Large-scale modeling of sand transport

Stephen Wiele -- USGS
Peter Wilcock -- JHU
Paul Grams – JHU/USU

Large-scale model of sand transport

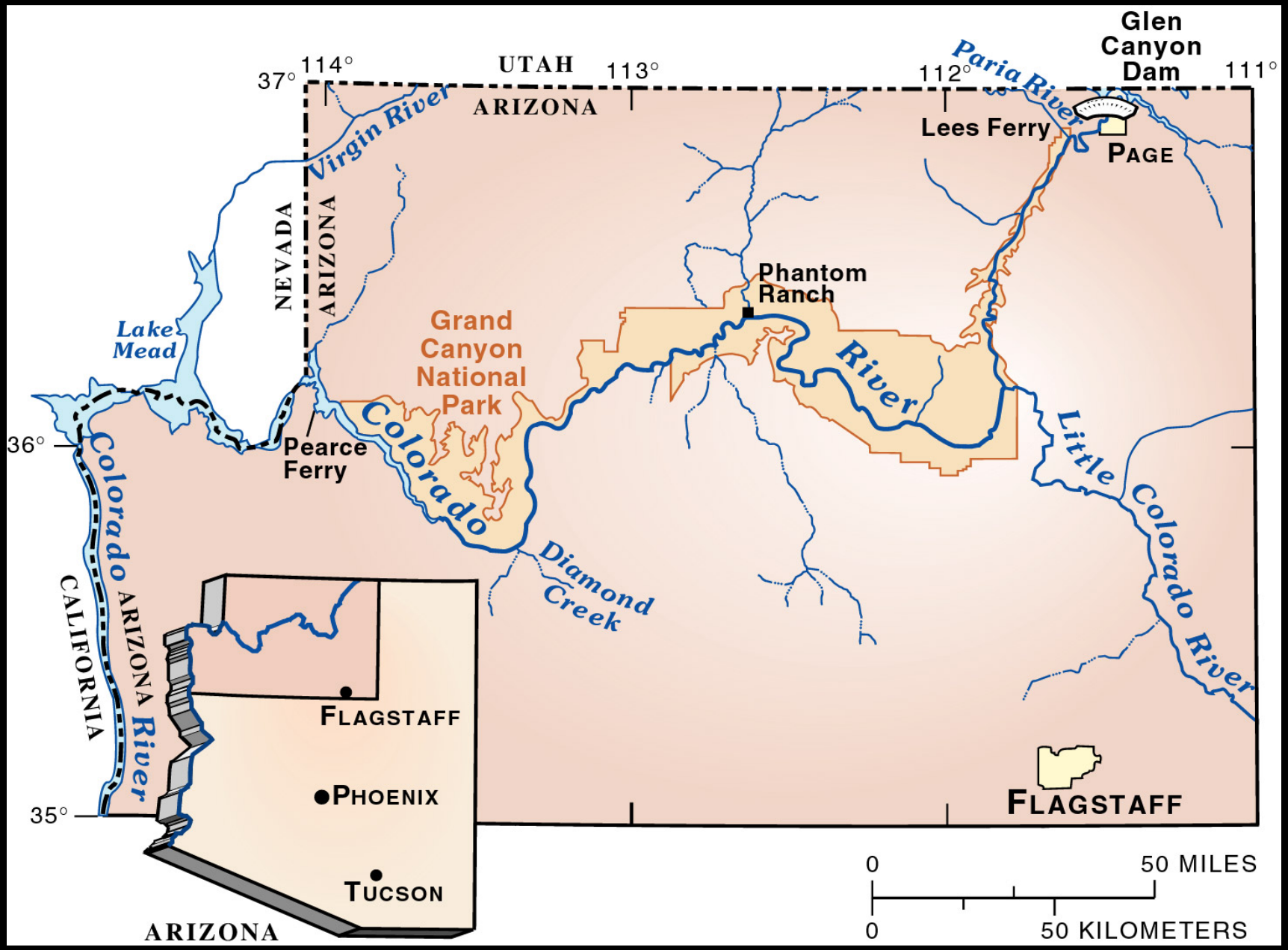
-- multiple grain sizes

-- time-varying flow

-- incorporates 2d model predictions of eddy gains and losses

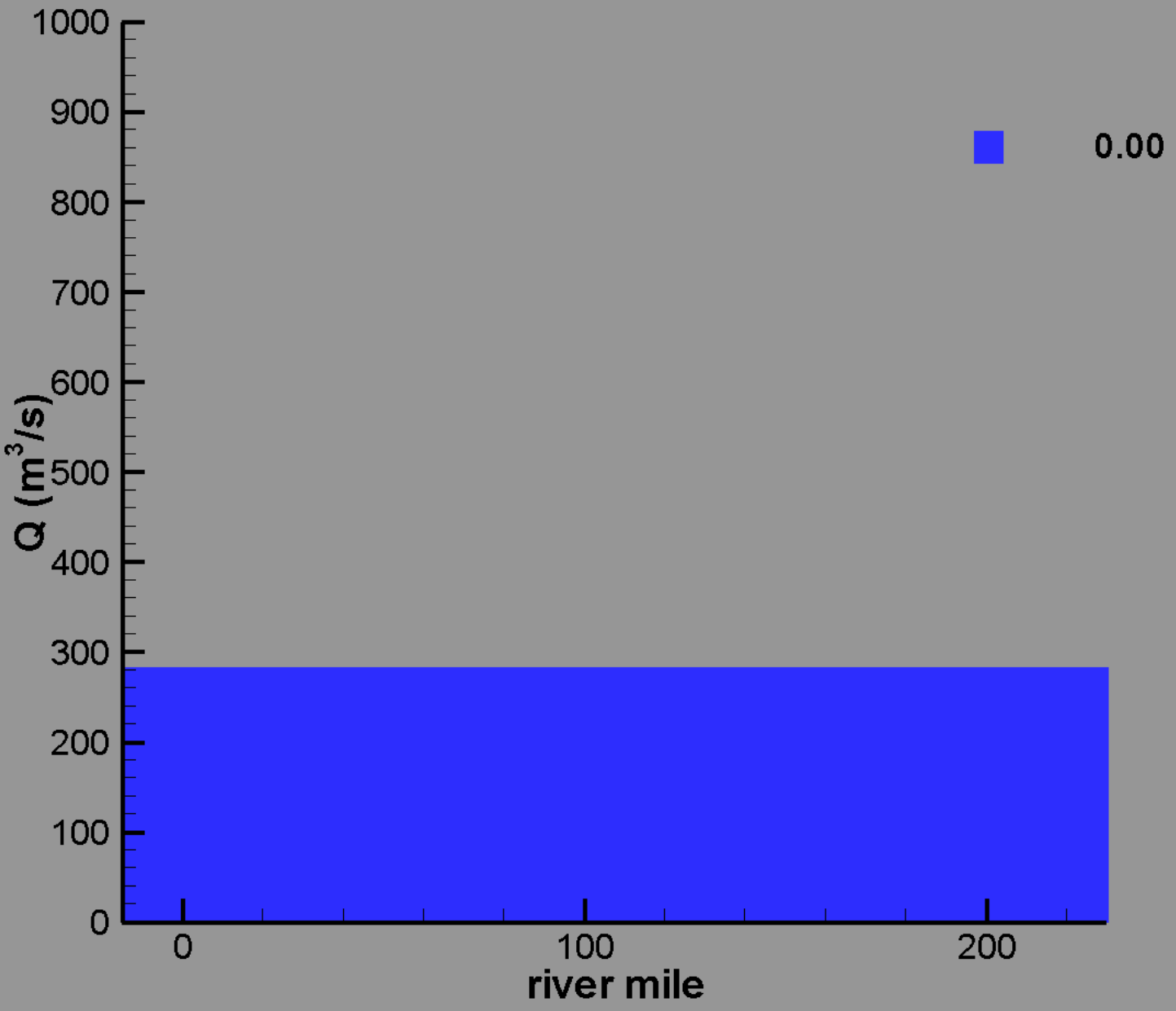
-- uses reach-averaged channel properties

