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SEDIMENT TRANSPORT ANALYSIS FOR SECURING WATER (CASE STUDY : UPPER JENEBERANG RIVER)

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Abstract - The Jeneberang River Basin, upstream of Bili-Bili Dam Reservoir is divided into five (5) major sub-basins, named upper and middle main Jeneberang (Bili-Bili Dam Basin : 384.40 km^2) , Salo Malino (85.89 km^2), Salo Kausisi (37.50 km^2), Jene Rakikang (42.2 km^2) and Binanga Jajang (22.7 km^2). Salo Malino is divided into more two (2) tributaries, named Salo Bulang (23.8km^2) and Salo Ahuwa (37.1 km^2). Bili-Bili dam is a multipurpose dam for irrigation, electricity, flood mitigation, and raw water. Bili-Bili Irrigation system covering 23,660 Ha of paddy field (Bissua system and Kampili system) of 270 bil.m^3, Capacity for flood control 41 bil.m^{3,} capacity for water supply 35 bil.m^{3,} and the total storagevcapacity is 375 bill. M^3, ofwhich the effective storage capacity is 346 bi.m^3.

Bili-Bili dam has been operated since 1999 year, serious sediment issues have been occurred in the Jeneberang river basin. Especially, after gigantic caldera collapse at March,2004, the sediment inflow volume in the reservoir have been reaches totally 49 million m3 as of May 2007. The objective of this study is to analyse the sediment transport at Upper Jeneberang river using HEC-RAS.. Which can be used to perform mobile bed computation. This study covering 32814.80 m length, consist of 80 reach (cross section). Large amount of sediment flowing to the dam could be reduce the capacity of the dam. Consequently the amount of water will reduced.

The result is a continuous simulation of the change in cross section as sedimentation processes adjust to the hydraulic condition imposed by the water-sediment hydrograph and the base level control boundary conditions. Based on the analysis which show the erosion area and the sediment accumulated area, the decision maker can make the right choice to construct specific river structures at certain places to prevent sediment flowing to the dam for securing water.

Keywords: Sedimentation, Sediment Transport, Securing Water

1. Introduction

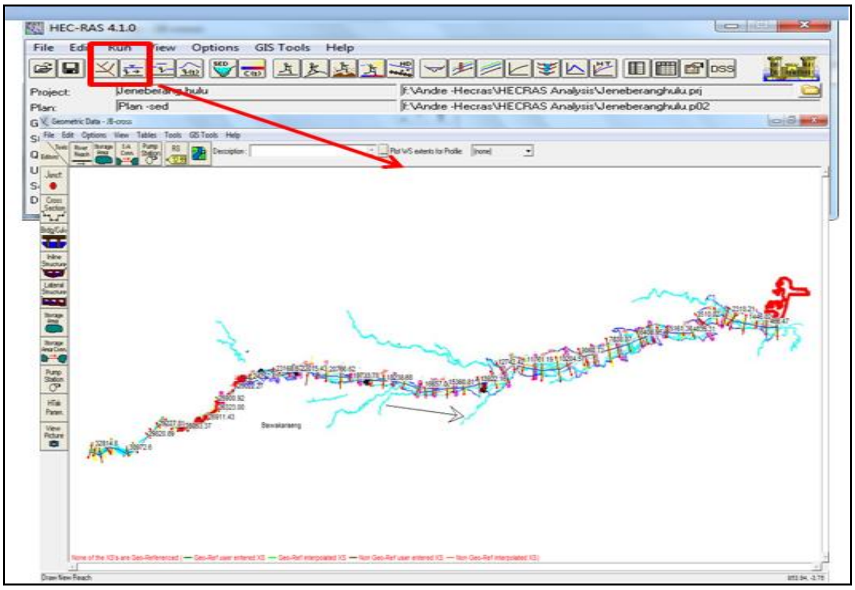
The Jeneberang River Basin upstream of Bili-Bili Dam Reservoir is divided into five (5) major sub-basins, named upper and middle main Jeneberang (Bili-Bili Dam Basin : 384.40 km^2) , Salo Malino (85.89 km^2), Salo Kausisi (37.50 km^2), Jene Rakikang (42.2 km^2) and Binanga Jajang (22.7 km^2). Salo Malino is divided into more two (2) tributaries, named Salo Bulang (23.8km^2) and Salo Ahuwa (37.1 km^2).

Bili-Bili dam has been operated since 1999 year, serious sediment issues have been occurred in the Jeneberang river basin. Especially, after gigantic caldera collapse at March,2004, the sediment inflow volume in the reservoir have been reaches totally 49 million m3 as of May 2007. Total storage capacity of the dam is 376 bil. M^3, and the effective storage capacity is 346 bil.m3. Due to the sedimentation, the design life of the dam would be shorten, and the water quality of water supply for municipal water would be deteriorated.

