MODELING STREAM BANK EROSION: QUANTIFYING FINE SEDIMENT SOURCE CONTROL IN AN SEZ

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Tahoe Basin SEZ Restoration Monitoring **February 9, 2010**

Presentation

- Overview of BSTEM and CONCEPTS
- Local Application Examples
- Enhancements of the Models
- Use in Stream Restoration Evaluation & Management

Bank Stability and Toe Erosion Model

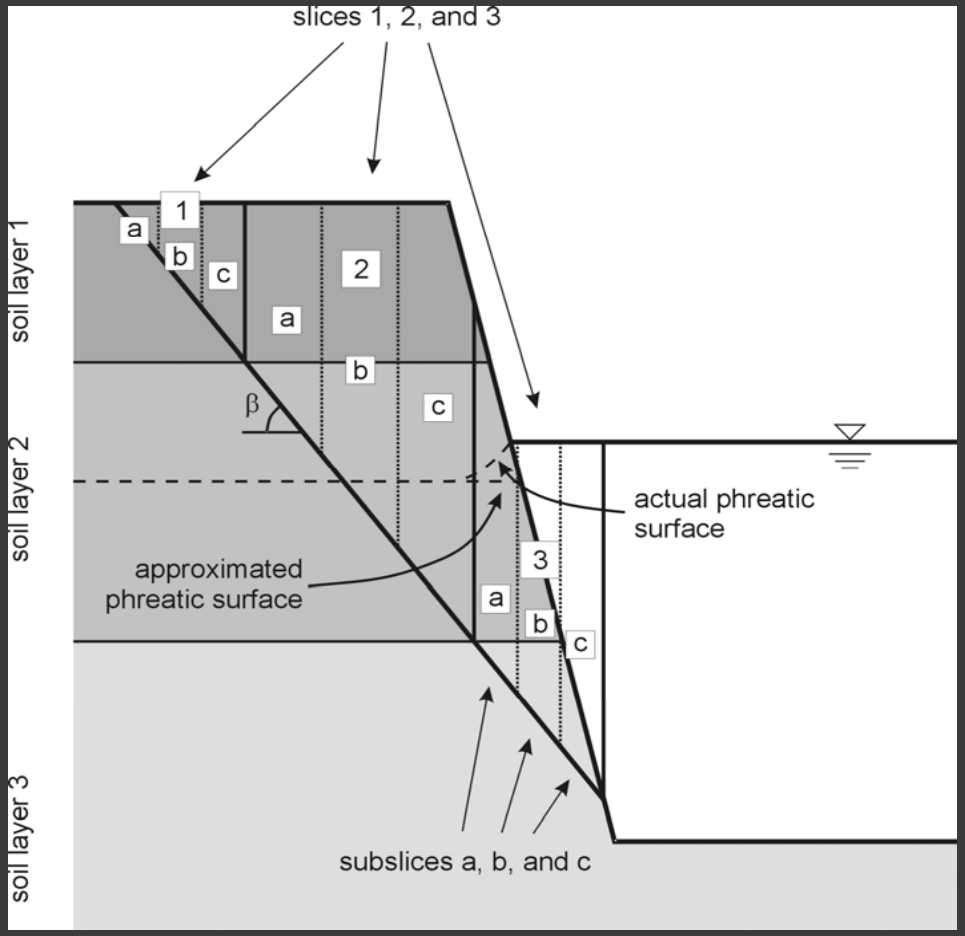
New! BSTEM 5.3

http://www.ars.usda.gov/Research

Andrew Simon, Robert Thomas,
Andrea Curini and Natasha Bankhead

USDA ARS National Sedimentation Laboratory

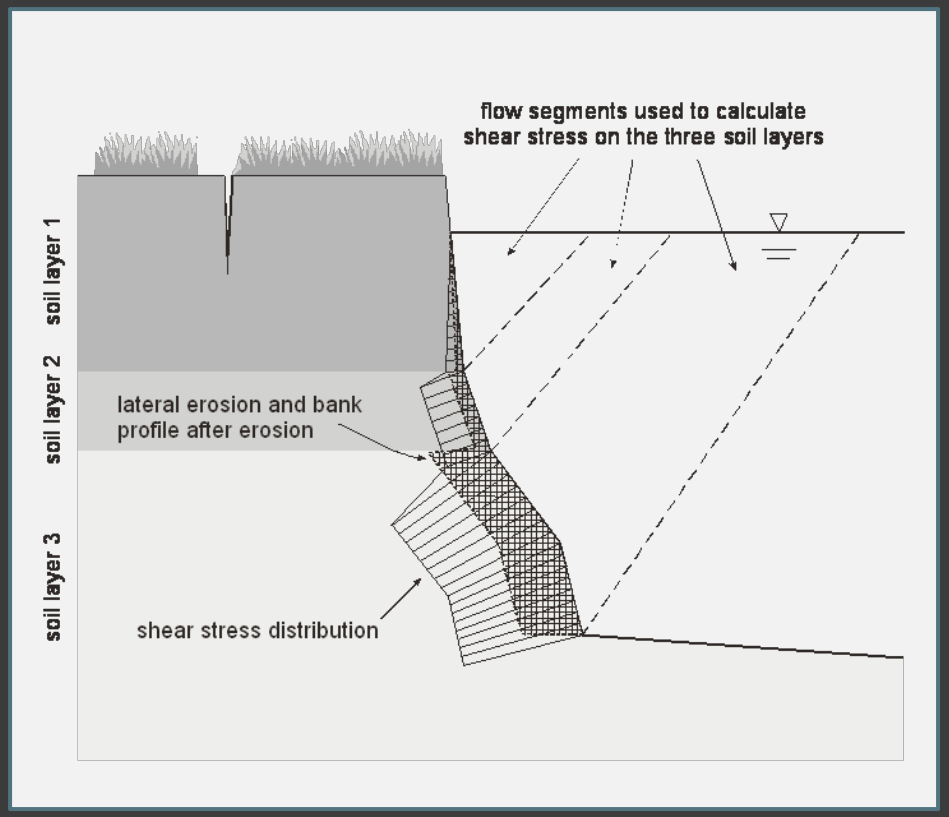
Bank Stability Model



Representation of vertical slices method

- Up to 5 layers
- Three failure modes
- Pore-Water pressure (+ and -)
- Confining pressure
- Vegetation reinforcement and surcharge