-- incorporates new research on near-bed sand concentrations over a rough boundary


Glen Canyon Dam
Paria River
37°
114°
UTAH
113°
112°
111°
ARIZONA
Virgin River
Lees Ferry
PAGE
NEVADA
ARIZONA
Phantom Ranch
Lake Mead
Grand Canyon National Park
River
Colorado
Little Colorado River
36°
Pearce Ferry
Colorado River
ARIZONA
CALIFORNIA
Diamond Creek
FLAGSTAFF
PHOENIX
35°
TUCSON
ARIZONA
FLAGSTAFF
0
50 MILES
0
50 KILOMETERS

1d unsteady flow model

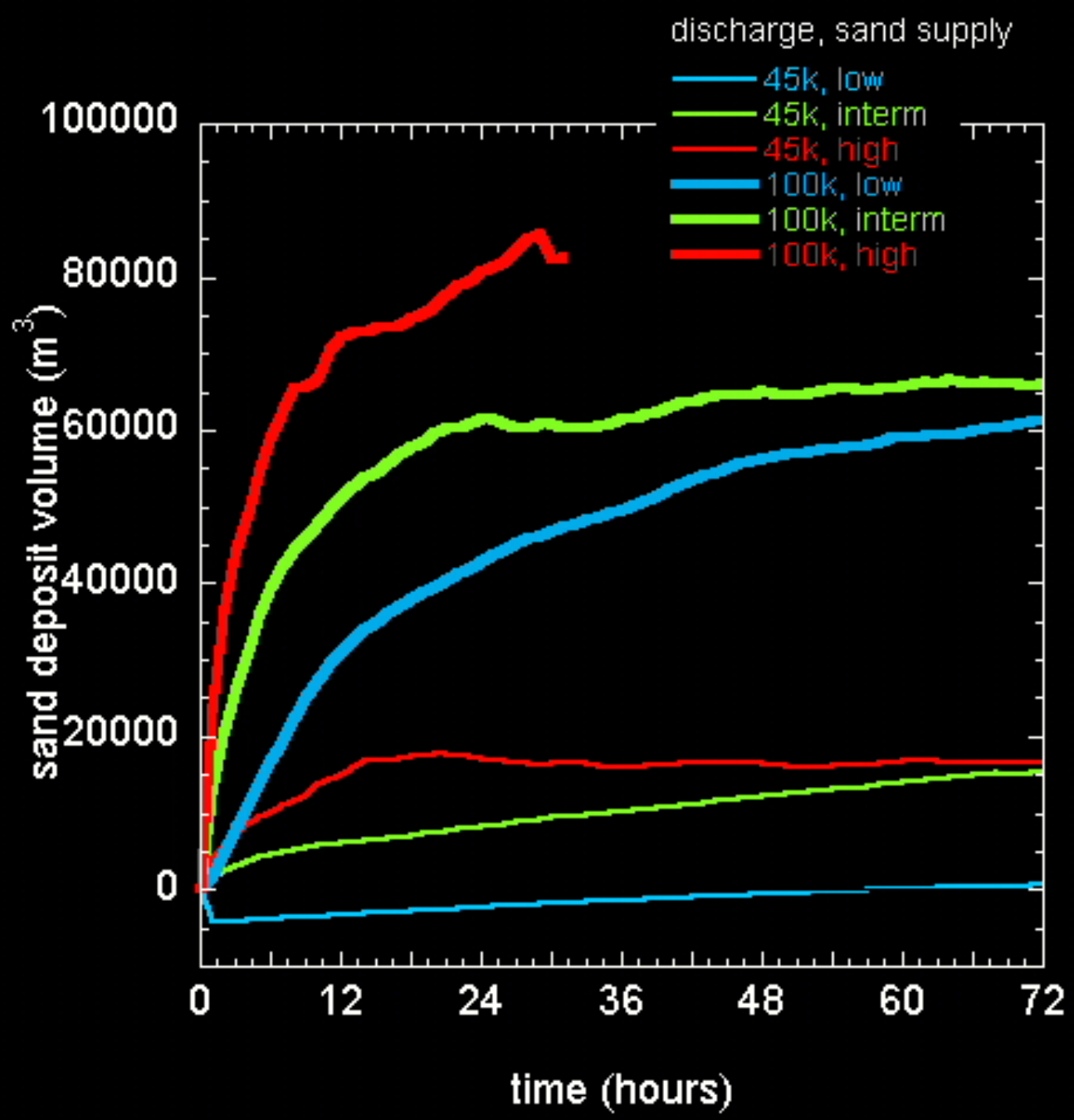
-- predict local discharge as a function of dam releases

