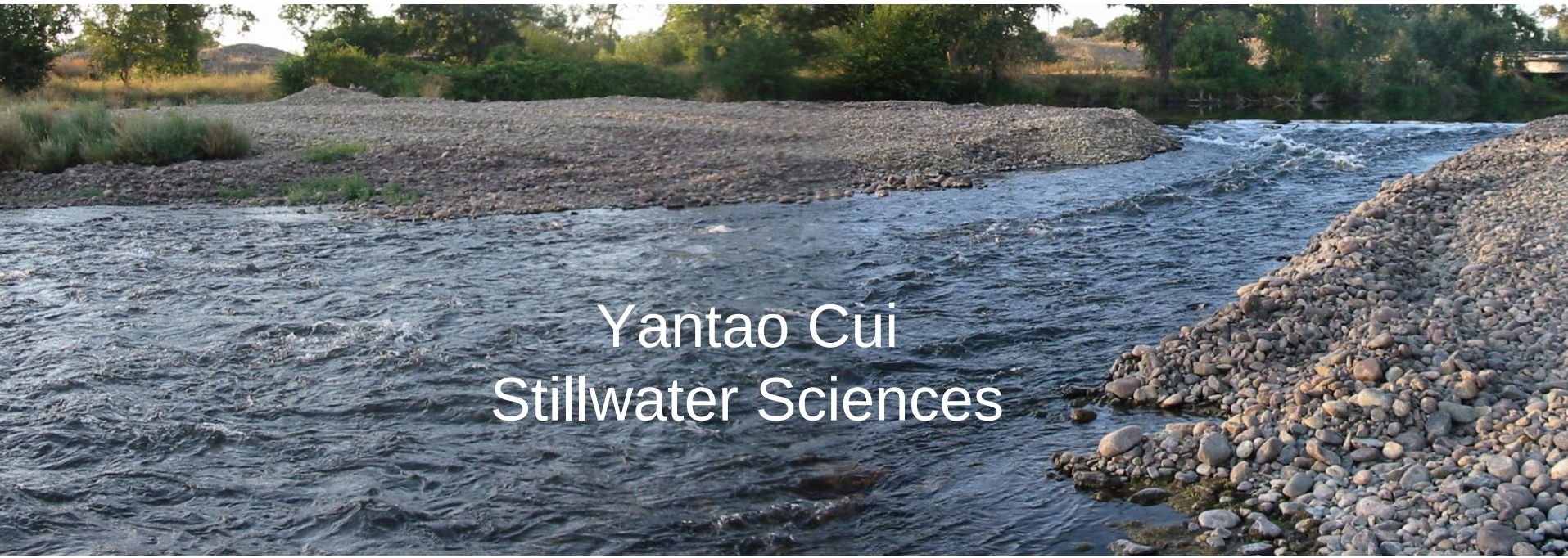
```
If Not EnoughGravel Then
    EstimateVolumeNeeded(MyVolume)
    AddGravel(MyVolume)
    EstimateEvolution(MyVolume, HydroSeries)
EndIf
```

Numerical modeling of gravel augmentation



Yantao Cui
Stillwater Sciences

Outline

- What kinds of tools are out there available for evaluation of gravel augmentation project?
  - Questions to answer:
    - *How much gravel to add?*
    - *How often?*
    - *What are the benefits?*

- What are we eyeing for in the future?

What tools are out there available for evaluation of gravel augmentation?

- There are probably not many tools specifically designed for gravel augmentation, *but*

- There are tools that can be used for evaluation of gravel augmentation.

Application of Bedload Equations

- Use of bedload transport equations will give us better understanding of the transport capacity of gravel, and thus, may give us a hint as how much gravel augmentation is needed and how long the augmented gravel may last.

- It will be only “qualitatively-quantitative” but it is easy to do and is better than nothing.

Examples of Bedload Equations

- Parker, Klingeman, and McLean (1982);
- Parker and Klingeman (1982);
- Parker (1990);
- Wilcock and Crowe (2003);
- …