2. Methodology of Study

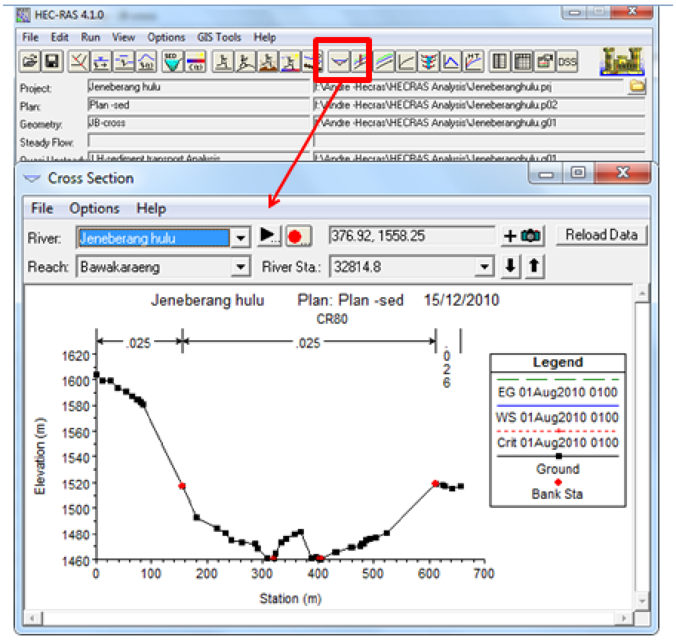
This study using Sediment Impact Analysis Methods (SIAM) in HEC RAS version 4.1, which can calculate sediment budget to compare in a reach of a river, if in that reach occur surplus or deficit. SIAM calculate the sediment transport capacity to decide , if the reach of a river has the imbalance potential and instability. The procedure to run this study are as follows :

- Topography data input : Survey data cross section of the river



Project: Jeneberang hulu F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.prj
Plan: Plan -sed F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.p02

Figure 1. Upper Jeneberang River Plan Drawing



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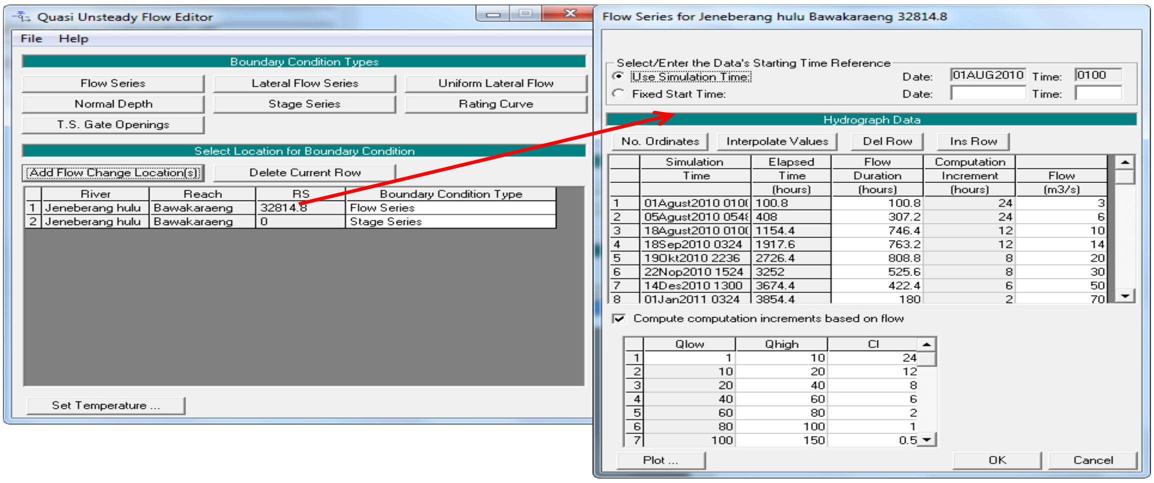
Plan: Plan -sed F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.p02
Geometry: JB-cross F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.g01
Steady Flow:
River: Jeneberang hulu
376.92, 1558.25
Reach: Bawakaraeng
River Sta.: 32814.8