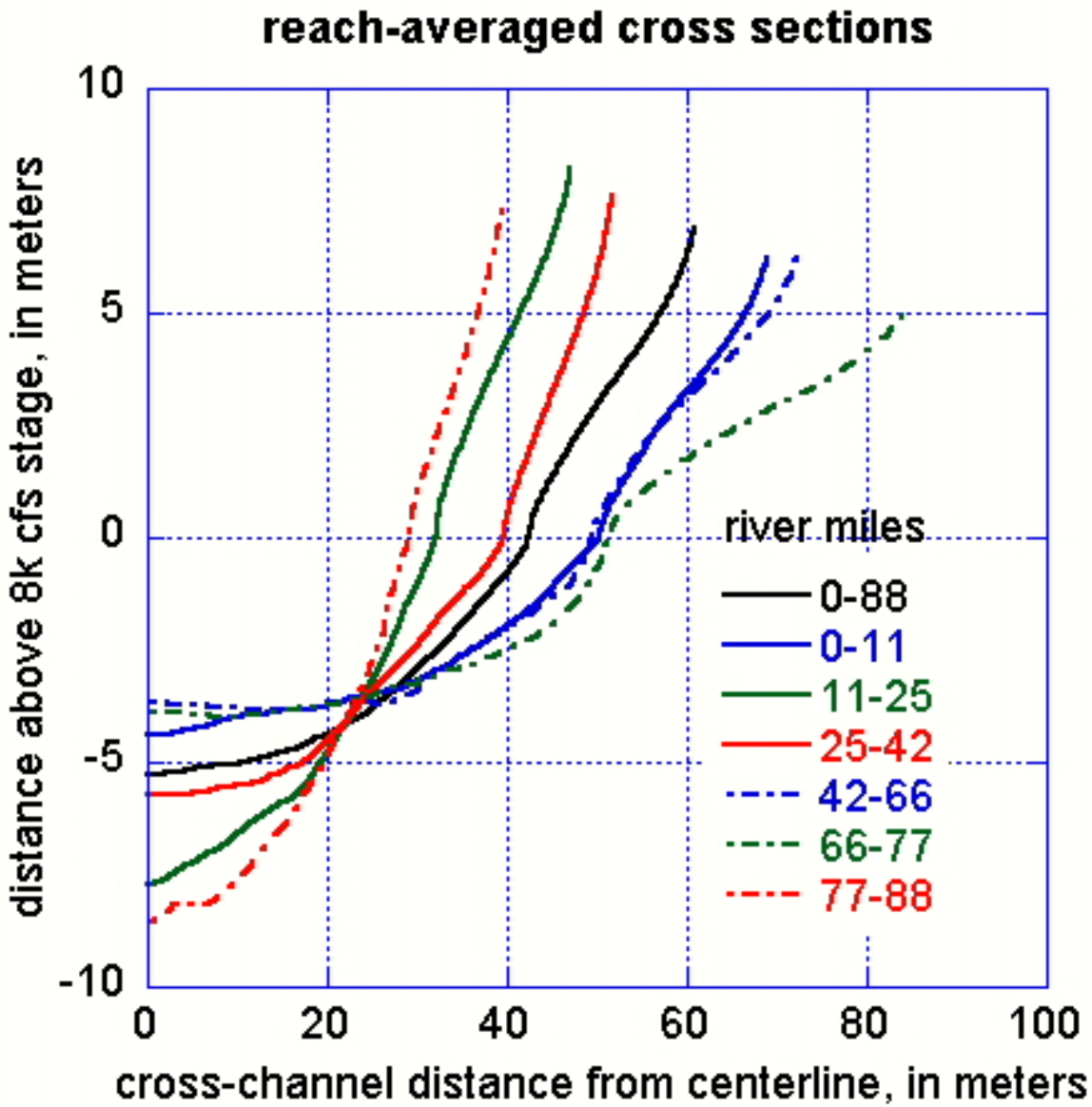

1000
900
800
700
600
500
400
300
200
100
0
Q (m3/s)
0
100
200
river mile
0.00

2d model of flow, sand transport, and bed evolution

-- calculate local flow field as a function of discharge

-- predict local sand deposition and scour as a function of discharge, sand supply, and initial sand deposit

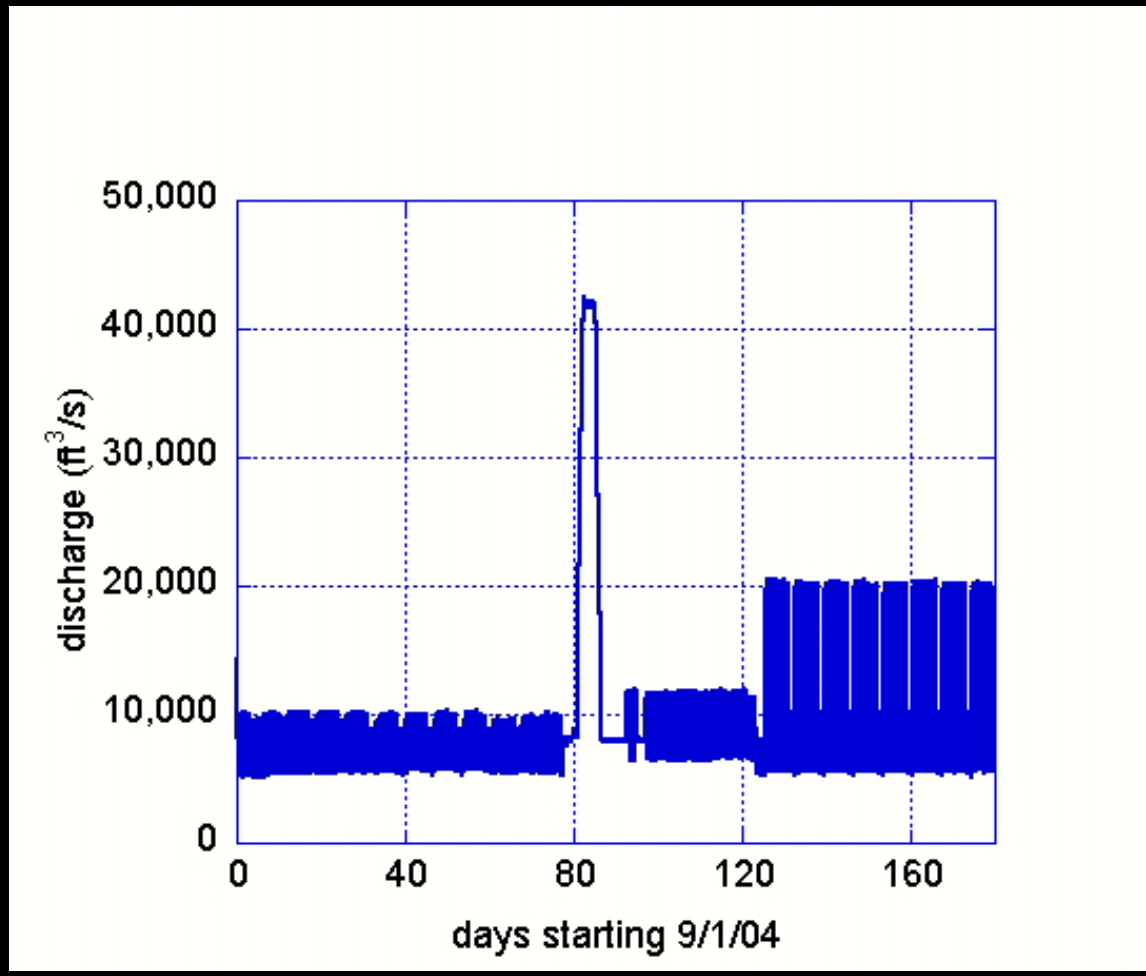

discharge, sand supply
45k, low
45k, interm
45k, high
100k, low
100k, interm
100k, high
100000
80000
60000
40000
20000
0
sand deposit volume (m3)
0
12
24
36
48
60
72
time (hours)