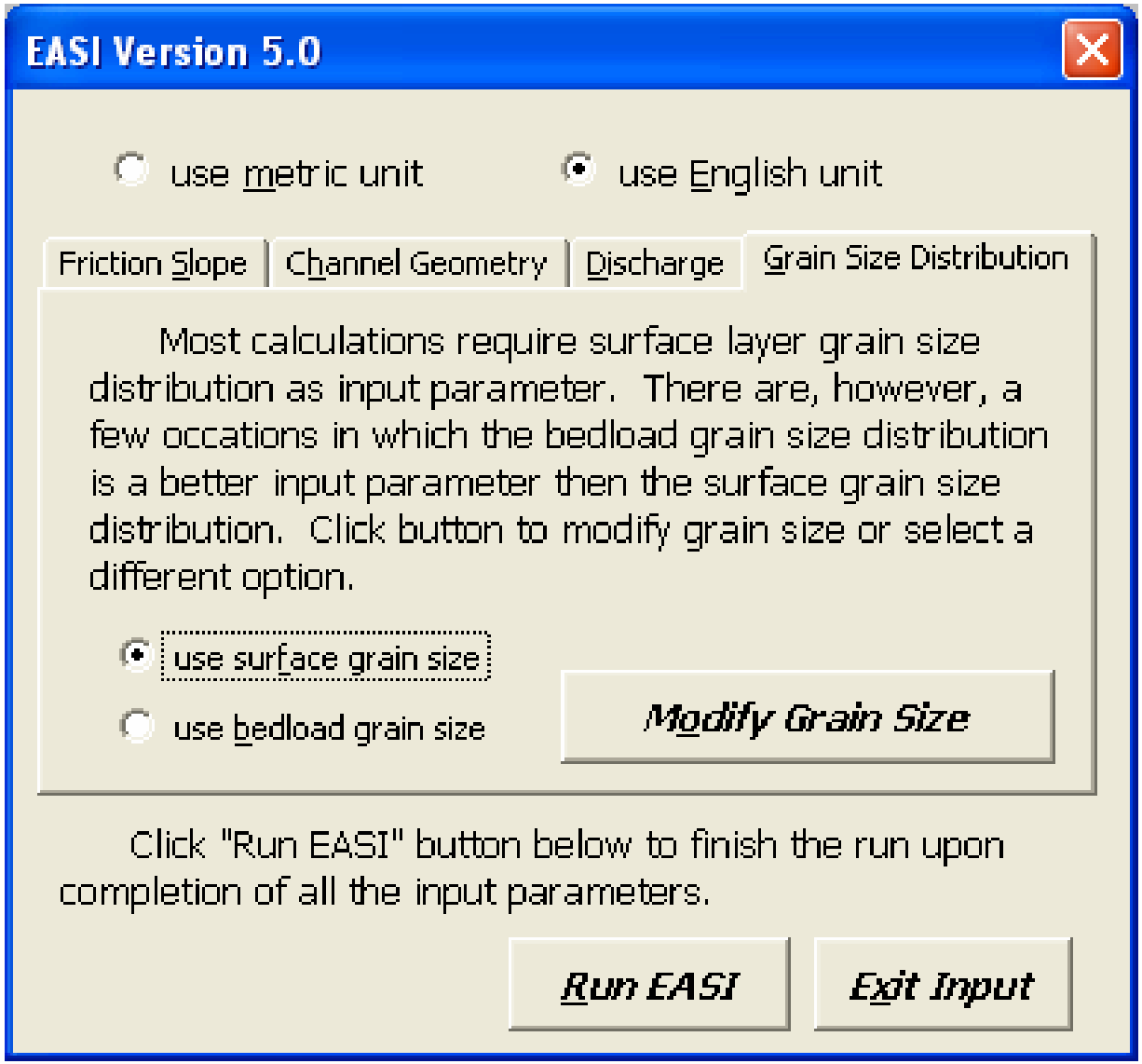
In terms of procedure:
Simpler

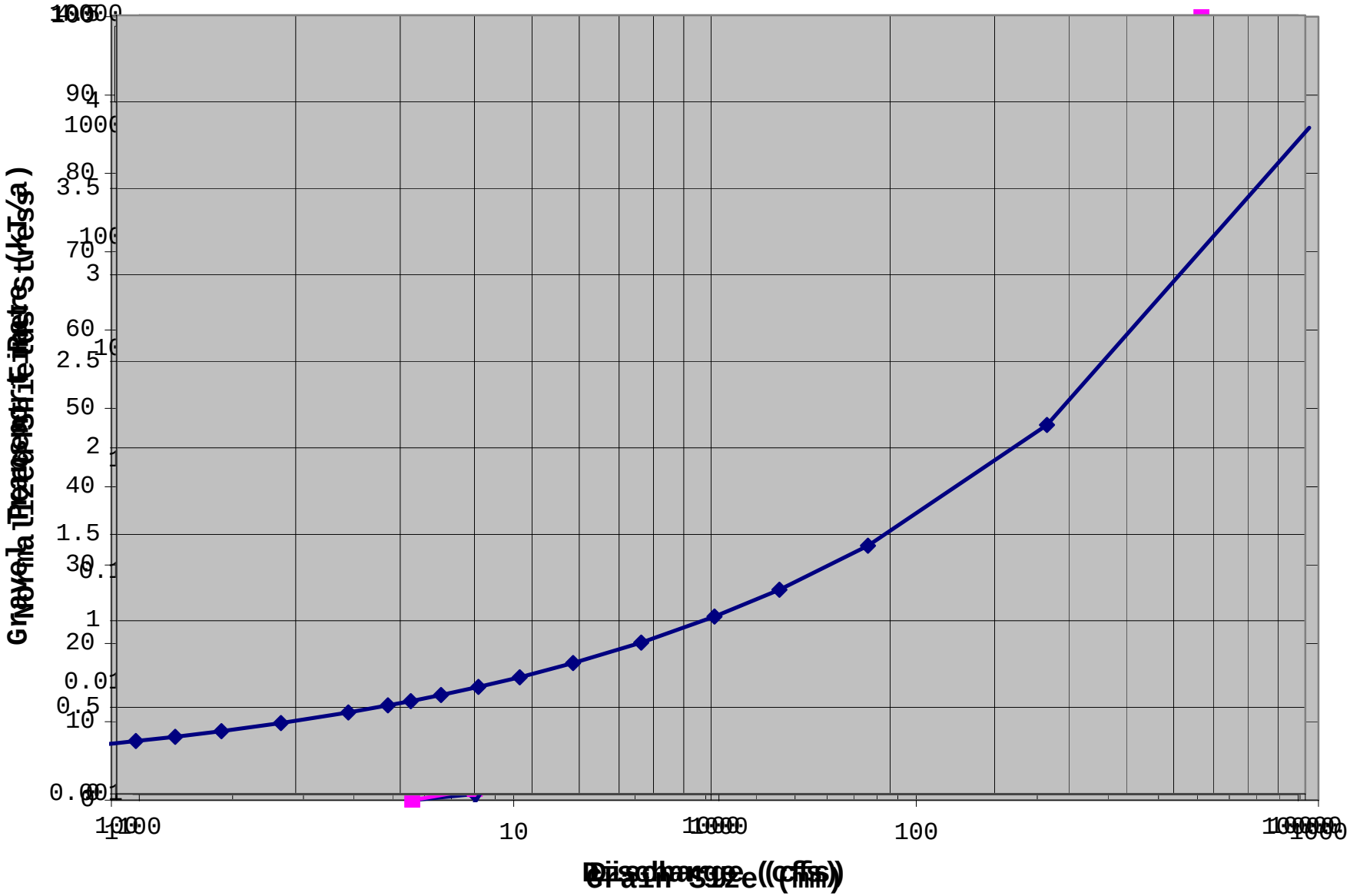
More
complicated

But field data for Parker (1990) and Wilcock and Crowe (2003) are much easier to collect than the other two procedures!

Parker (1990) and ***EASI***

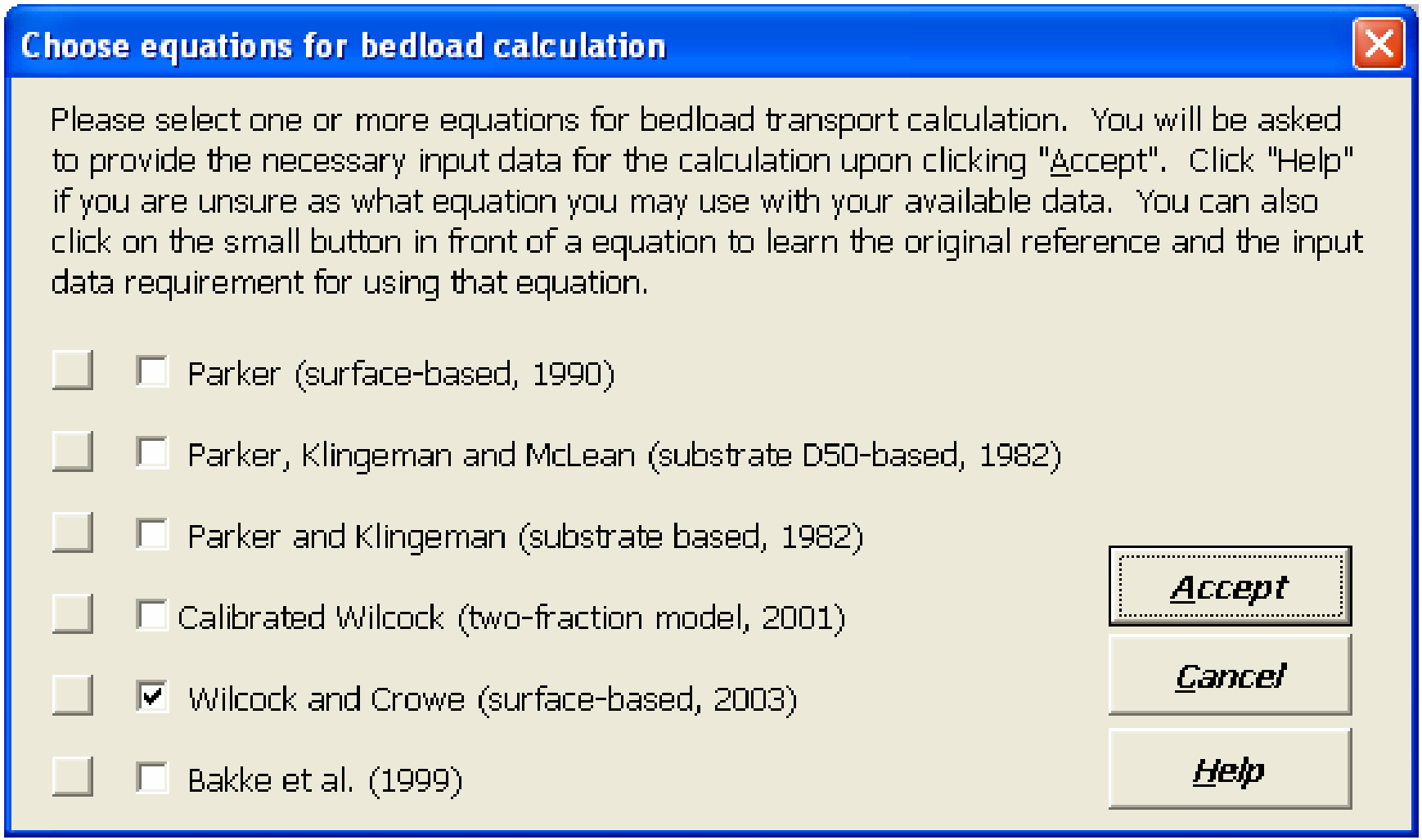
- Parker implemented his 1990 equation with PASCAL language and named the programs *ACRONYM2* and *ACRONYM3*;
  - A direct implementation of his equation!
- Stillwater Sciences put Parker (1990) together and extended the input parameters to more readily variables and developed *EASI* program (***E***nhanced ***A***cronym ***S***eries with ***I***nterface).


