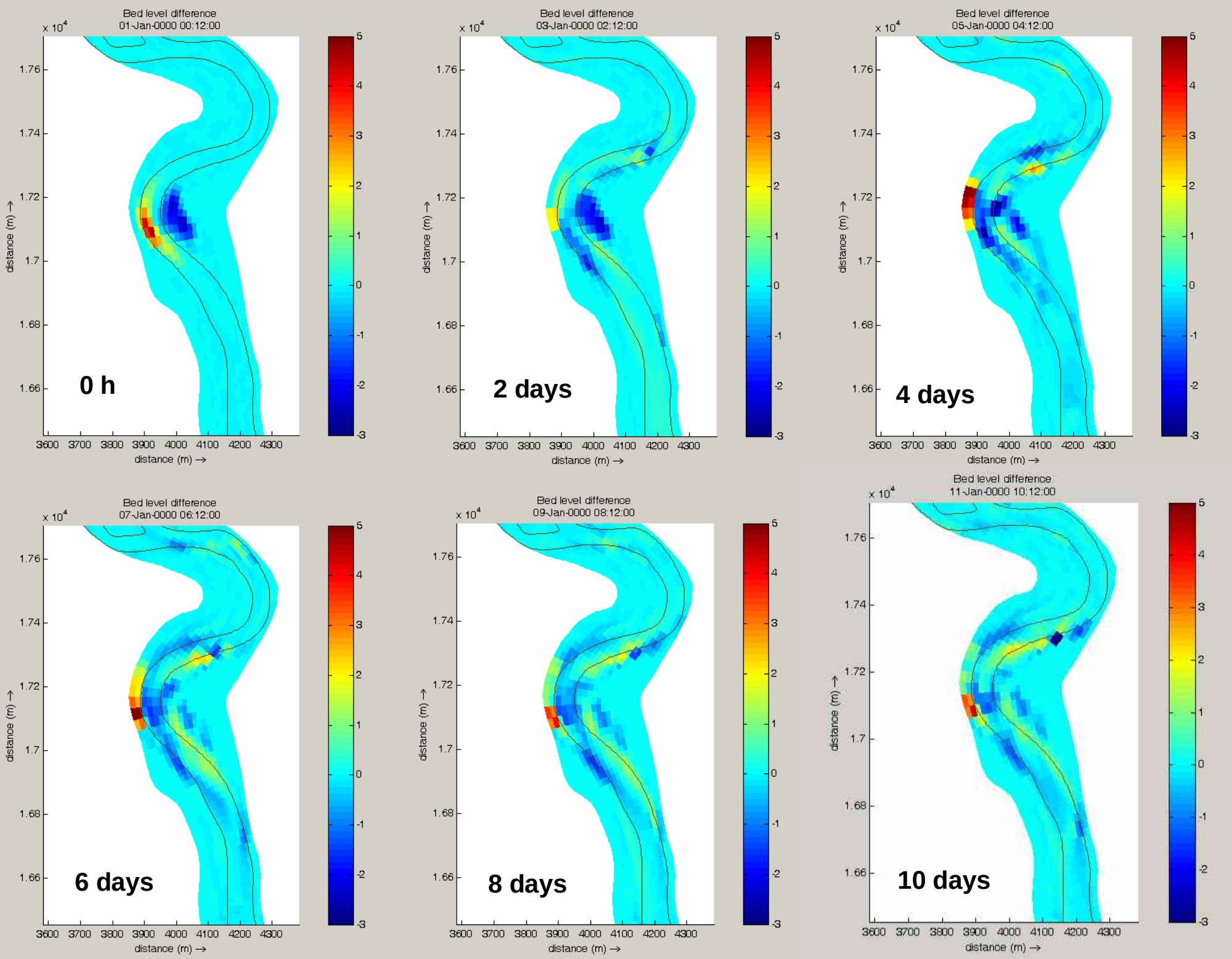


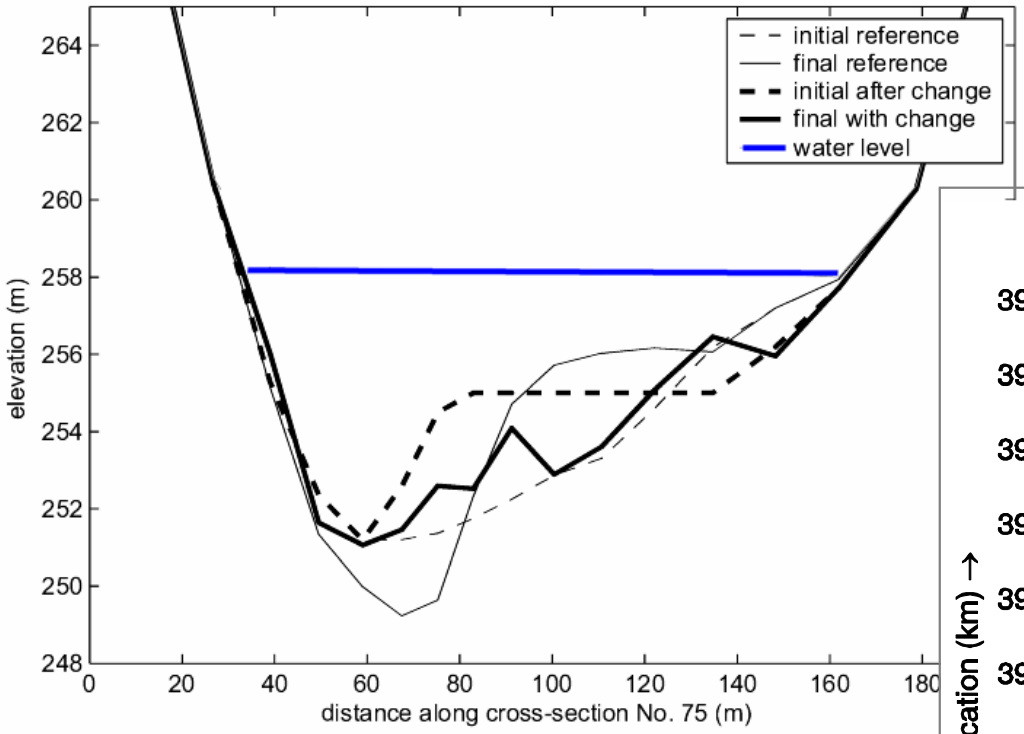


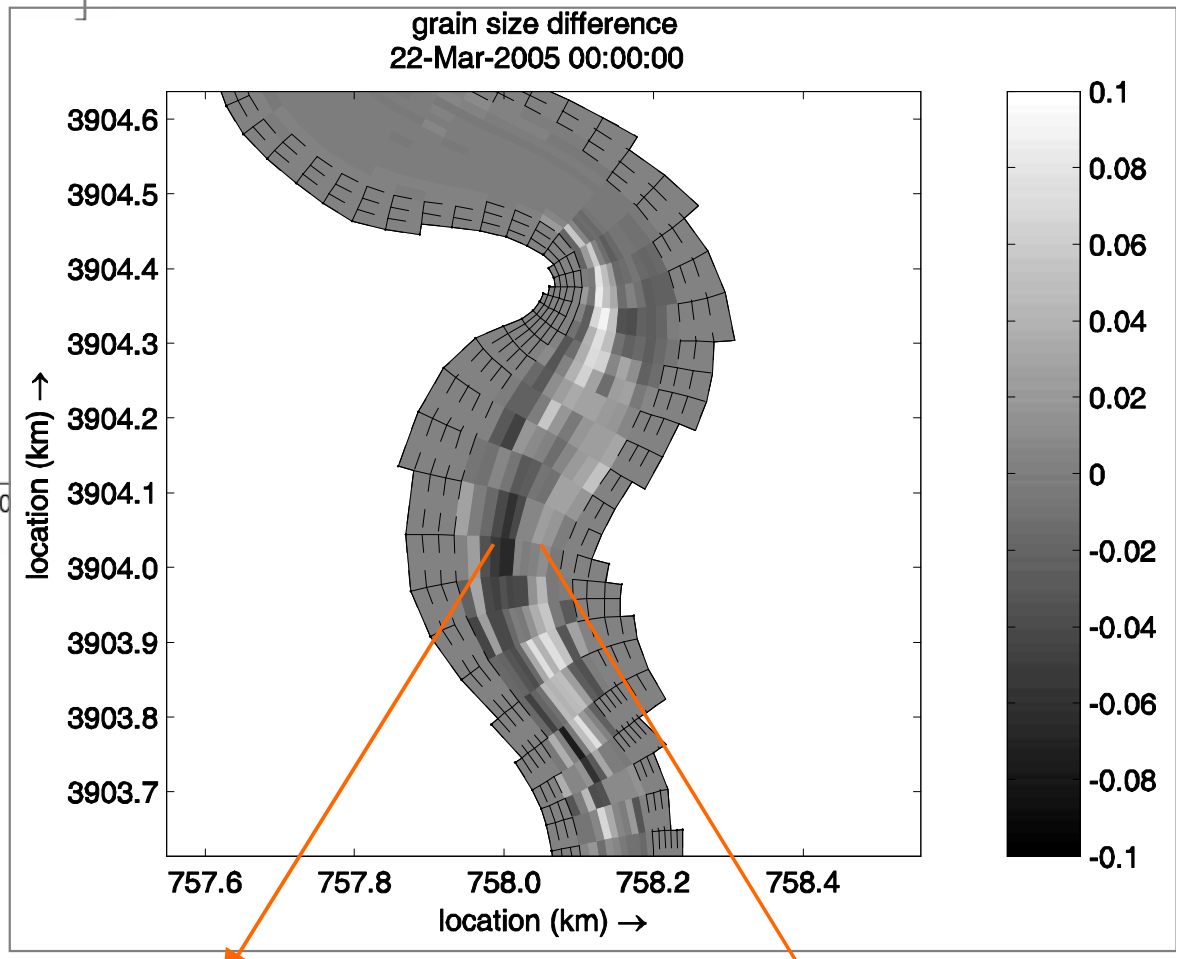
Lowered > 1 m

Raised > 1 m




Bed level difference
01-Jan-0000 00:12:00
0 h
Bed level difference
03-Jan-0000 02:12:00
2 days
Bed level difference
05-Jan-0000 04:12:00
4 days
Bed level difference
07-Jan-0000 06:12:00
6 days
Bed level difference
09-Jan-0000 08:12:00
8 days
Bed level difference
11-Jan-0000 10:12:00
10 days
x 10^4
distance (m) →
3600 3700 3800 3900 4000 4100 4200 4300
1.66 1.68 1.7 1.72 1.74 1.76
-3 -2 -1 0 1 2 3 4 5





Finer in outer bend

Coarser in outer bend

Conclusions

- Displaced sediment leads to a combined 1-D and 2-D response of the riverbed
- In situations with reasonably uniform sediment (no sorting) 1-D propagation is faster and more effective than the 2D behavior.
- Efficacy is improved if:
  - sediments are distributed evenly over the cross-section of the flushing channel,
  - and water levels are lowered to such an extent that the flow is concentrated within this channel.
  - particularly the fine sediments are pushed into the channel
- For practical applications the effect of sediment sorting and unsteadiness of flow need to be accounted for, as these effects appear to have an important impact