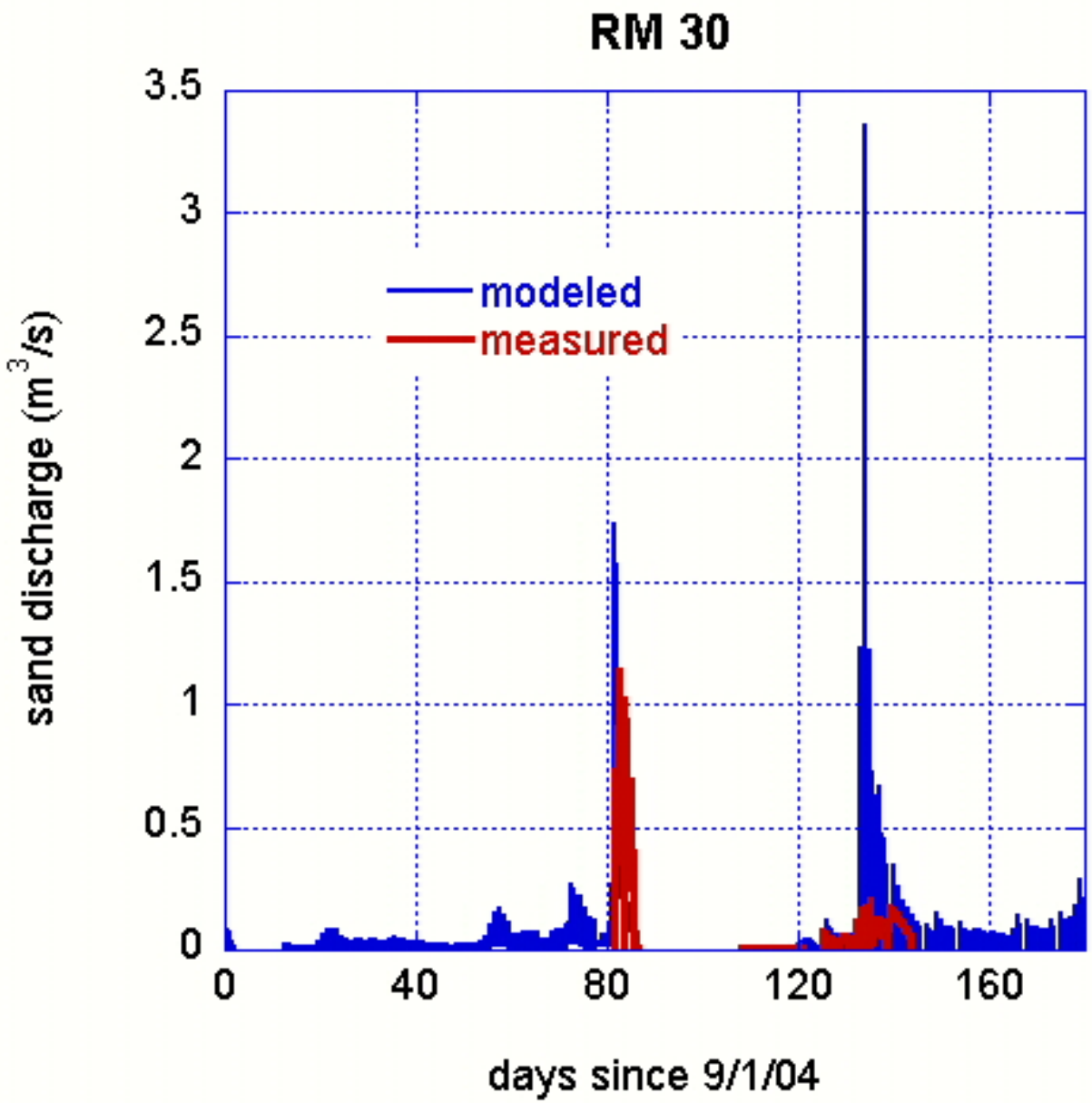

reach-averaged cross sections
10
5
0
-5
-10
distance above 8k cfs stage, in meters
0
20
40
60
80
100
cross-channel distance from centerline, in meters
river miles
0-88
0-11
11-25
25-42
42-66
66-77
77-88

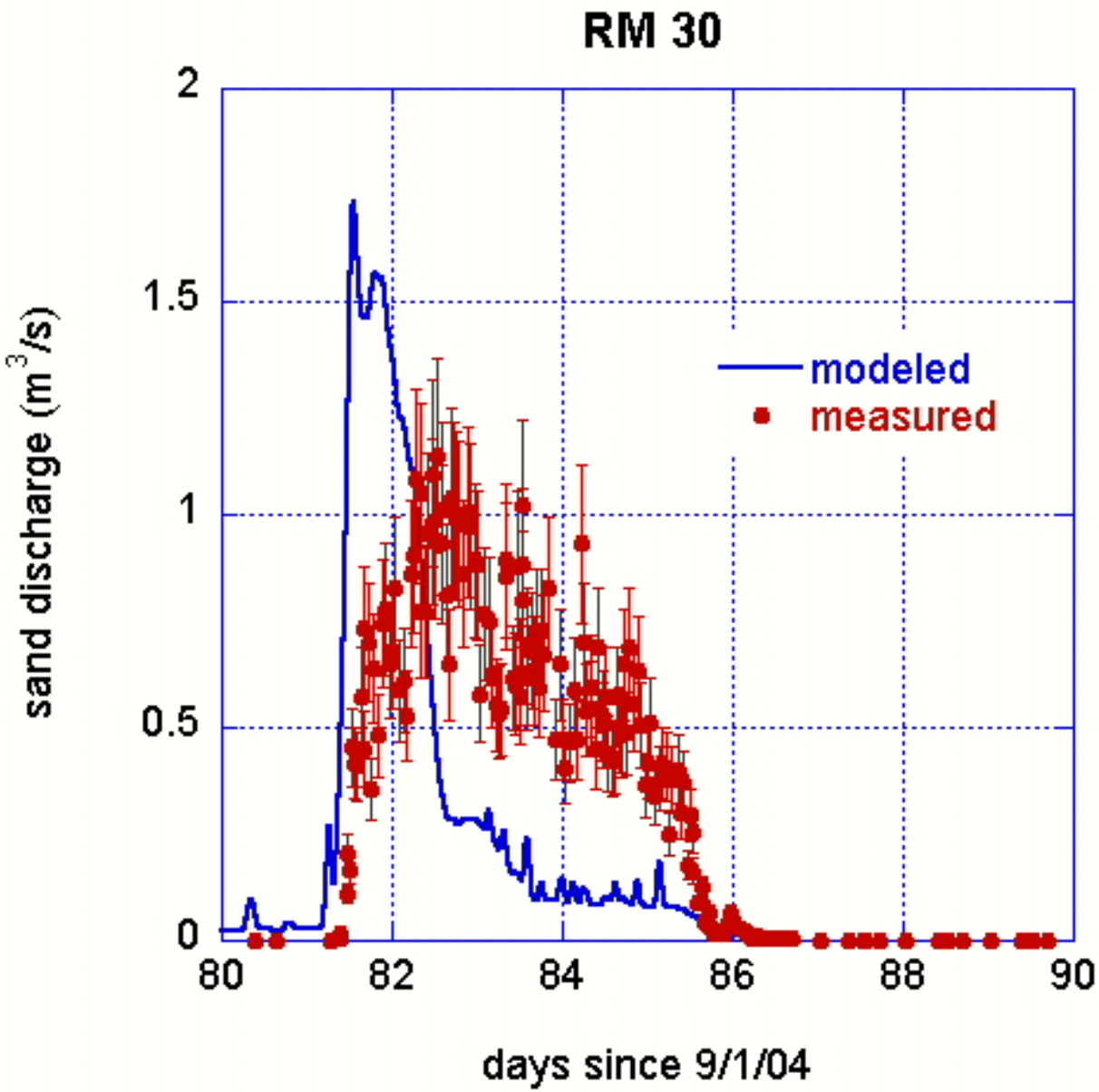
near-bed sand concentration
over a gravel bed