EASI Version 5.0
use metric unit
use English unit
Friction Slope
Channel Geometry
Discharge
Grain Size Distribution
Most calculations require surface layer grain size distribution as input parameter. There are, however, a few occations in which the bedload grain size distribution is a better input parameter then the surface grain size distribution. Click button to modify grain size or select a different option.
use surface grain size
use bedload grain size
Modify Grain Size
Click "Run EASI" button below to finish the run upon completion of all the input parameters.
Run EASI
Exit Input



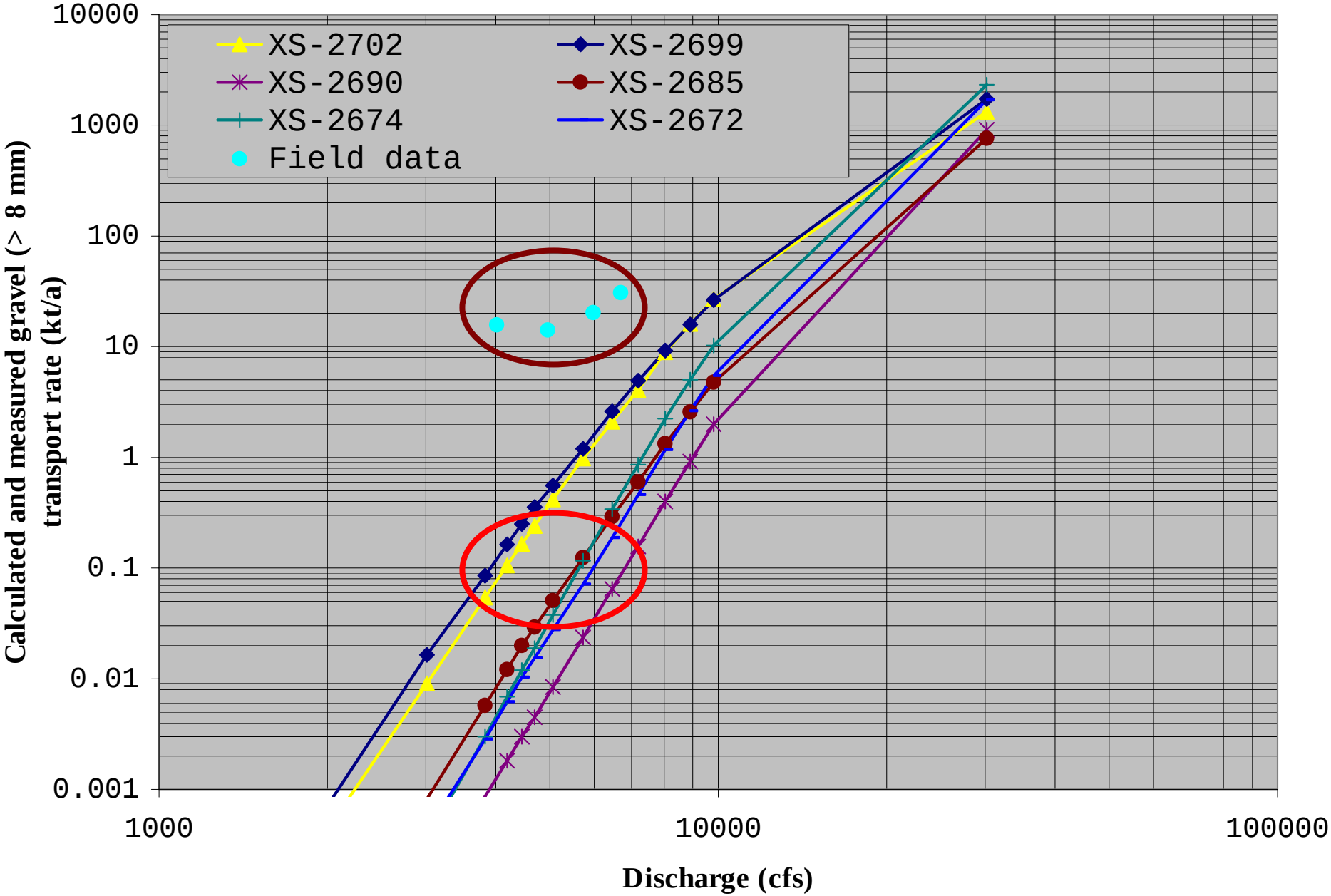
Normal Transport Rate (kT/a)
Grain Size (mm)
Discharge (cfs)
1000
10
100
1000