Figure 2. Cross Section Data Editor

Quasi unsteady flow data : as boundaries condition at upstream

Table 1. Discharge Hydrograph as upstream boundary condition

Time Ratio (t/tp)	TP hours	T hours	Discharge Ratio (q/qp)	Qp m^3/s	Q m^3/s	Stage /EL
0.00	1.40	0.00	0.000	800	0.00	
0.10	1.40	0.14	0.030	800	24.00	103.105
0.20	1.40	0.28	0.100	800	80.00	103.535
0.30	1.40	0.42	0.190	800	152.00	103.823
0.40	1.40	0.56	0.310	800	248.00	104.083
0.50	1.40	0.70	0.470	800	376.00	104.288
0.60	1.40	0.84	0.660	800	528.00	104.516
0.70	1.40	0.98	0.820	800	656.00	104.621
0.80	1.40	1.12	0.930	800	744.00	104.693
0.90	1.40	1.26	0.990	800	792.00	104.733
1.00	1.40	1.40	1.000	800	800.00	104.739
1.10	1.40	1.54	0.990	800	792.00	104.733
1.20	1.40	1.68	0.930	800	744.00	104.693
1.30	1.40	1.82	0.860	800	688.00	104.647
1.40	1.40	1.96	0.780	800	624.00	104.595
1.50	1.40	2.10	0.680	800	544.00	104.529
1.60	1.40	2.24	0.560	800	448.00	104.403
1.70	1.40	2.38	0.460	800	368.00	104.275
1.80	1.40	2.52	0.390	800	312.00	104.185
1.90	1.40	2.66	0.330	800	264.00	104.108
2.00	1.40	2.80	0.280	800	224.00	104.044
2.20	1.40	3.08	0.207	800	165.60	103.877
2.40	1.40	3.36	0.147	800	117.60	103.685
2.60	1.40	3.64	0.107	800	85.60	103.557
2.80	1.40	3.92	0.077	800	61.60	103.419
3.00	1.40	4.20	0.055	800	44.00	103.272
3.20	1.40	4.48	0.040	800	32.00	103.172
3.40	1.40	4.76	0.029	800	23.20	103.098
3.60	1.40	5.04	0.021	800	16.80	103.045
3.80	1.40	5.32	0.015	800	12.00	103.004
4.00	1.40	5.60	0.011	800	8.80	102.978
4.50	1.40	6.30	0.005	800	4.00	102.937
5.00	1.40	7.00	0.000	800	0.00	



	River	Reach	RS	Boundary Condition Type
1	Jeneberang hulu	Bawakaraeng	32814.8	Flow Series
2	Jeneberang hulu	Bawakaraeng	0	Stage Series

Select/Enter the Data's Starting Time Reference

● Use Simulation Time: Date: 01AUG2010 Time: 0100

○ Fixed Start Time: Date: Time:

	Simulation Time	Elapsed Time (hours)	Flow Duration (hours)	Computation Increment (hours)	Flow (m3/s)
1	01Agust2010 010(	100.8	100.8	24	3
2	05Agust2010 054{	408	307.2	24	6
3	18Agust2010 010(	1154.4	746.4	12	10
4	18Sep2010 0324	1917.6	763.2	12	14
5	19Okt2010 2236	2726.4	808.8	8	20
6	22Nop2010 1524	3252	525.6	8	30
7	14Des2010 1300	3674.4	422.4	6	50
8	01Jan2011 0324	3854.4	180	2	70

☑ Compute computation increments based on flow

	Qlow	Qhigh	CI
1	1	10	24
2	10	20	12
3	20	40	8
4	40	60	6
5	60	80	2
6	80	100	1
7	100	150	0.5

Upstream Boundary Condition

Figure 3. Quasi Unsteady Flow -Upstream Boundary Condition Editor

Table 2. Discharge calculation for Rating Curve

No.	Elevation	Area	Wetted Perimeter	Hydraulic Radius	n manning	Slope (S)	Velocity	Discharge
	(m)	A (m2)	P(m)	R (m)			(m/s)	Q (m3/s)
1	103.000	10.126	39.893	0.254	0.025	0.005	1.134	11.482
2	103.500	40.632	83.289	0.488	0.025	0.005	1.753	71.220
3	104.000	101.167	177.902	0.569	0.025	0.005	1.941	196.407
4	104.500	220.466	299.545	0.736	0.025	0.005	2.306	508.323
5	105.000	392.606	388.826	1.010	0.025	0.005	2.847	1117.643
6	106.000	869.898	558.888	1.556	0.025	0.005	3.799	3304.525
7	107.000	1448.628	599.326	2.417	0.025	0.005	5.094	7379.570
8	108.000	2066.678	632.371	3.268	0.025	0.005	6.229	12873.157
9	109.000	2705.586	646.772	4.183	0.025	0.005	7.343	19867.647
10	110.000	3357.097	661.173	5.077	0.025	0.005	8.356	28050.551
11	111.000	4306.527	798.786	5.391	0.025	0.005	8.696	37451.566