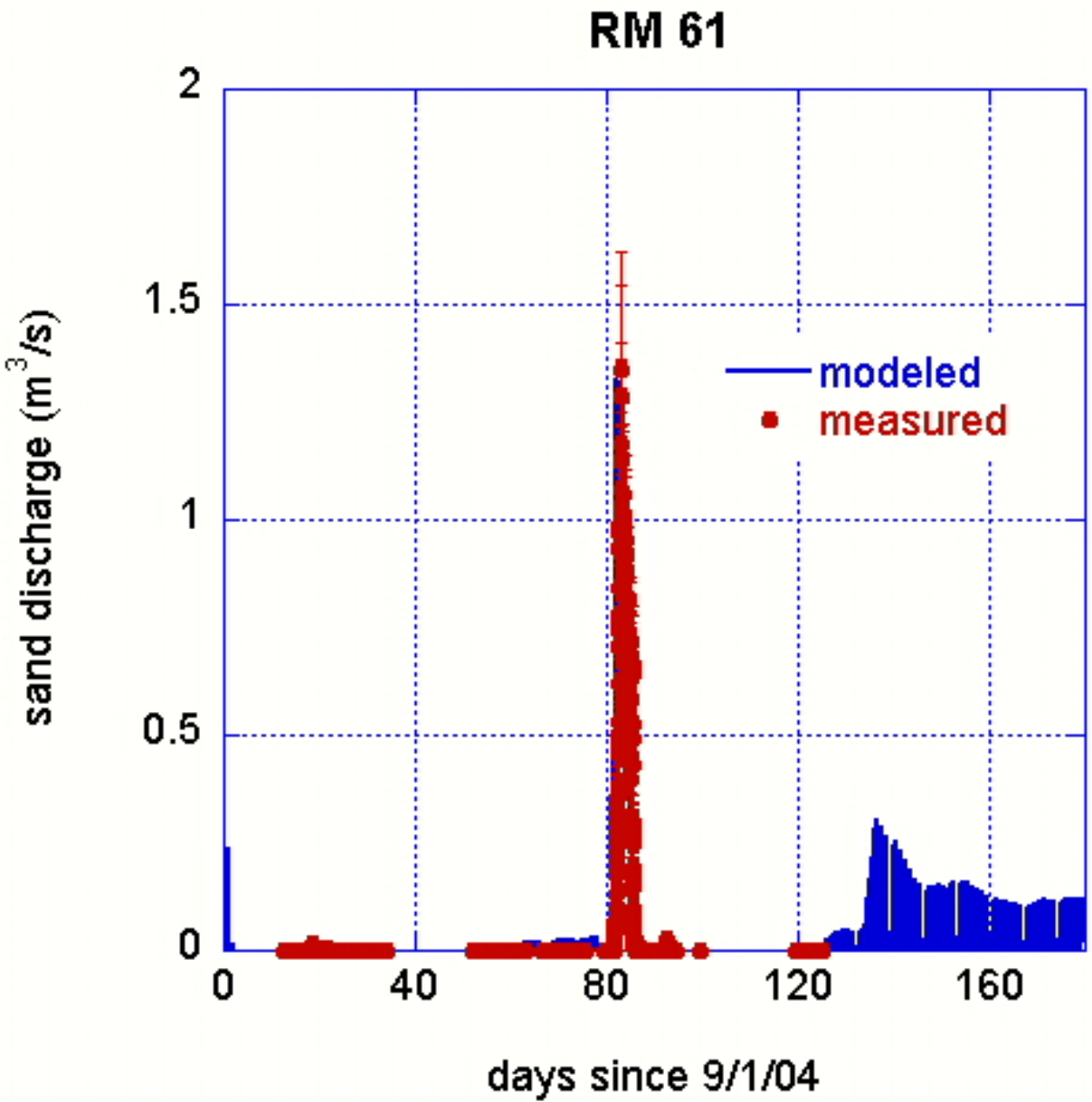
St. Anthony Falls Hydraulic Lab

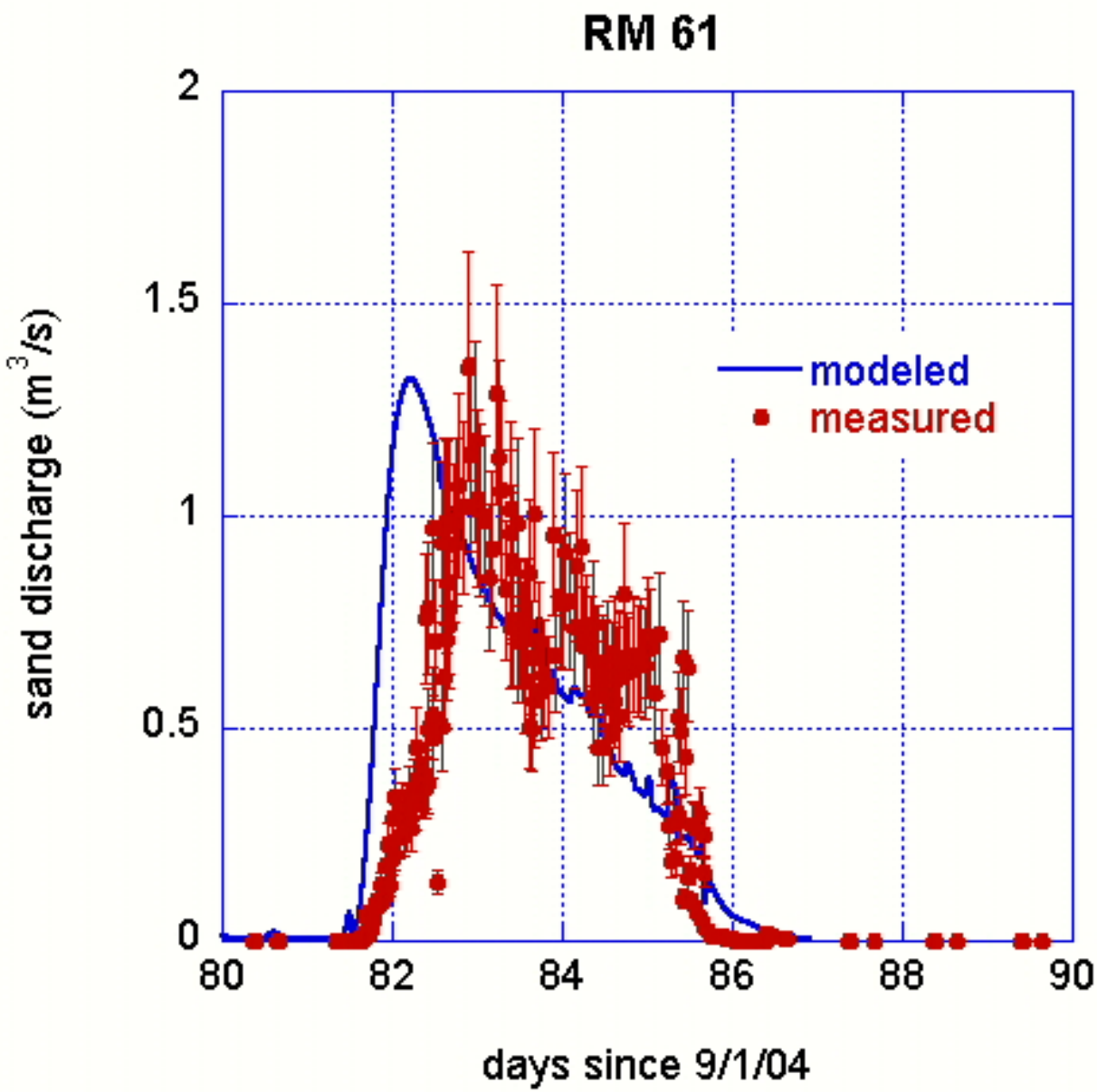
- Sediment inputs at Paria and LCR Rivers (WRD Flagstaff, Topping)
- Sediment measurements at river miles 30, 61, and 87 (GCMRC)
- Sand bar surveys (NAU – FIST)