More Equations and ***BAGS***



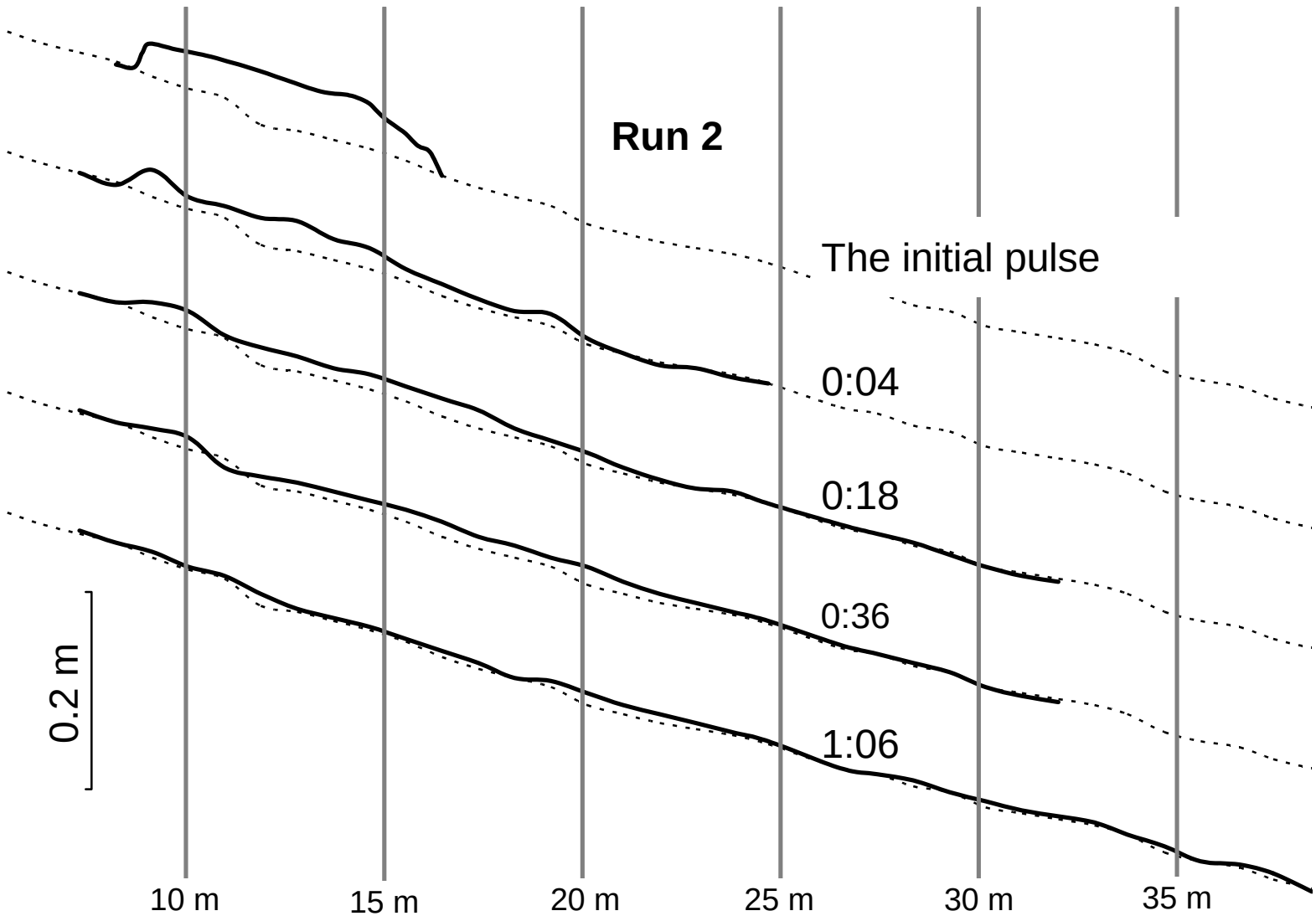
Realizing the Limitations

- Introducing gravel to a channel in an augmentation project will usually significantly increase the short-term sediment transport capacity, sometimes by orders of magnitude. This effect cannot be evaluated with a bedload equation!
  - Field data;
  - Laboratory data;
  - Results of more sophisticated models.