Toe Erosion Model



Representation of shear stress distribution

- Hydraulic Effects of boundary shear
- Straight or curved planform options
- Bank and Bank Toe resistance/erodibility
- Fixed bed
- Eroded material assumed removed

Model Input

Bank Stability Model

- Bank Geometry
  - Height
  - Slope
- Bank Materials
  - Layers
  - Composition
- Water Table
- Vegetation

Toe Erosion Model

- Water Stage Relation
  - Depth/height of flow
- Flow Duration
- Channel Geometry
  - Planform
  - Slope
- Bank Material
  - Layers
  - Erodibility

Select material types (or select "own data" and add values below)

Bank Material

Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	**Bank Toe Material**
Own data	Own data	Own data	Own data	Own data	Own data

Bank and bank-toe material data tables.

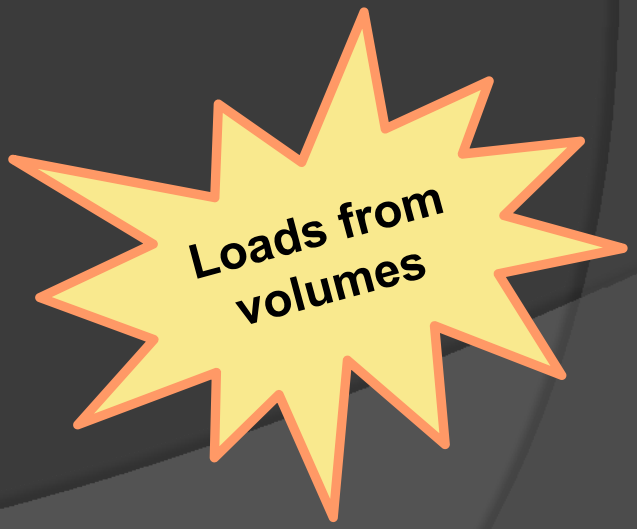
These are the default parameters used in the model. Changing the values or descriptions will change the values used when selecting soil types from the list boxes above. Add your own data using the white boxes.

Material Descriptors			**Bank Model Input Data**				
Bank material type	*Description*	*Mean grain size, D_{50} (m)*	*Friction angle ϕ' (degrees)*	*Cohesion c' (kPa)*	*Saturated unit weight (kN/m^3)*	*ϕ^b (degrees)*	*Chemical concentration (kg/kg)*
1	Boulders	0.512	42.0	0.0	20.0	15.0	-
2	Cobbles	0.128	42.0	0.0	20.0	15.0	-
3	Gravel	0.0113	36.0	0.0	20.0	15.0	-
4a and 4b	Angular sand	0.00035	36.0	0.0	18.0	15.0	-
5a and 5b	Rounded sand	0.00035	27.0	0.0	18.0	15.0	-
6a, 6b and 6c	Silt	-	30.0	3.0	18.0	15.0	-
7a, 7b and 7c	Soft clay	-	25.0	10.0	18.0	15.0	-
8a, 8b and 8c	Stiff clay	-	20.0	15.0	18.0	15.0	-
	Own data layer 1						
	Own data layer 2						
9	Own data layer 3						
	Own data layer 4						
	Own data layer 5						
	Own data Bank Toe						

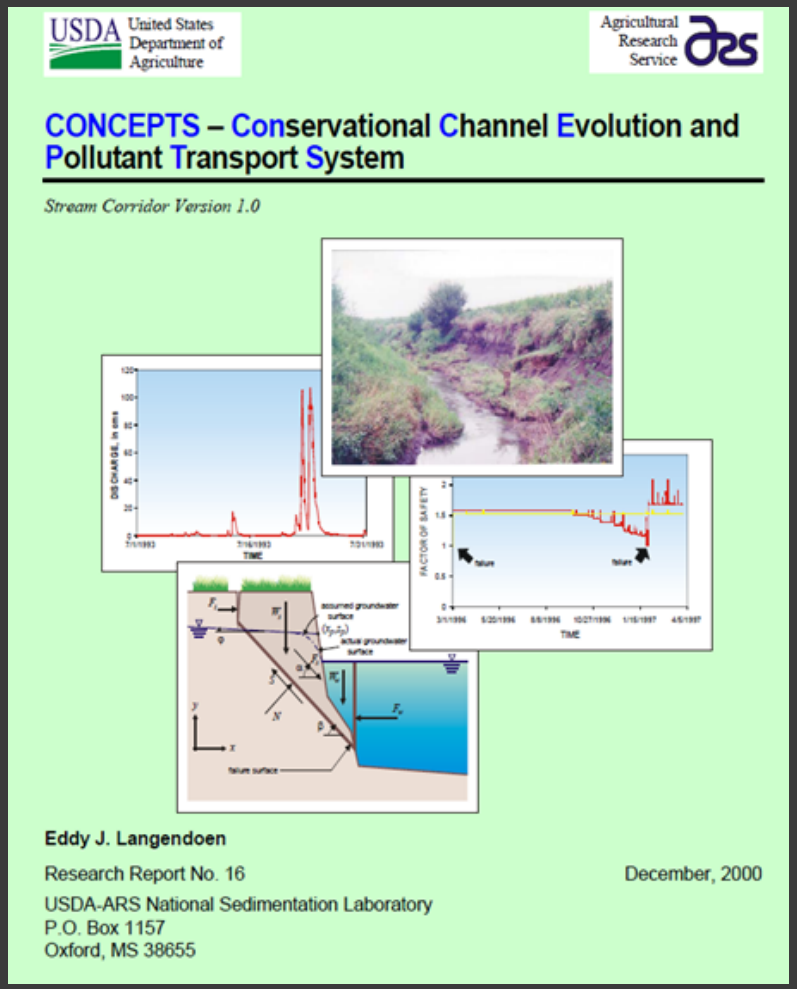
Need to know the critical shear stress (τ_c) ?	**Need to know the erodibility coefficient (k) ?**

