Geomorphic Overlays

Using SAM to Determine the “Effective Discharge”
Geomorphic Overlays

- **Part 1**
  - HEFR Adjustments to Daily Flows

- **Part 2**
  - Quick Introduction to Single Representative Discharges

- **Part 3**
  - Using SAM to Determine the “Effective Discharge”
### HEFR FLOWS

**Overbank Flows**

- **Return Period (R):** 0.8 (years)
- **Duration (D):** 32 (days)
- **Volume (V):** 1353987 (ac-ft)
- **Peak Flow (Q):** 31800 (cfs)

<table>
<thead>
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<th>High Flow Pulses</th>
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<th>F: 1</th>
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<td>V: 17009</td>
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### Base Flows (cfs)

- Dec: 6110
- Jan: 6640
- Feb: 2190
- Mar: 1430
- Apr: 2800
- May: 4000
- Jun: 1220
- Jul: 870
- Aug: 1540
- Sep: 2340
- Oct: 770
- Nov: 703

### Subsistence Flows (cfs)

- Dec: 703
- Jan: 703
- Feb: 703
- Mar: 703
- Apr: 703
- May: 703
- Jun: 703
- Jul: 703
- Aug: 703
- Sep: 703
- Oct: 703
- Nov: 703
Average Hydrograph
Dry Hydrograph

Flow (cfs)

- BON WIER USGS FLOW
- BON WIER ADJ-HEFR FLOW
Wet Hydrograph

Flow (cfs)

- BON WIER USGS FLOW
- BON WIER ADJ-HEFR FLOW

January 1972 to November 1973

The graph shows the flow of water in cubic feet per second (cfs) for each month from January 1972 to November 1973. The flow values range from 0 to 45,000 cfs. The blue line represents the BON WIER USGS FLOW, and the red line represents the BON WIER ADJ-HEFR FLOW.
Charley River–USGS Alaska
A River in Europe
Mississippi River
Tensas River
The Point

- An alluvial stream will adjust the dimensions of its channel to the wide range of flows that mobilize its boundary sediments.
- Will Sabine or Neches Rivers change as a result of Proposed Environmental Flow regime?
Single Representative Discharge

- Research has shown that in many rivers a single discharge can be used to determine a stable channel geometry.

- The Single Representative Discharge is sometimes called:
  - Dominant Discharge
  - Channel Forming Discharge
  - Effective Discharge
  - Bankfull Discharge
Single Representative Discharge

- For my talk Channel-forming Discharge and dominant discharge are equivalent
  - The theoretical discharge that if maintained indefinitely would result in the same channel geometry as the existing channel geometry with the natural range of flow events.
Single Representative Discharge

Three methods for determining Channel Forming Discharge

- Bankfull
- Specified recurrence interval discharge
- Effective Discharge
Figure 5.2  Downstream width-discharge relationships in sand-bed streams based on data from various sources.
Regime Equations

- Regime Equations from Julien and Wargadalam

- $W \approx 0.512Q^{0.53}d_s^{-0.33}\tau_*^{-0.2}$
- $V \approx 14.7Q^{0.07}d_s^{0.33}\tau_*^{0.47}$
- $h \approx 0.133Q^{0.40}\tau_*^{-0.2}$
- $S \approx 14.7Q^{-0.4}d_s\tau_*^{1.2}$

- Where: $Q =$ dominant flow discharge, $d_s = d_{50}$ of the bed material, $\tau_* =$ Shields parameter $S =$ slope, $V =$ velocity $h =$ depth
PART 2
Using SAM to Determine the “Effective Discharge”

- What is Effective Discharge?
- Terms and Definitions
- What is SAM?
- Example Application of SAM to the Sabine River at Bon Wier for development of a Geomorphic Overlay
EFFECTIVE DISCHARGE:
Effective discharge is defined as the mean of the discharge increment that transports the largest fraction of the annual sediment load over a period of years (Andrews 1980). It is calculated by integrating the flow-duration curve and a bed-material-sediment rating curve. (USACE 2000)
Effective Discharge:
The effective discharge incorporates the principle prescribed by Wolman and Miller (1960) that the channel-forming discharge is a function of both the magnitude of the event and its frequency of occurrence.
Terms and Definitions

- Effective discharge is calculated using only the *Total Bed Material Load*

- *Wash Load* is not included in computations
The SAM package is designed to provide hydraulic engineers smooth transition from making hydraulic calculations to calculating sediment transport capacity to making sediment yield determinations.
Required Data For SAM Computations of Effective Discharge