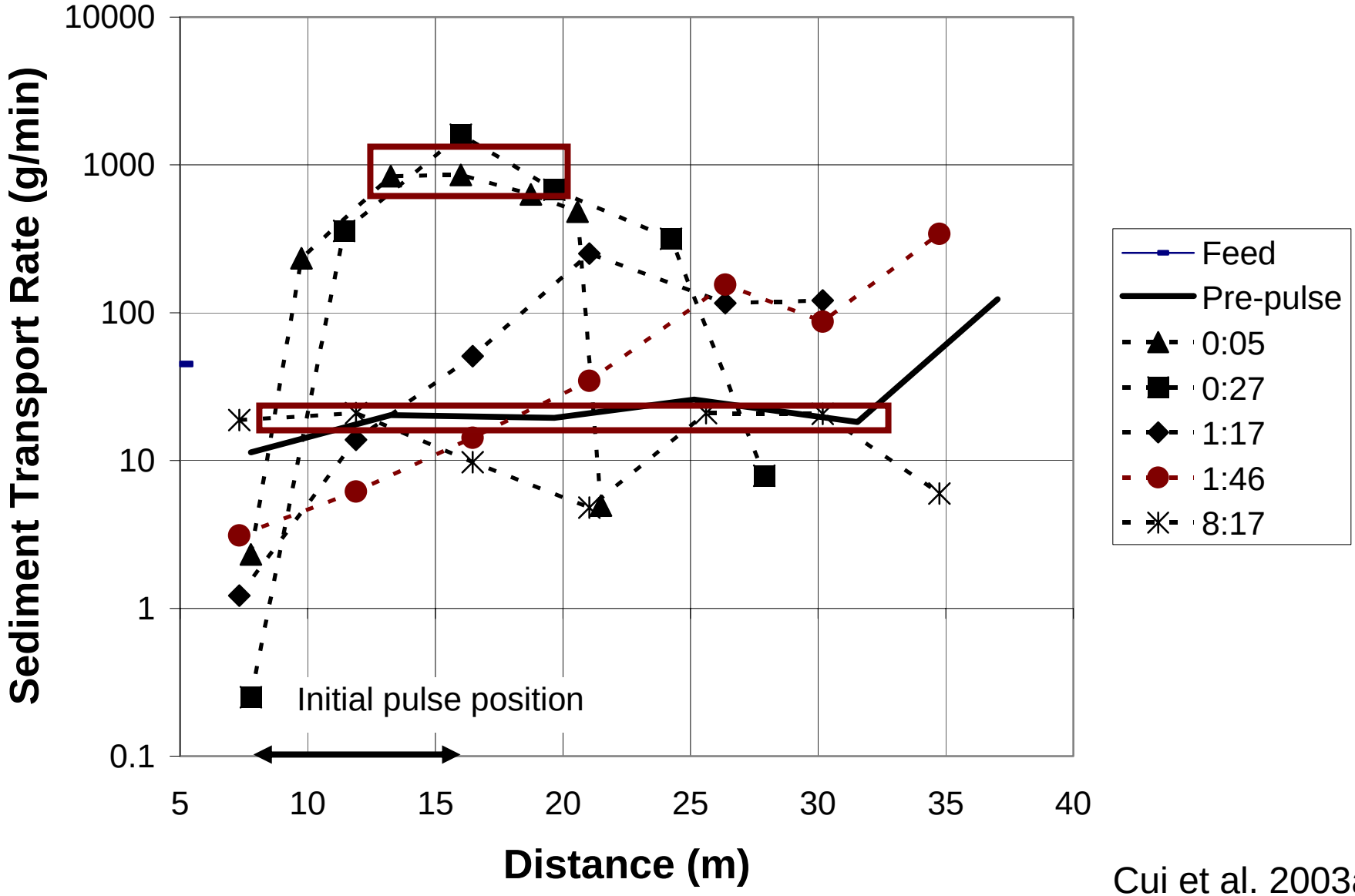
Tuolumne River Data, from McBain & Trush