Model Output

- Bank Failure
  - Events/occurrences
  - Eroded volumes
  - Peak or drawdown conditions
  - Modified geometry
- Toe Erosion
  - Events/occurrences
  - Retreat distances
  - Eroded volumes
  - Modified geometry



CONservational Channel Evolution and Pollutant Transport System

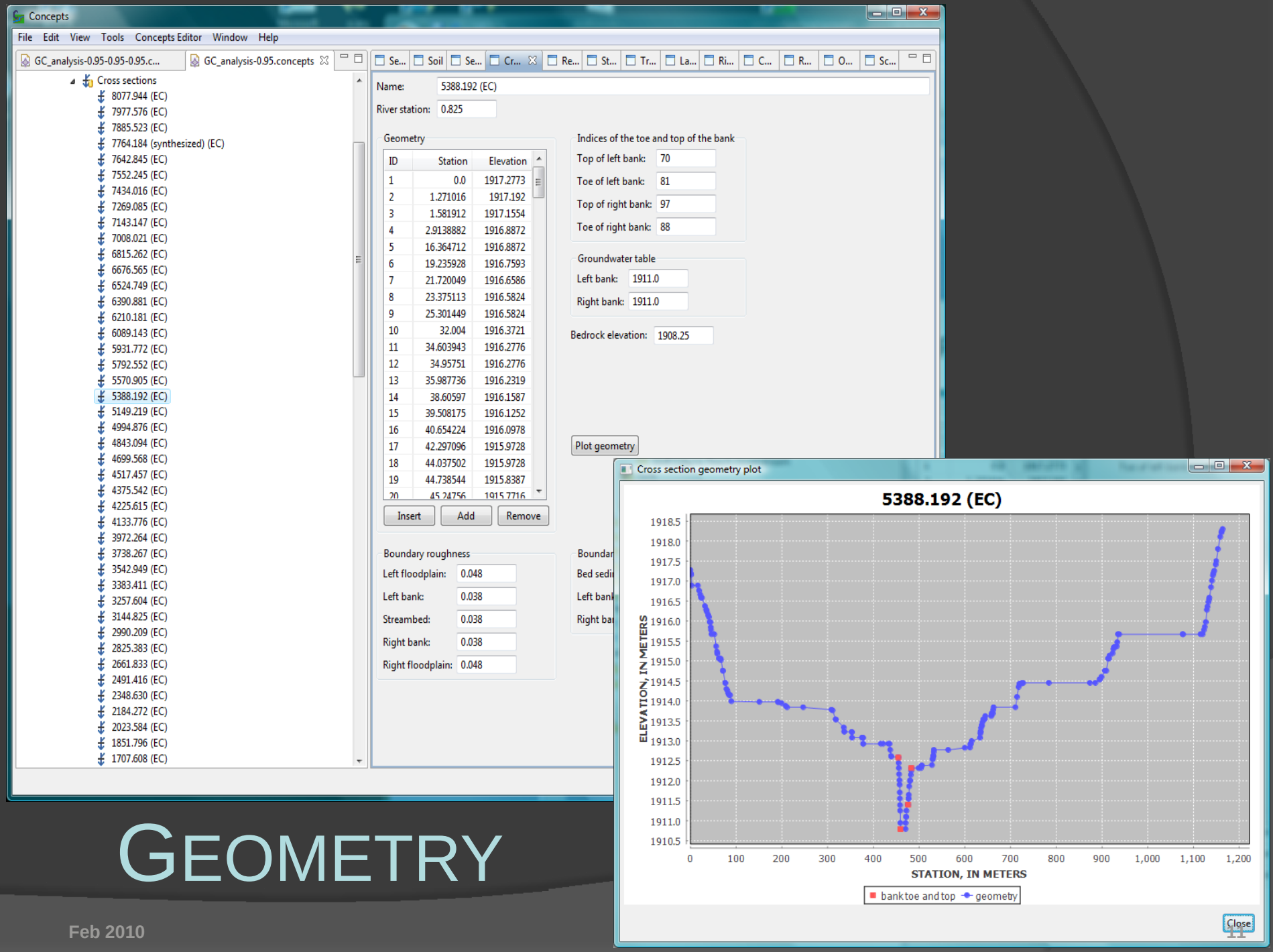


CONCEPTS simulates response of channels to loadings of water and sediment, and to in-stream structures