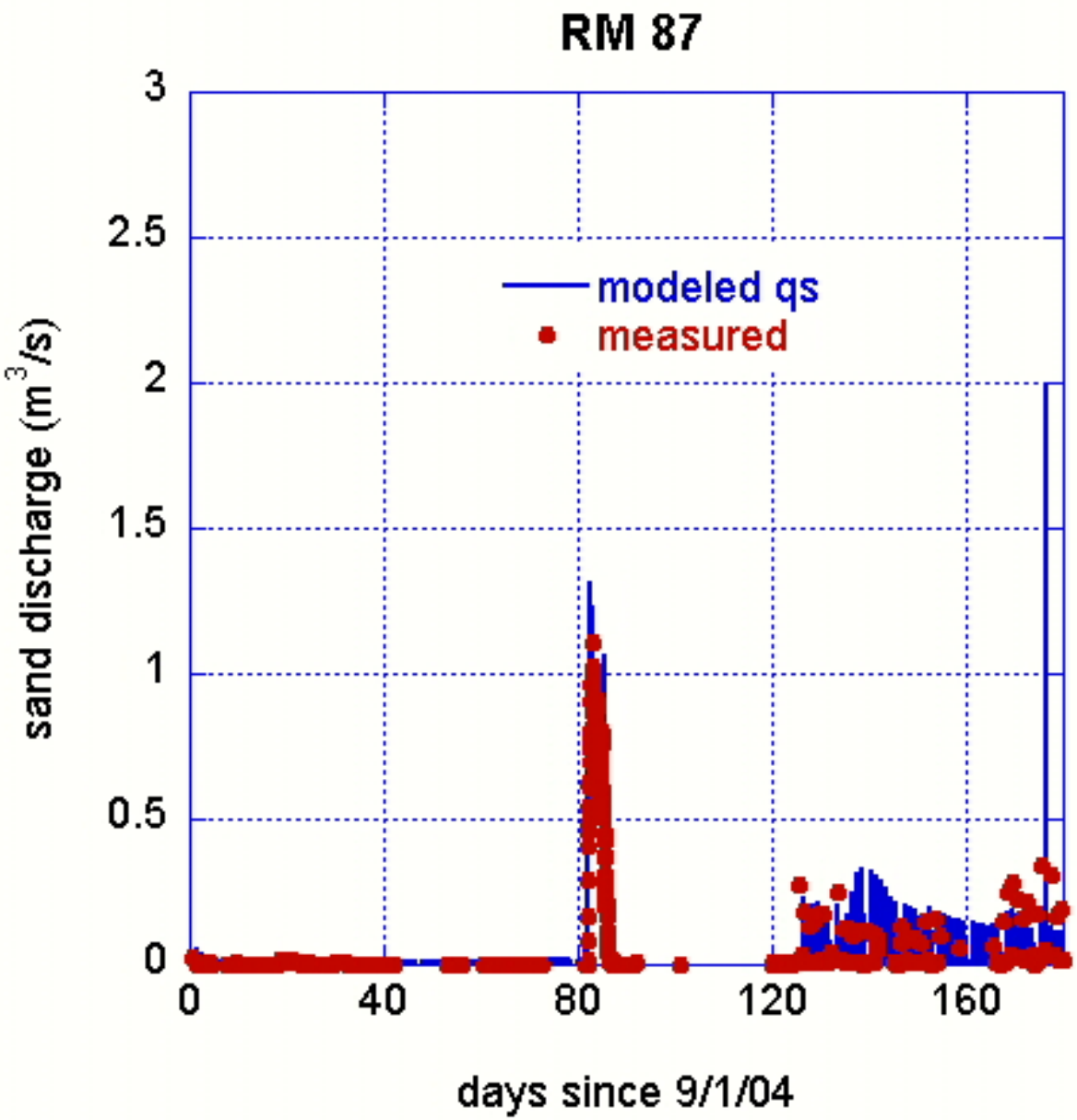


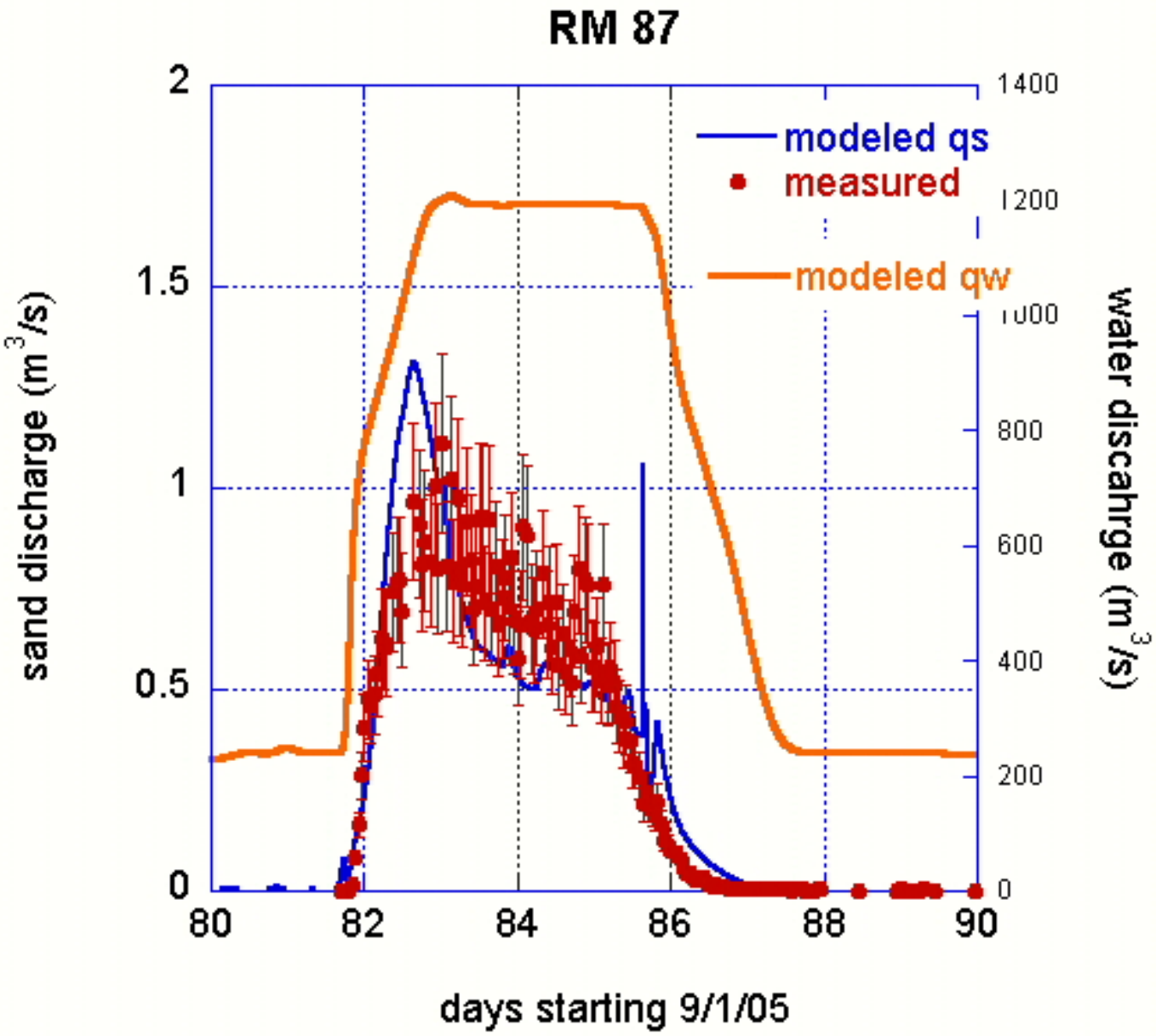

RM 30
modeled
measured
sand discharge (m3/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