SAFL Sediment Pulse Experiment



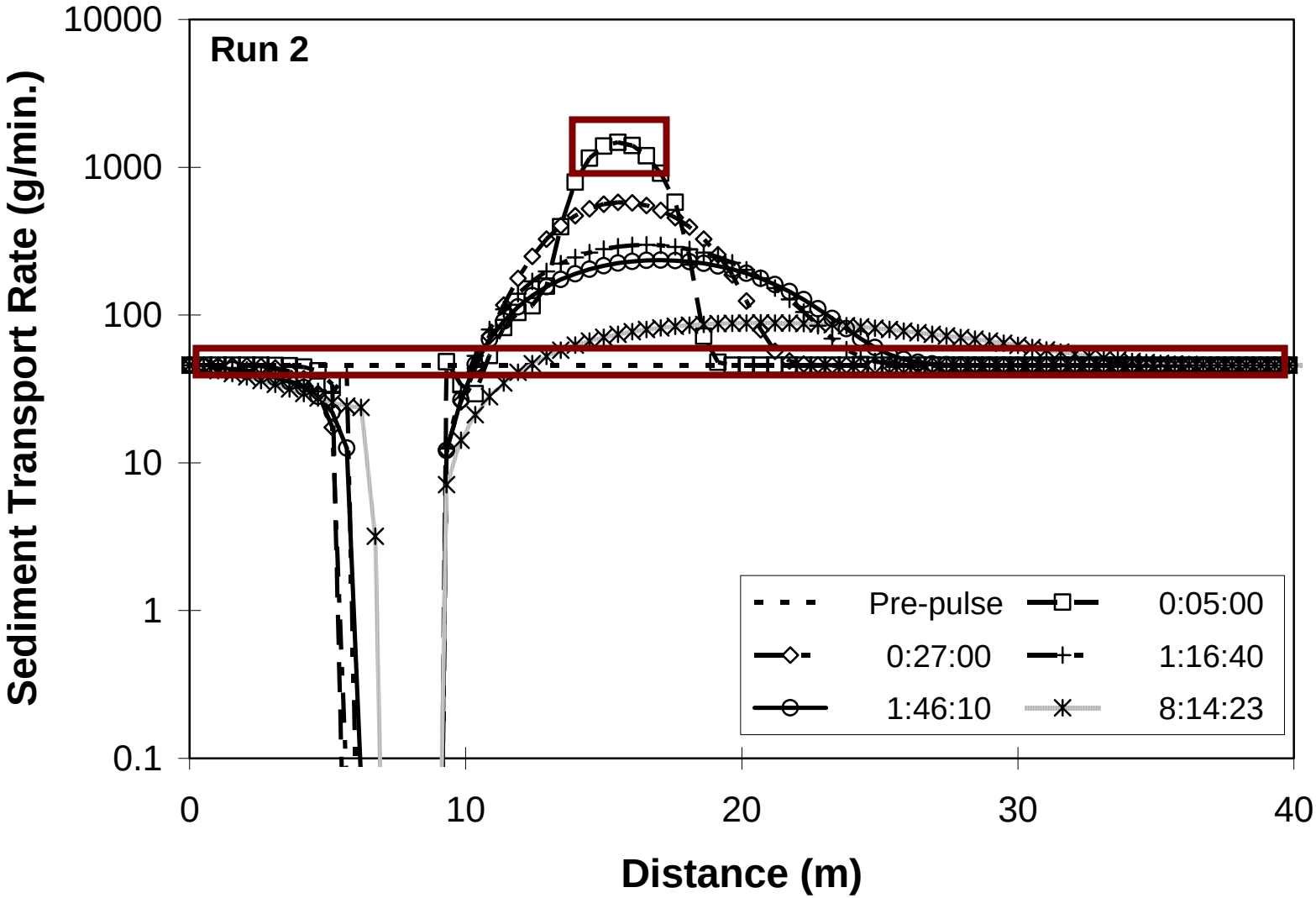
Cui et al. 2003a

SAFL Sediment Pulse Experiment



Cui et al. 2003a

Simulation of SAFL Pulse Experiment

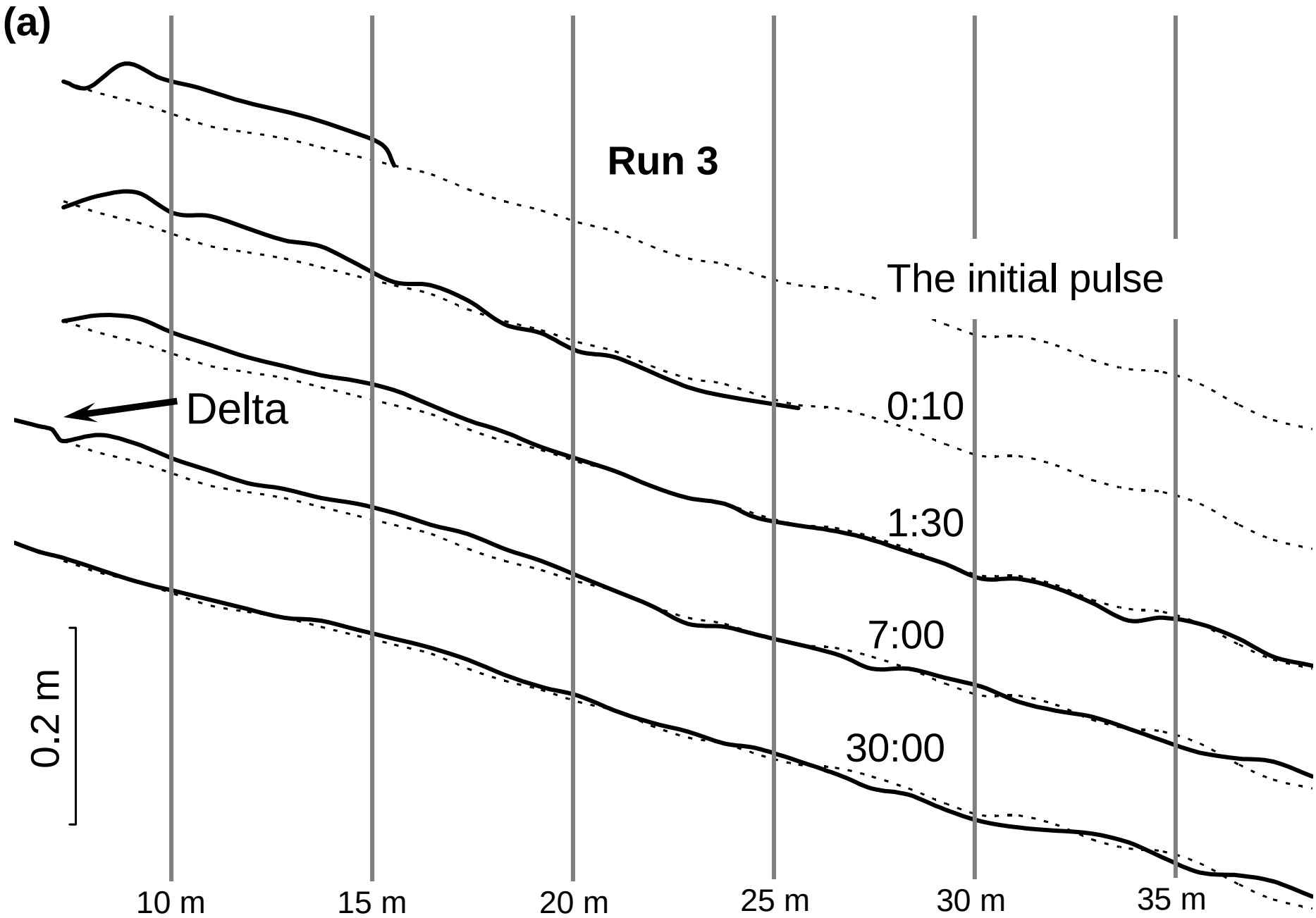


Cui et al. 2003b