http://www.ars.usda.gov/Research

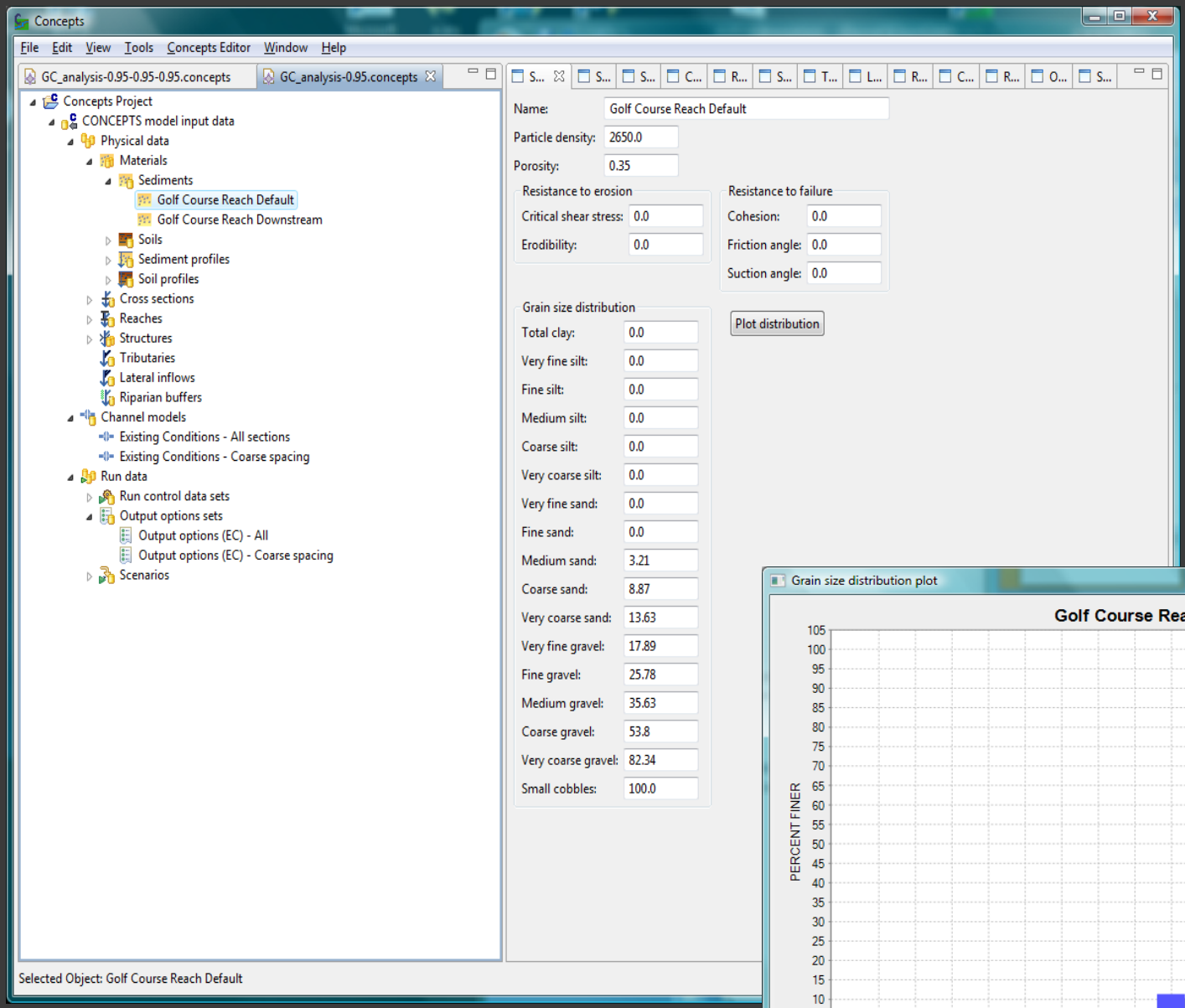
CONCEPTS INPUT

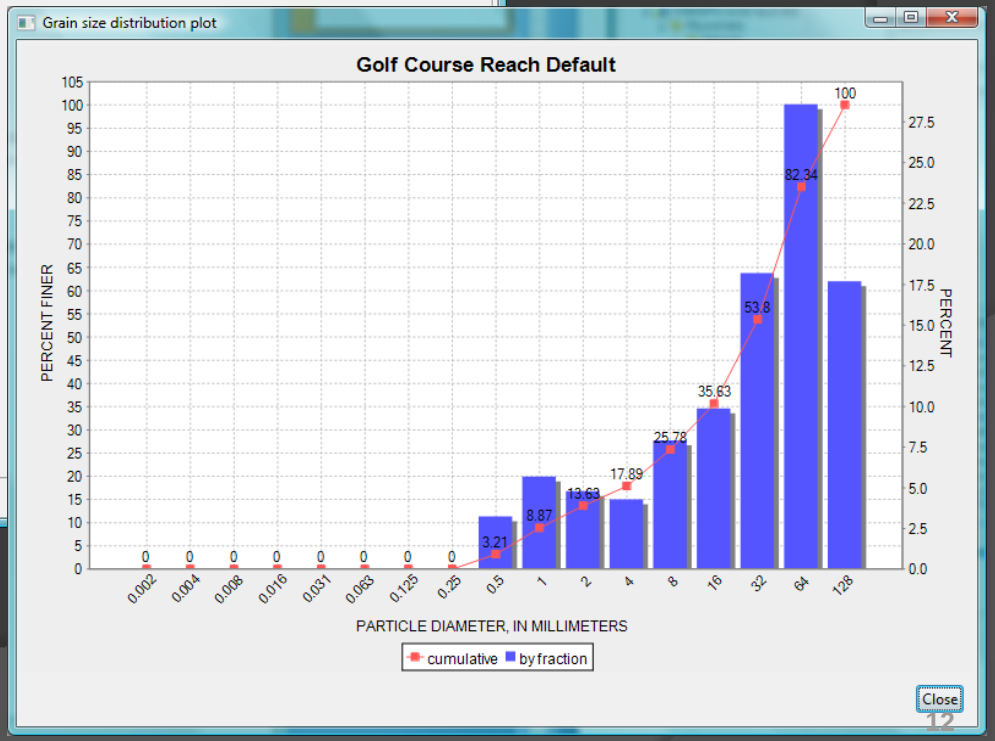
- Channel Network
- Channel Geometry
- Roughness Characteristics
- Bed and Bank Composition
- Flow and Sediment
  - Upstream boundary
  - Tributaries