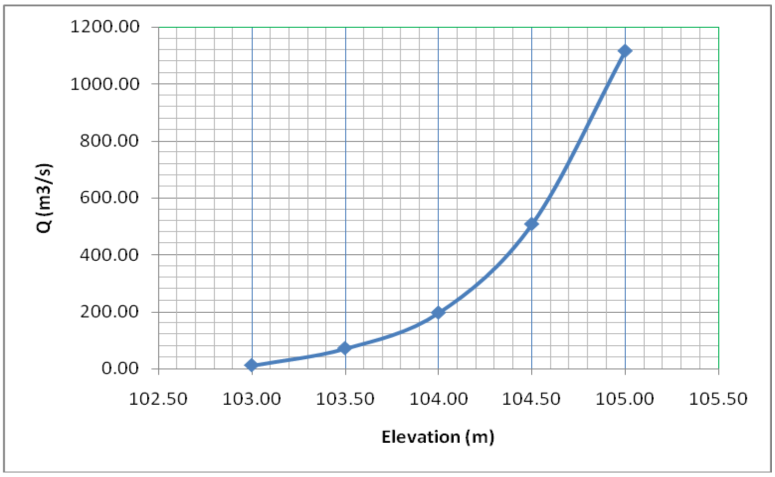
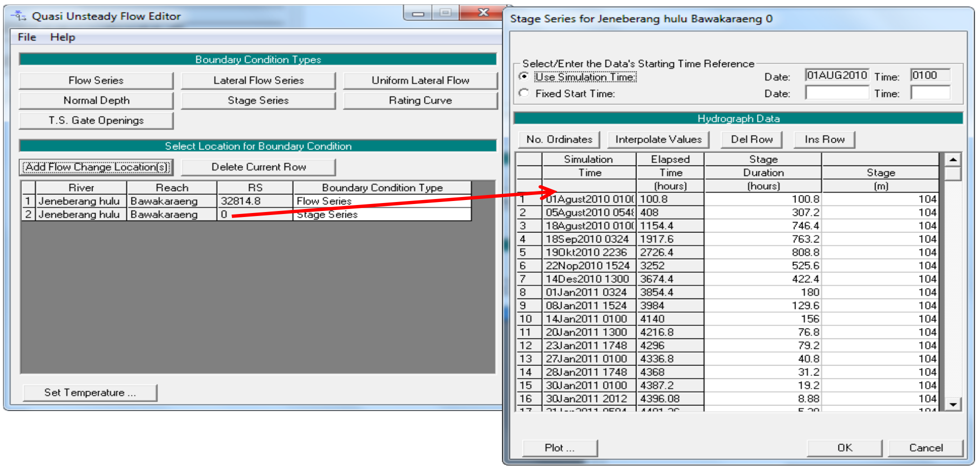


Figure 4. Rating Curve as downstream boundary Condition



	River	Reach	RS	Boundary Condition Type
1	Jeneberang hulu	Bawakaraeng	32814.8	Flow Series
2	Jeneberang hulu	Bawakaraeng	0	Stage Series

Select/Enter the Data's Starting Time Reference
● Use Simulation Time: Date: 01AUG2010 Time: 0100
○ Fixed Start Time: Date: Time:

	Simulation Time	Elapsed Time (hours)	Stage Duration (hours)	Stage (m)
1	01Agust2010 010	100.8	100.8	104
2	05Agust2010 054	408	307.2	104
3	18Agust2010 010	1154.4	746.4	104
4	18Sep2010 0324	1917.6	763.2	104
5	19Okt2010 2236	2726.4	808.8	104
6	22Nop2010 1524	3252	525.6	104
7	14Des2010 1300	3674.4	422.4	104
8	01Jan2011 0324	3854.4	180	104
9	08Jan2011 1524	3984	129.6	104
10	14Jan2011 0100	4140	156	104
11	20Jan2011 1300	4216.8	76.8	104
12	23Jan2011 1748	4296	79.2	104
13	27Jan2011 0100	4336.8	40.8	104
14	28Jan2011 1748	4368	31.2	104
15	30Jan2011 0100	4387.2	19.2	104
16	30Jan2011 2012	4396.08	8.88	104

Downstream Boundary Condition

Figure 5. Boundary Condition Editor

SP1

	Class	diam (mm)	% finer
1	Clay	0.004	0.1
2	VFM	0.008	0.23
3	FM	0.016	0.8
4	MM	0.032	1.2
5	CM	0.0625	2
6	VFS	0.125	5
7	FS	0.25	11
8	MS	0.5	15
9	CS	1	18
10	VCS	2	21
11	VFG	4	22
12	FG	8	27
13	MG	16	33
14	CG	32	38
15	VCG	64	42
16	SC	128	91
17	LC	256	96
18	SB	512	99
19	MB	1024	100
20	LB	2048	100