40
80
120
160
days since 9/1/04

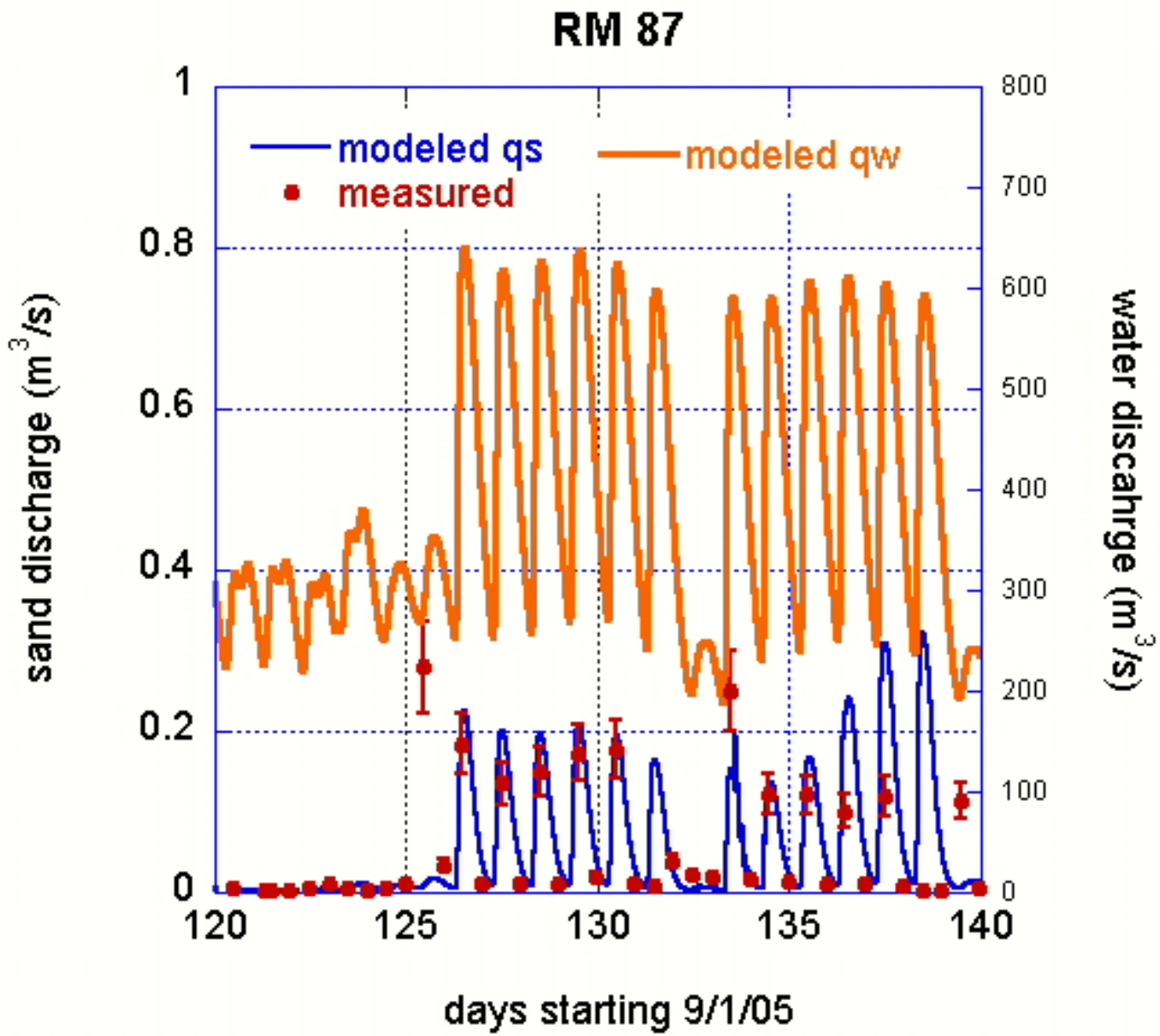

RM 30
sand discharge (m3/s)
2
1.5
1
0.5
0
80
82
84
86
88
90
days since 9/1/04
modeled
measured