Concepts
File Edit View Tools Concepts Editor Window Help
GC_analysis-0.95-0.95-0.95.c...
GC_analysis-0.95.concepts
Cross sections
8077.944 (EC)
7977.576 (EC)
7885.523 (EC)
7764.184 (synthesized) (EC)
7642.845 (EC)
7552.245 (EC)
7434.016 (EC)
7269.085 (EC)
7143.147 (EC)
7008.021 (EC)
6815.262 (EC)
6676.565 (EC)
6524.749 (EC)
6390.881 (EC)
6210.181 (EC)
6089.143 (EC)
5931.772 (EC)
5792.552 (EC)
5570.905 (EC)
5388.192 (EC)
5149.219 (EC)
4994.876 (EC)
4843.094 (EC)
4699.568 (EC)
4517.457 (EC)
4375.542 (EC)
4225.615 (EC)
4133.776 (EC)
3972.264 (EC)
3738.267 (EC)
3542.949 (EC)
3383.411 (EC)
3257.604 (EC)
3144.825 (EC)
2990.209 (EC)
2825.383 (EC)
2661.833 (EC)
2491.416 (EC)
2348.630 (EC)
2184.272 (EC)
2023.584 (EC)
1851.796 (EC)
1707.608 (EC)
Se... Soil Se... Cr... Re... St... Tr... La... Ri... C... R... O... Sc...
Name: 5388.192 (EC)
River station: 0.825
Geometry
ID Station Elevation
1 0.0 1917.2773
2 1.271016 1917.192
3 1.581912 1917.1554
4 2.9138882 1916.8872
5 16.364712 1916.8872
6 19.235928 1916.7593
7 21.720049 1916.6586
8 23.375113 1916.5824
9 25.301449 1916.5824
10 32.004 1916.3721
11 34.603943 1916.2776
12 34.95751 1916.2776
13 35.987736 1916.2319
14 38.60597 1916.1587
15 39.508175 1916.1252
16 40.654224 1916.0978
17 42.297096 1915.9728
18 44.037502 1915.9728
19 44.738544 1915.8387
Insert Add Remove
Indices of the toe and top of the bank
Top of left bank: 70
Toe of left bank: 81
Top of right bank: 97
Toe of right bank: 88
Groundwater table
Left bank: 1911.0
Right bank: 1911.0
Bedrock elevation: 1908.25
Plot geometry
Boundary roughness
Left floodplain: 0.048
Left bank: 0.038
Streambed: 0.038
Right bank: 0.038
Right floodplain: 0.048
Cross section geometry plot
5388.192 (EC)
ELEVATION, IN METERS
STATION, IN METERS
bank toe and top
geometry
Close