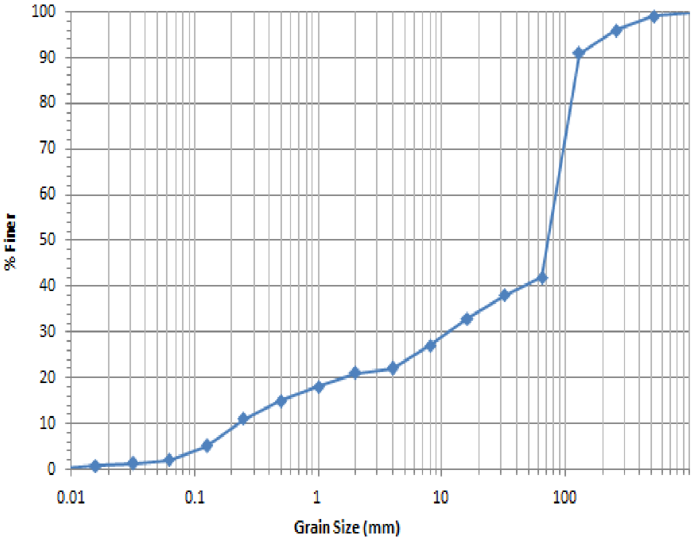
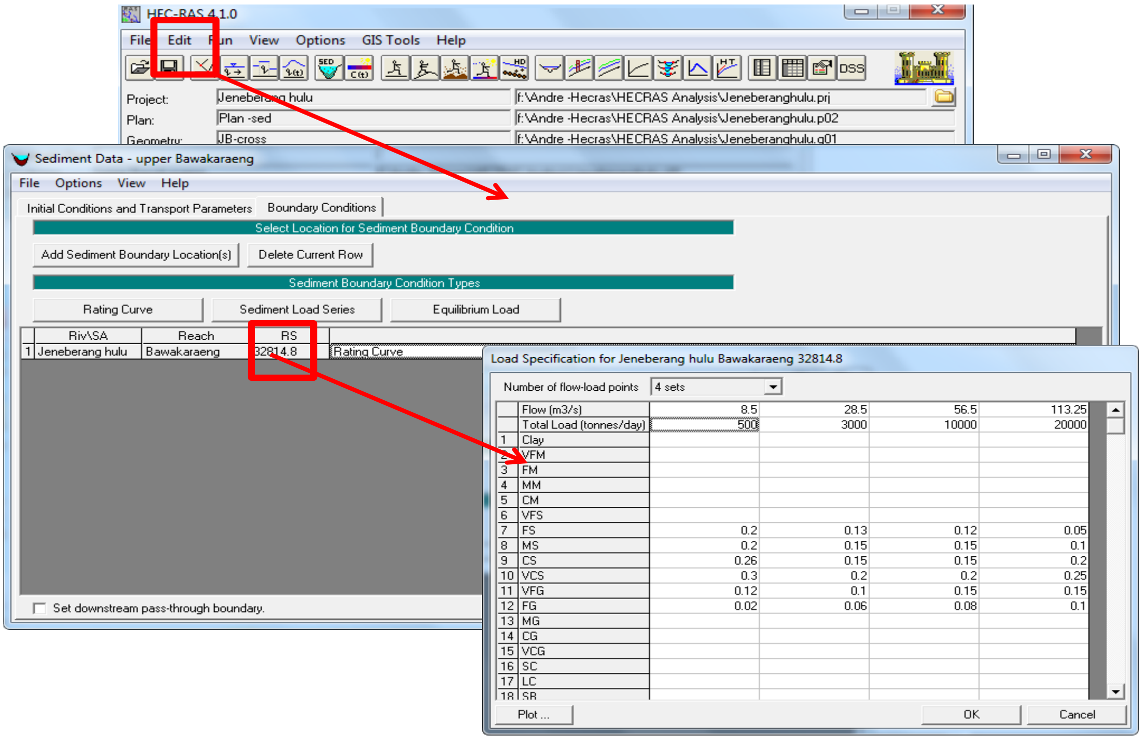


Figure 6. Grainsize of River Bed Material



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Geometry: JB-cross f:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.g01

	Riv\SA	Reach	RS	
1	Jeneberang hulu	Bawakaraeng	32814.8	Rating Curve

☐ Set downstream pass-through boundary.