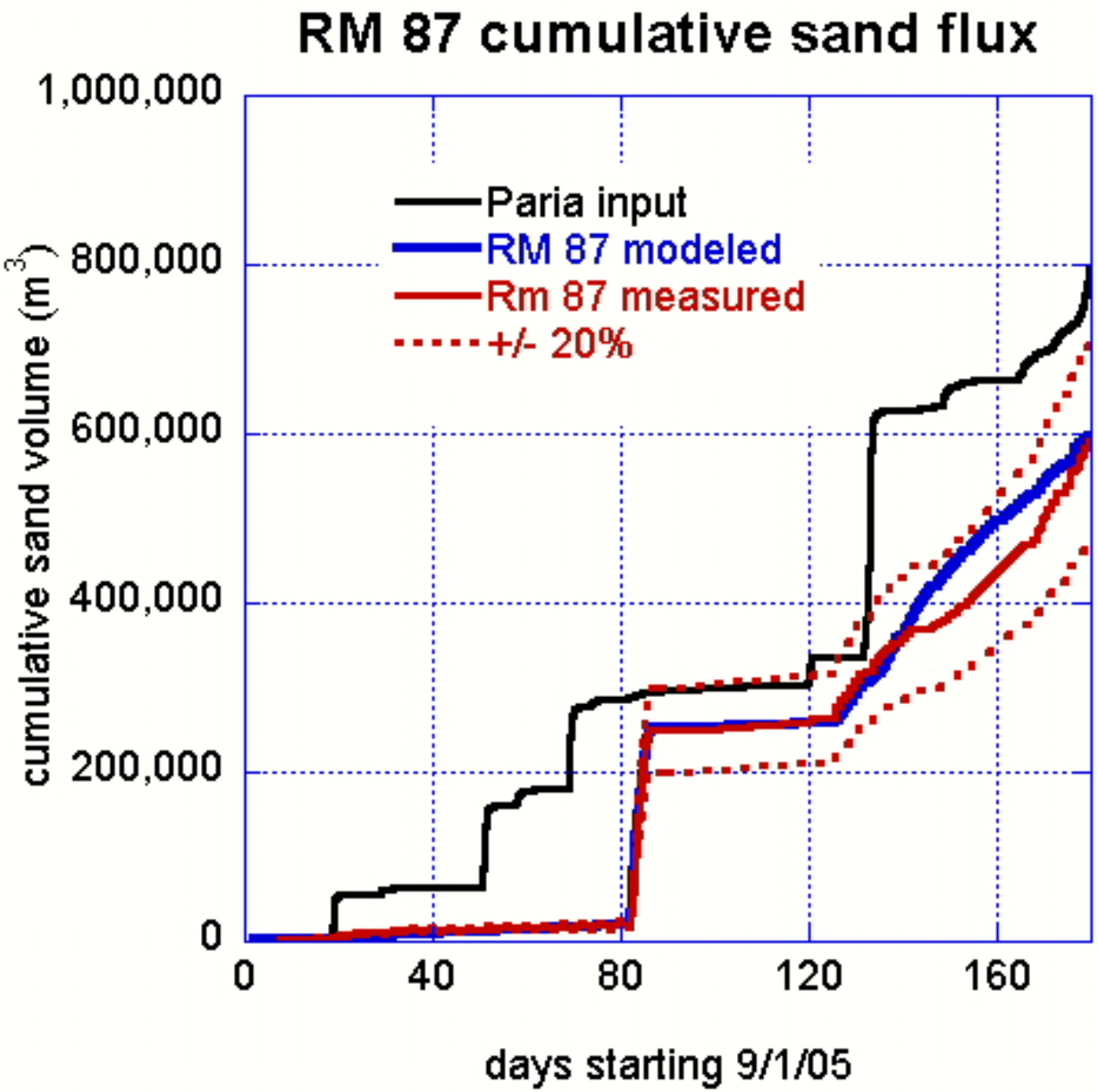

RM 61
sand discharge (m3/s)
2
1.5
1
0.5
0
0
40
80
120
160
days since 9/1/04
modeled
measured

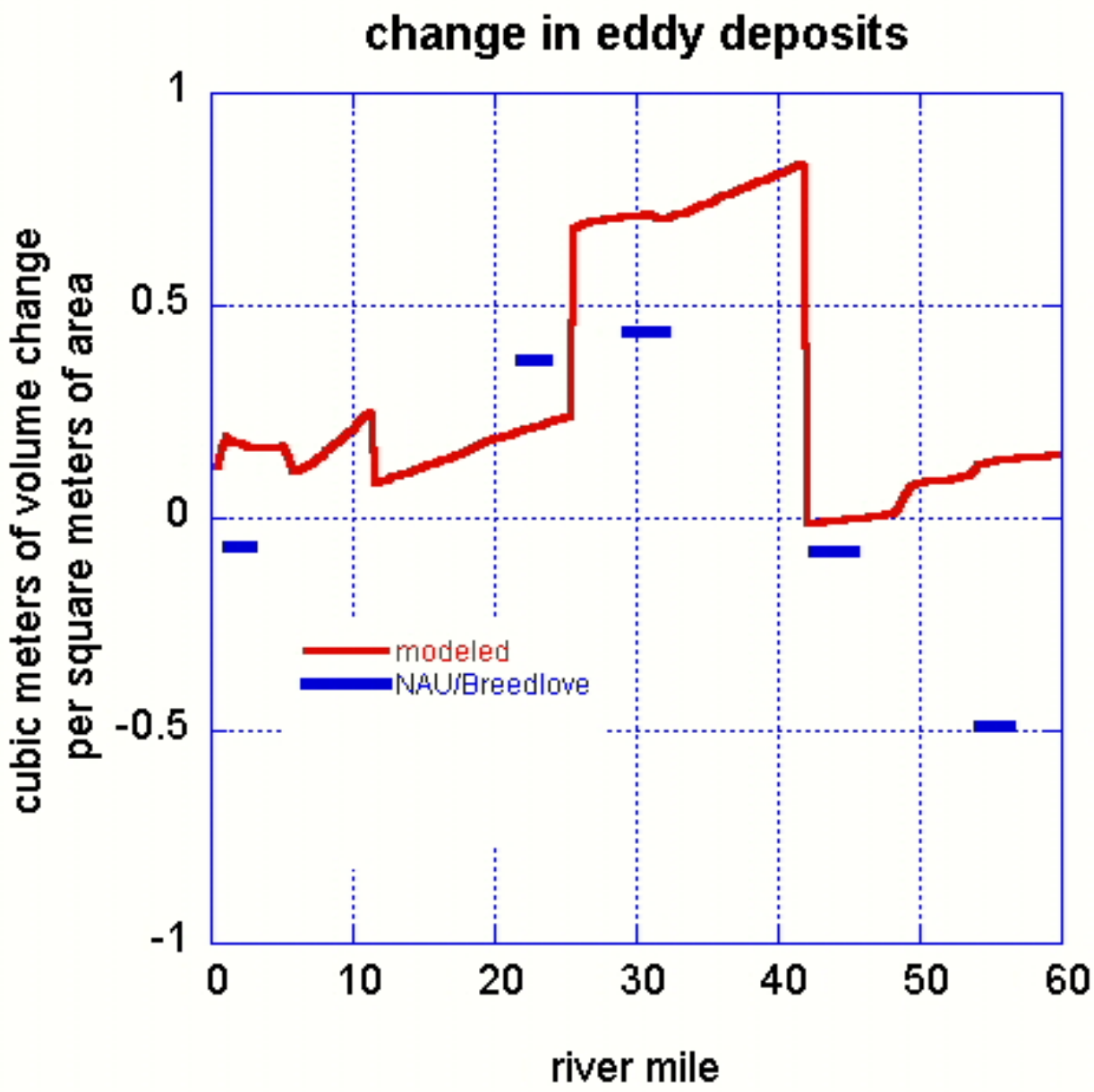

RM 61
sand discharge (m3/s)
2
1.5
1
0.5
0
80
82
84
86
88
90
days since 9/1/04
modeled
measured


RM 87
modeled qs
measured
sand discharge (m3/s)
days since 9/1/04
0
0.5
1
1.5
2
2.5
3
0
40
80
120
160


RM 87
modeled qs
measured
modeled qw
sand discharge (m3/s)
water discahrge (m3/s)
days starting 9/1/05
0
0.5
1
1.5
2
0
200
400
600
800
1000
1200
1400
80
82
84
86
88
90


RM 87
modeled qs
measured
modeled qw
sand discharge (m3/s)
water discahrge (m3/s)
days starting 9/1/05
0
0.2
0.4
0.6
0.8
1
0
100
200
300
400
500
600
700
800
120
125
130
135
140


RM 87 cumulative sand flux
1,000,000
800,000
600,000
400,000
200,000
0
cumulative sand volume (m3)
Paria input
RM 87 modeled
Rm 87 measured
+/- 20%
0
40
80
120
160
days starting 9/1/05


change in eddy deposits
cubic meters of volume change
per square meters of area
1
0.5
0
-0.5
-1
0
10
20
30
40
50
60
river mile
modeled
NAU/Breedlove

Large-scale 1d model applications

- track major tributary inputs

  -- predict movement of sand wave and response to dam releases
- set upstream sediment boundary condition for multi-dimensional model
- optimize dam releases to make best use of available sand