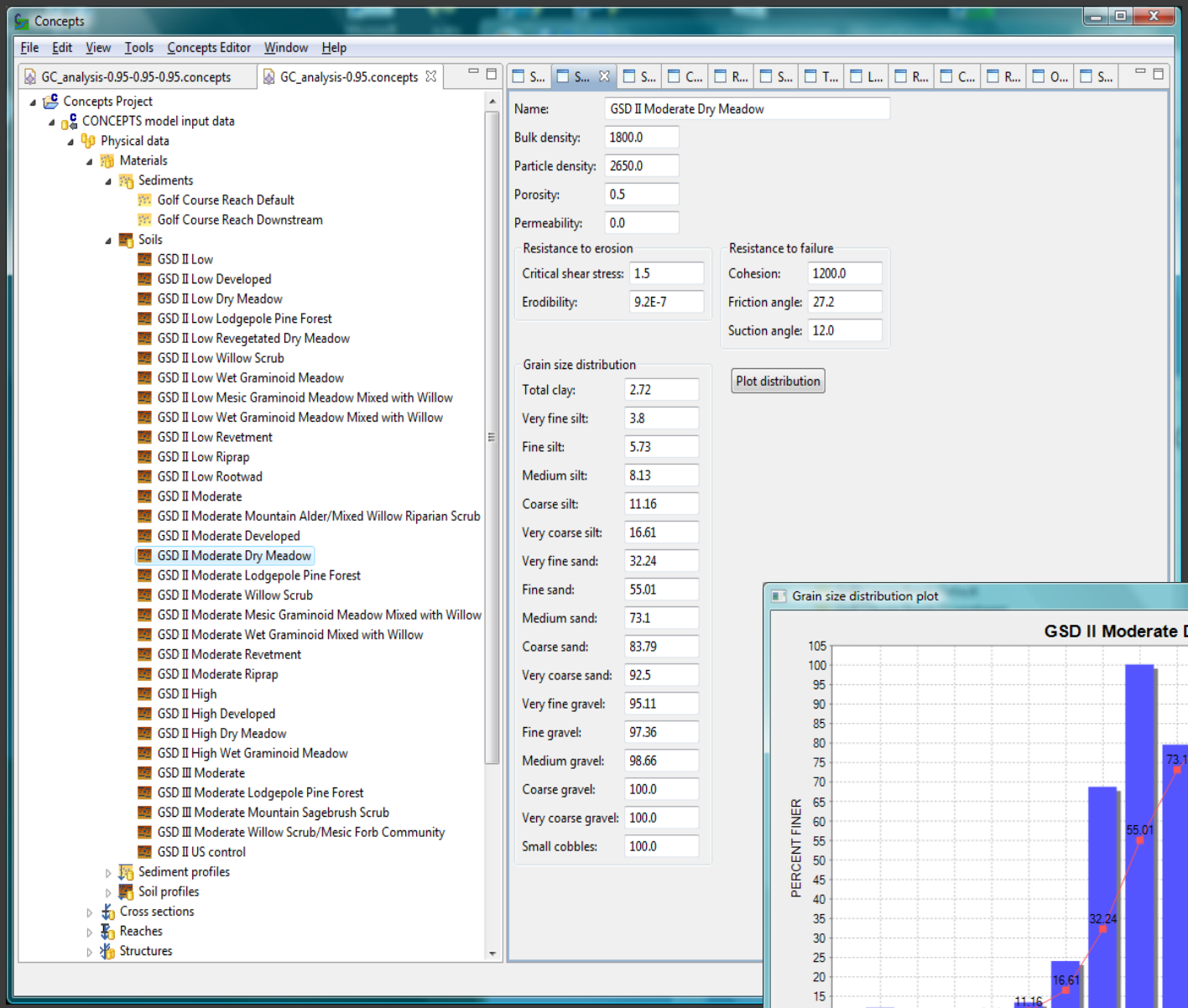
GEOMETRY

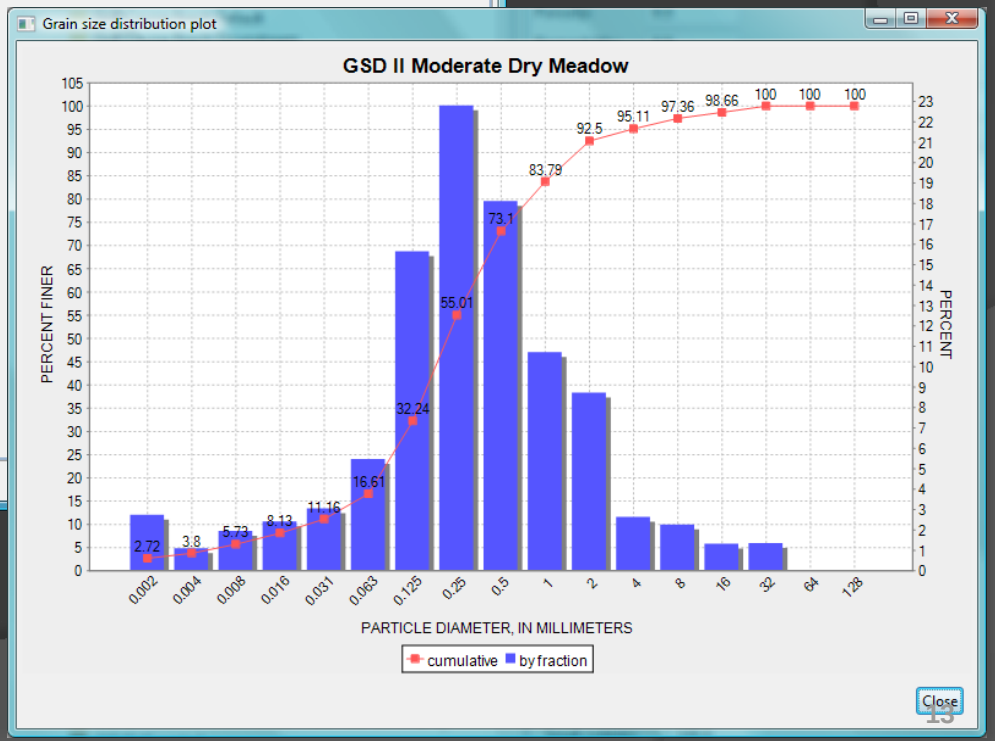
SEDIMENTS


Concepts
File Edit View Tools Concepts Editor Window Help
GC_analysis-0.95-0.95-0.95.concepts
GC_analysis-0.95.concepts
Concepts Project
CONCEPTS model input data
Physical data
Materials
Sediments
Golf Course Reach Default
Golf Course Reach Downstream
Soils
Sediment profiles
Soil profiles
Cross sections
Reaches
Structures
Tributaries
Lateral inflows
Riparian buffers
Channel models
Existing Conditions - All sections
Existing Conditions - Coarse spacing
Run data
Run control data sets
Output options sets
Output options (EC) - All
Output options (EC) - Coarse spacing
Scenarios
Name: Golf Course Reach Default
Particle density: 2650.0
Porosity: 0.35
Resistance to erosion
Critical shear stress: 0.0
Erodibility: 0.0
Resistance to failure
Cohesion: 0.0
Friction angle: 0.0
Suction angle: 0.0
Grain size distribution
Total clay: 0.0
Very fine silt: 0.0
Fine silt: 0.0
Medium silt: 0.0
Coarse silt: 0.0
Very coarse silt: 0.0
Very fine sand: 0.0
Fine sand: 0.0
Medium sand: 3.21
Coarse sand: 8.87
Very coarse sand: 13.63
Very fine gravel: 17.89
Fine gravel: 25.78
Medium gravel: 35.63
Coarse gravel: 53.8
Very coarse gravel: 82.34
Small cobbles: 100.0
Plot distribution
Selected Object: Golf Course Reach Default