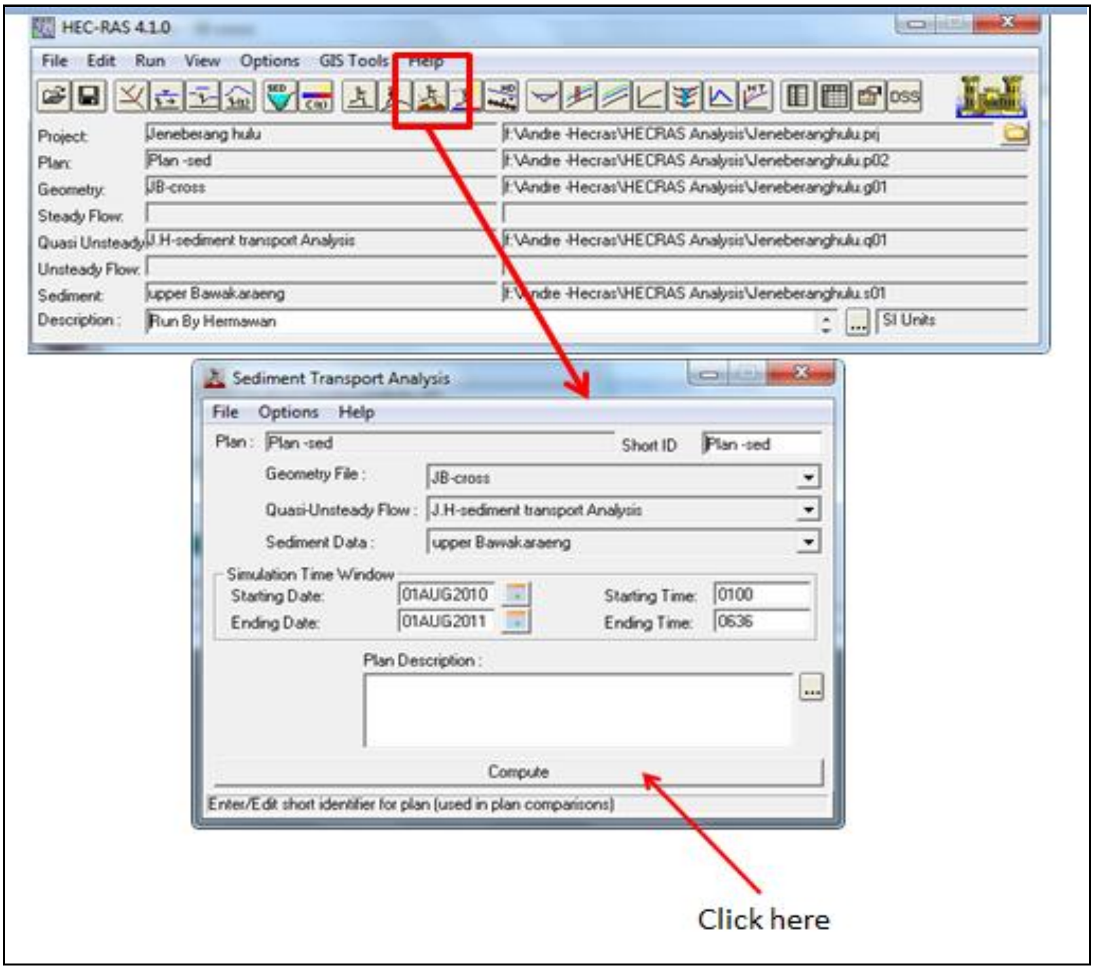
Load Specification for Jeneberang hulu Bawakaraeng 32814.8

Number of flow-load points: 4 sets

	Flow (m3/s)	8.5	28.5	56.5	113.25
	Total Load (tonnes/day)	500	3000	10000	20000
1	Clay				
2	VFM				
3	FM				
4	MM				
5	CM				
6	VFS				
7	FS	0.2	0.13	0.12	0.05
8	MS	0.2	0.15	0.15	0.1
9	CS	0.26	0.15	0.15	0.2
10	VCS	0.3	0.2	0.2	0.25
11	VFG	0.12	0.1	0.15	0.15
12	FG	0.02	0.06	0.08	0.1
13	MG				
14	CG				
15	VCG				
16	SC				
17	LC				
18	SB				

Figure 7. Sediment Data Editor

- Run simulation



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Plan: Plan -sed F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.p02
Geometry: JB-cross F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.g01
Steady Flow:
Quasi Unsteady: J.H-sediment transport Analysis F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.q01
Unsteady Flow:
Sediment: upper Bawakaraeng F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.s01
Description: Run By Hermawan SI Units