Channel Cross Section
Bed Material Gradation
Channel Bed Slope
Flow Duration Curve
Cross-Section Sabine River at Bon Wier

Distance in Feet

Elevation in Feet NGVD

USGS Measurement
SAM Cross Section
Sam Input
Bed Material Gradation

- From USACE Report
- $D_{16} = 0.0625\, \text{mm}$
- $D_{50} = 0.14\, \text{mm}$
- $D_{84} = 0.30\, \text{mm}$
- $D_{100} = 0.5\, \text{mm}$
- Channel Bottom Slope = $0.00014\, \text{ft/ft}$
or about $0.75\, \text{ft per mile}$
Flow duration Curve

Flow Duration Curve
1972-2007

Flow in CFS

Percent of Time Flows equaled or Exceeded

Observed Flows
Sam output

- Hydraulics
SAM OUTPUT

- Observed Hydrologic Regime
  - Annual Water Yield = 5,465,145 AC FT
  - Annual Sediment Yield = 3,342,038 Tons
Sediment Histograms

Sediment Load in Tons

Mid-Point of Discharge Bin in CFS
Sediment Histograms

Existing Conditions

Mid Point of Discharge Bin in CFS

Sediment Load in Tons

0 50000 100000 150000 200000 250000 300000 350000 400000 450000

1284 3238 5192 7146 9099 11053 13007 14961 16915 18869 20823 22776
Adjusted the yearly Hydrographs
From 1972-2007 to reflect full implementation of the HEFR Flow regime
New Flow duration Curve

Flow Duration Curve

- Observed Flows
- HEFR Adjusted Flows

Flow in CFS vs Percent of Time Flows equaled or Exceeded
SAM OUTPUT

- HEFR Hydrologic Regime
  - Annual Water Yield = 2,397,320 AC FT
  - Annual Sediment Yield = 1,068,724 Tons
Sediment Histograms

HEFR Adjusted FLOWS

Sediment Load in Tons

Mid Point of Discharge Bin in CFS

[Graph showing sediment histograms with midpoints and amounts in tons]
Sediment Histograms

HEFR Adjusted Flows

<table>
<thead>
<tr>
<th>Mid Point of Discharge Bin in CFS</th>
<th>Sediment Load in Tons</th>
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Comparison of Results

- Significant Decrease in Water and Sediment Yield
- Water Yield
  - 5.5 to 2.4 Million ac-ft.
- Sediment Yield
  - 3.3 to 1.0 tons annually
- Significant Changes in Effective Discharge
Comparison of Results

- Decrease in discharge and Bed material Load can lead to:
  - Reduction in width
  - Depth changes (+/-)
  - Decrease in width-depth ratio
  - Slope changes (+/-)
  - Increase in Sinuosity

- From Stan Schumm (1969)
Channel Incision
Now, if I wanted to be one of those ponderous scientific people, and 'let on' to prove ....... In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles.

..... Therefore, any calm person, who is not blind or idiotic can see that in the Old Oolitic Silurian Period,' just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. ...... that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together ..... There is something fascinating about science One gets such wholesale returns of conjecture out of such a trifling investment of fact.

“Life on the Mississippi” Mark Twain
**Bed Load**: Component of the total sediment load made up of sediment moving in frequent, successive contact with the bed (Bagnold 1966)

**Bed-Material Load**: Portion of the total sediment load composed of grain size found in appreciable quantities in the stream bed, in sand-bed streams significant quantities of bed-material load move as suspended load.
Terms and Definitions

- **Fine Material Load (Wash Load)**: Portion of the total sediment load composed of particles finer than those found in the stream bed, frequently assumed to be the fraction finer than .0625mm.

- **Suspended Load (Total Suspended Load)**: is the Suspended bed material load Plus the Fine material Load.
Terms and Definitions

**Total Bed Material Load**: is Suspended Bed Material Load Plus the Bed load

**Total Sediment Load**: is Bed Material Load Plus the Wash Load
The Hydraulics Module calculates normal depth and composite hydraulic parameters from distributed roughness, including bed roughness predictors.
SAM Sediment Module

- The Sediment Transport Module calculates bed material discharge curves using sediment transport theories.
The Sediment Yield Module calculates sediment yield using the Flow-Duration Sediment-Discharge Rating Curve Method.
SAM provides guidance in the selection of the most applicable sediment transport function for a given stream using bed-material gradations and hydraulic parameters for that stream.
SAM
Hydraulic Design Package for Channels

- Hydraulics Module
- Sediment Transport Module
- Sediment Yield Module
- SAM.AID