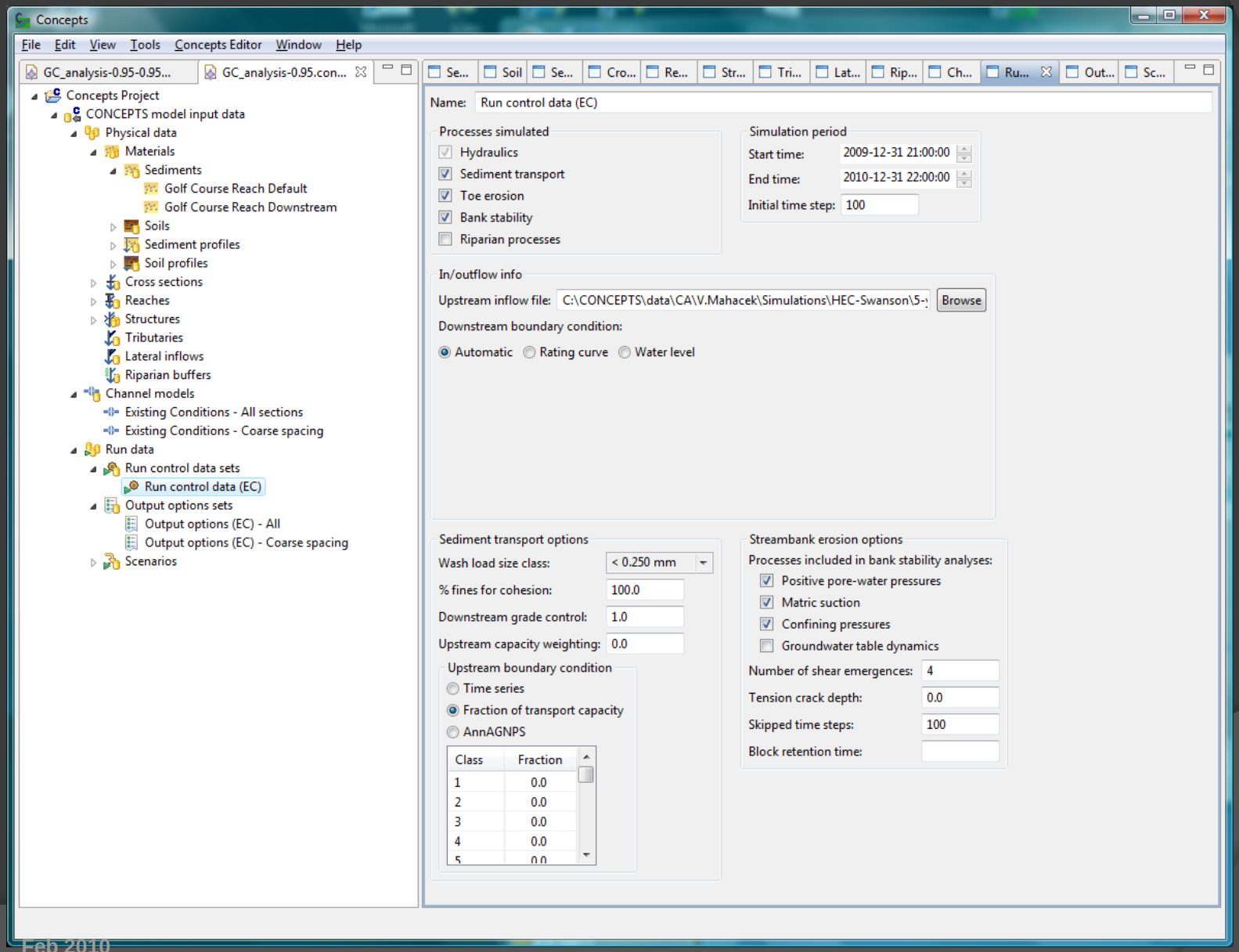

Grain size distribution plot
Golf Course Reach Default
PERCENT FINER
PERCENT
PARTICLE DIAMETER, IN MILLIMETERS
0.002 0.004 0.008 0.016 0.031 0.063 0.125 0.25 0.5 1 2 4 8 16 32 64 128
0 0 0 0 0 0 0 0 3.21 8.87 13.63 17.89 25.78 35.63 53.8 82.34 100
cumulative
by fraction
Close

SOILS


Concepts
File Edit View Tools Concepts Editor Window Help
GC_analysis-0.95-0.95-0.95.concepts
GC_analysis-0.95.concepts
Concepts Project
CONCEPTS model input data
Physical data
Materials
Sediments
Golf Course Reach Default
Golf Course Reach Downstream
Soils
GSD II Low
GSD II Low Developed
GSD II Low Dry Meadow
GSD II Low Lodgepole Pine Forest
GSD II Low Revegetated Dry Meadow
GSD II Low Willow Scrub
GSD II Low Wet Graminoid Meadow
GSD II Low Mesic Graminoid Meadow Mixed with Willow
GSD II Low Wet Graminoid Meadow Mixed with Willow
GSD II Low Revetment
GSD II Low Riprap
GSD II Low Rootwad
GSD II Moderate
GSD II Moderate Mountain Alder/Mixed Willow Riparian Scrub
GSD II Moderate Developed
GSD II Moderate Dry Meadow
GSD II Moderate Lodgepole Pine Forest
GSD II Moderate Willow Scrub
GSD II Moderate Mesic Graminoid Meadow Mixed with Willow
GSD II Moderate Wet Graminoid Mixed with Willow
GSD II Moderate Revetment
GSD II Moderate Riprap
GSD II High
GSD II High Developed
GSD II High Dry Meadow
GSD II High Wet Graminoid Meadow
GSD III Moderate
GSD III Moderate Lodgepole Pine Forest
GSD III Moderate Mountain Sagebrush Scrub
GSD III Moderate Willow Scrub/Mesic Forb Community
GSD II US control
Sediment profiles
Soil profiles
Cross sections
Reaches
Structures
Name: GSD II Moderate Dry Meadow
Bulk density: 1800.0
Particle density: 2650.0
Porosity: 0.5
Permeability: 0.0
Resistance to erosion
Critical shear stress: 1.5
Erodibility: 9.2E-7
Resistance to failure
Cohesion: 1200.0
Friction angle: 27.2
Suction angle: 12.0
Grain size distribution
Total clay: 2.72
Very fine silt: 3.8
Fine silt: 5.73
Medium silt: 8.13
Coarse silt: 11.16
Very coarse silt: 16.61
Very fine sand: 32.24
Fine sand: 55.01
Medium sand: 73.1
Coarse sand: 83.79
Very coarse sand: 92.5
Very fine gravel: 95.11
Fine gravel: 97.36
Medium gravel: 98.66
Coarse gravel: 100.0
Very coarse gravel: 100.0
Small cobbles: 100.0
Plot distribution