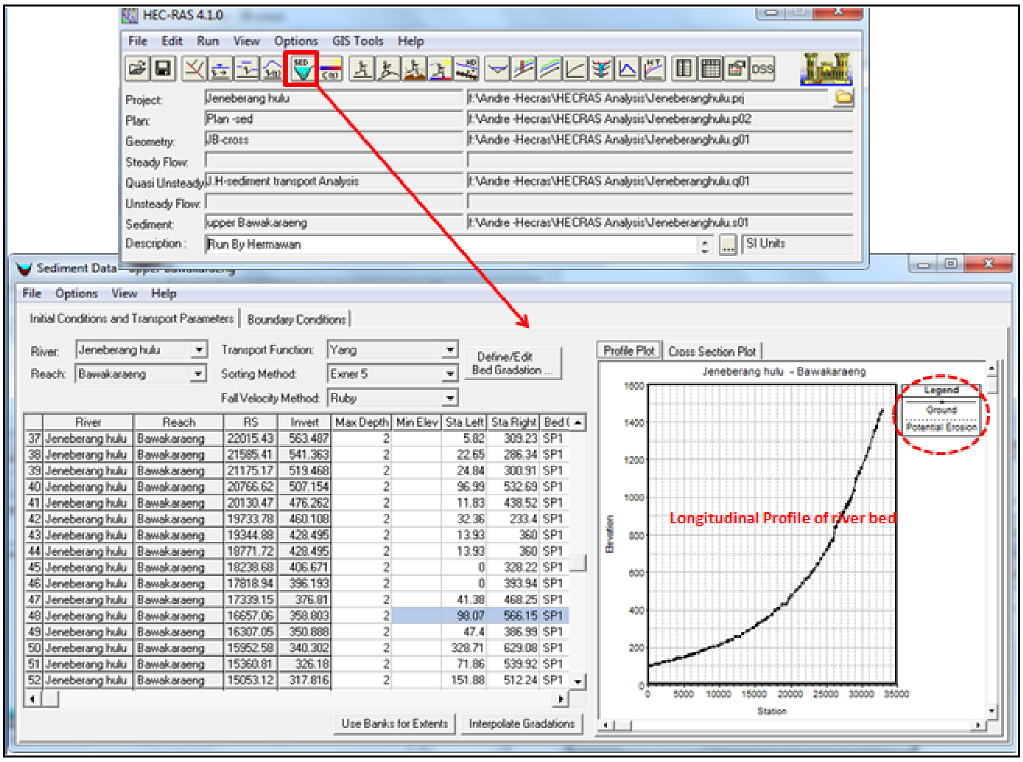
Plan: Plan -sed Short ID Plan -sed
Geometry File: JB-cross
Quasi-Unsteady Flow: J.H-sediment transport Analysis
Sediment Data: upper Bawakaraeng
Simulation Time Window
Starting Date: 01AUG2010 Starting Time: 0100
Ending Date: 01AUG2011 Ending Time: 0636
Plan Description:
Enter/Edit short identifier for plan (used in plan comparisons)

Figure 8. Run Editor

3. The result of simulation

The result of the study is a continuous simulation of the change in cross section, as sedimerntation processes adjust to the hydraulic condition imposed by the water-sediment hydrograph and the base level control boundary conditions.

In figure 9, showing the longitudinal profile of riverbed, and in Figure 10. Showing that the solid line is the original profile, and the dot line is the profile after simulation.



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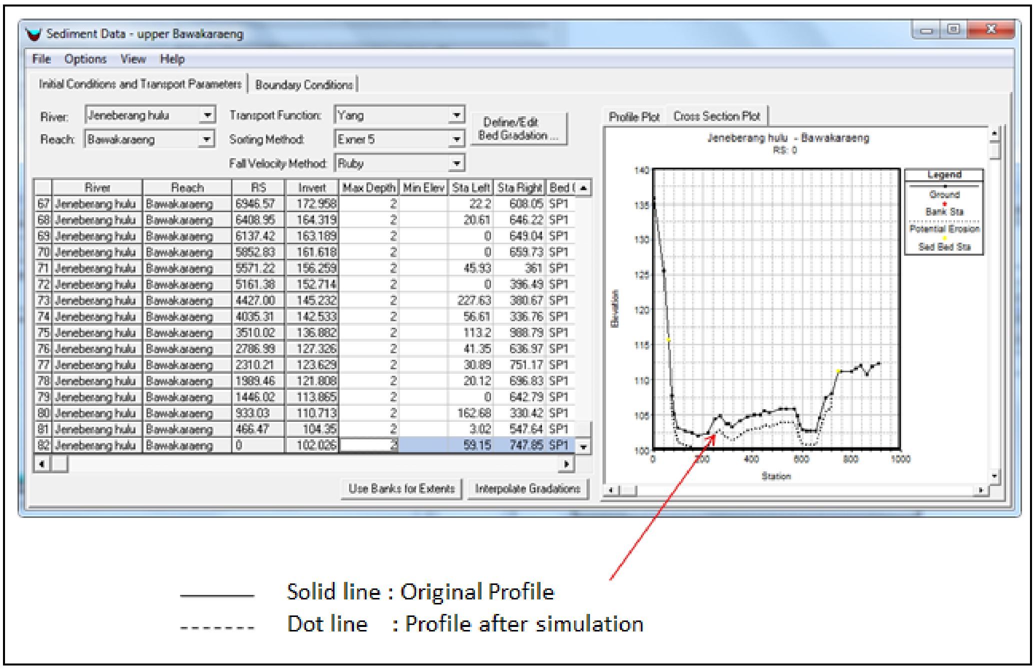
Plan: Plan -sed — F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.p02
Geometry: JB-cross — F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.g01
Steady Flow:
Quasi Unsteady: J.H-sediment transport Analysis — F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.q01
Unsteady Flow:
Sediment: upper Bawakaraeng — F:\Andre -Hecras\HECRAS Analysis\Jeneberanghulu.s01
Description : Run By Hermawan
SI Units