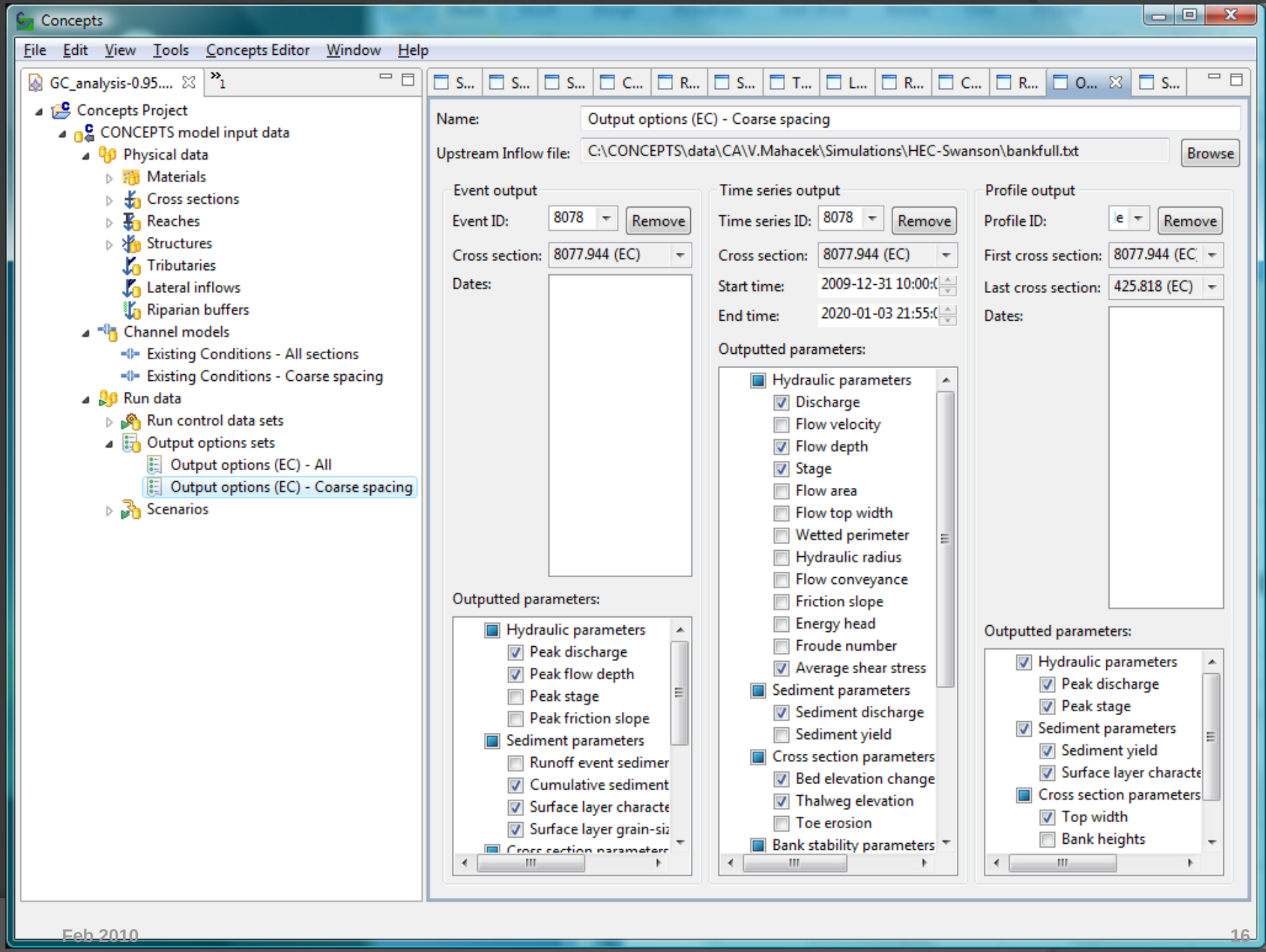

Grain size distribution plot
GSD II Moderate Dry Meadow
PERCENT FINER
PERCENT
PARTICLE DIAMETER, IN MILLIMETERS
0.002
0.004
0.008
0.016
0.031
0.063
0.125
0.25
0.5
1
2
4
8
16
32
64
128
2.72
3.8
5.73
8.13
11.16
16.61
32.24
55.01
73.1
83.79
92.5
95.11
97.36
98.66
100
100
100
cumulative
by fraction
Close

Run Control Options



CONCEPTS OUTPUT

- Parameters
  - Channel Geometry
  - Hydraulic Variables
  - Sediment Yield
- Formats
  - For a location (XS) at a specific time step
  - For a location (XS) over time period
  - For an event (time step or period) for a reach (XSs)


Concepts
File Edit View Tools Concepts Editor Window Help
GC_analysis-0.95....
Concepts Project
CONCEPTS model input data
Physical data
Materials
Cross sections
Reaches
Structures
Tributaries
Lateral inflows
Riparian buffers
Channel models
Existing Conditions - All sections
Existing Conditions - Coarse spacing
Run data
Run control data sets
Output options sets
Output options (EC) - All
Output options (EC) - Coarse spacing
Scenarios
Name: Output options (EC) - Coarse spacing
Upstream Inflow file: C:\CONCEPTS\data\CA\V.Mahacek\Simulations\HEC-Swanson\bankfull.txt
Browse
Event output
Event ID: 8078
Remove
Cross section: 8077.944 (EC)
Dates:
Outputted parameters:
Hydraulic parameters
Peak discharge
Peak flow depth
Peak stage
Peak friction slope
Sediment parameters
Runoff event sedimer
Cumulative sediment
Surface layer characte
Surface layer grain-siz
Time series output
Time series ID: 8078
Remove
Cross section: 8077.944 (EC)
Start time: 2009-12-31 10:00:0
End time: 2020-01-03 21:55:0
Outputted parameters:
Hydraulic parameters
Discharge
Flow velocity
Flow depth
Stage
Flow area
Flow top width
Wetted perimeter
Hydraulic radius
Flow conveyance
Friction slope
Energy head
Froude number
Average shear stress
Sediment parameters
Sediment discharge
Sediment yield
Cross section parameters
Bed elevation change
Thalweg elevation
Toe erosion
Bank stability parameters
Profile output
Profile ID: e
Remove
First cross section: 8077.944 (EC
Last cross section: 425.818 (EC)
Dates:
Outputted parameters:
Hydraulic parameters
Peak discharge
Peak stage
Sediment parameters
Sediment yield
Surface layer characte
Cross section parameters
Top width
Bank heights