River: Jeneberang hulu
Reach: Bawakaraeng
Transport Function: Yang
Sorting Method: Exner 5
Fall Velocity Method: Ruby

	River	Reach	RS	Invert	Max Depth	Min Elev	Sta Left	Sta Right	Bed (
37	Jeneberang hulu	Bawakaraeng	22015.43	563.487	2		5.82	309.23	SP1
38	Jeneberang hulu	Bawakaraeng	21585.41	541.363	2		22.65	286.34	SP1
39	Jeneberang hulu	Bawakaraeng	21175.17	519.468	2		24.84	300.91	SP1
40	Jeneberang hulu	Bawakaraeng	20766.62	507.154	2		96.99	532.69	SP1
41	Jeneberang hulu	Bawakaraeng	20130.47	476.262	2		11.83	438.52	SP1
42	Jeneberang hulu	Bawakaraeng	19733.78	460.108	2		32.36	233.4	SP1
43	Jeneberang hulu	Bawakaraeng	19344.88	428.495	2		13.93	360	SP1
44	Jeneberang hulu	Bawakaraeng	18771.72	428.495	2		13.93	360	SP1
45	Jeneberang hulu	Bawakaraeng	18238.68	406.671	2		0	328.22	SP1
46	Jeneberang hulu	Bawakaraeng	17818.94	396.193	2		0	393.94	SP1
47	Jeneberang hulu	Bawakaraeng	17339.15	376.81	2		41.38	468.25	SP1
48	Jeneberang hulu	Bawakaraeng	16657.06	358.803	2		98.07	566.15	SP1
49	Jeneberang hulu	Bawakaraeng	16307.05	350.888	2		47.4	386.99	SP1
50	Jeneberang hulu	Bawakaraeng	15952.58	340.302	2		328.71	629.08	SP1
51	Jeneberang hulu	Bawakaraeng	15360.81	326.18	2		71.86	539.92	SP1
52	Jeneberang hulu	Bawakaraeng	15053.12	317.816	2		151.88	512.24	SP1

Figure 9. Longitudinal Profile of Riverbed after Simulation



Sediment Data - upper Bawakaraeng

River: Jeneberang hulu
Reach: Bawakaraeng
Transport Function: Yang
Sorting Method: Exner 5
Fall Velocity Method: Ruby

	River	Reach	RS	Invert	Max Depth	Min Elev	Sta Left	Sta Right	Bed (
67	Jeneberang hulu	Bawakaraeng	6946.57	172.958	2		22.2	608.05	SP1
68	Jeneberang hulu	Bawakaraeng	6408.95	164.319	2		20.61	646.22	SP1
69	Jeneberang hulu	Bawakaraeng	6137.42	163.189	2		0	649.04	SP1
70	Jeneberang hulu	Bawakaraeng	5852.83	161.618	2		0	659.73	SP1
71	Jeneberang hulu	Bawakaraeng	5571.22	156.259	2		45.93	361	SP1
72	Jeneberang hulu	Bawakaraeng	5161.38	152.714	2		0	396.49	SP1
73	Jeneberang hulu	Bawakaraeng	4427.00	145.232	2		227.63	380.67	SP1
74	Jeneberang hulu	Bawakaraeng	4035.31	142.533	2		56.61	336.76	SP1
75	Jeneberang hulu	Bawakaraeng	3510.02	136.882	2		113.2	988.79	SP1
76	Jeneberang hulu	Bawakaraeng	2786.99	127.326	2		41.35	636.97	SP1
77	Jeneberang hulu	Bawakaraeng	2310.21	123.629	2		30.89	751.17	SP1
78	Jeneberang hulu	Bawakaraeng	1989.46	121.808	2		20.12	696.83	SP1
79	Jeneberang hulu	Bawakaraeng	1446.02	113.865	2		0	642.79	SP1
80	Jeneberang hulu	Bawakaraeng	933.03	110.713	2		162.68	330.42	SP1
81	Jeneberang hulu	Bawakaraeng	466.47	104.35	2		3.02	547.64	SP1
82	Jeneberang hulu	Bawakaraeng	0	102.026	2		59.15	747.85	SP1

——— Solid line : Original Profile
------- Dot line : Profile after simulation

Figure 10. Cross Section Profile after Simulation

The result of the simulation (Figure 10) shows the river bed profile after simulation, if the new profile were belower than the original ones, then the degradation were occurred, and if the new profile were above than that original ones, it means , the agradation were occured.

4. Conclusion And Recommendation

Based on the analysis which show the erosion area and the sediment accumulated area, the decision maker can make the right choice to construct specific sediment control structures , at specific location to prevent sediment flowing to the dam. With the right type and the right place of these river structures constructed for securing water.

Acknowledgements

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