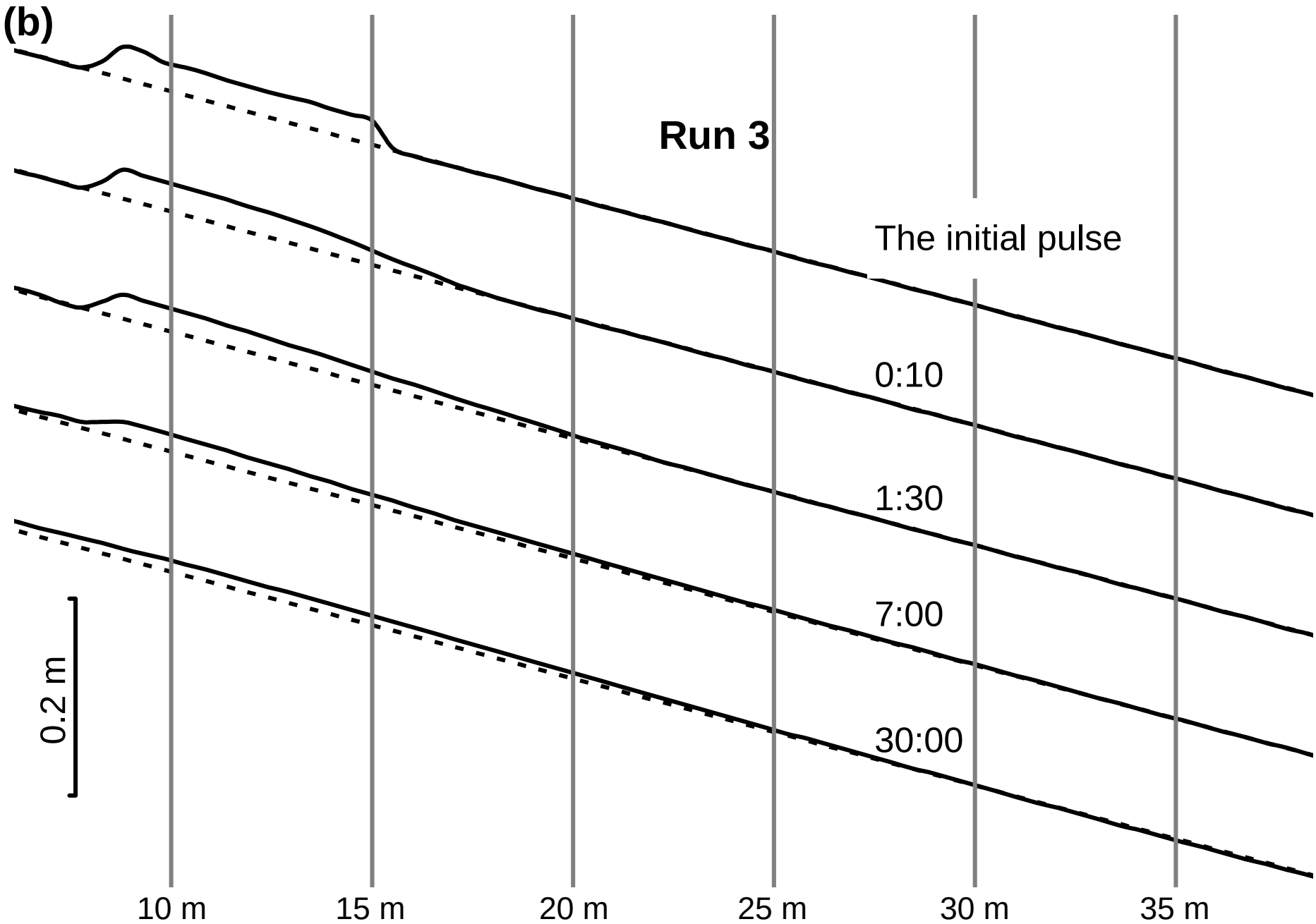
Numerical Modeling

- The numerical model for evolution of gravel pulses developed by Cui, Parker, Lisle and Pizzuto may be a good first step toward a useful tool for gravel augmentation.

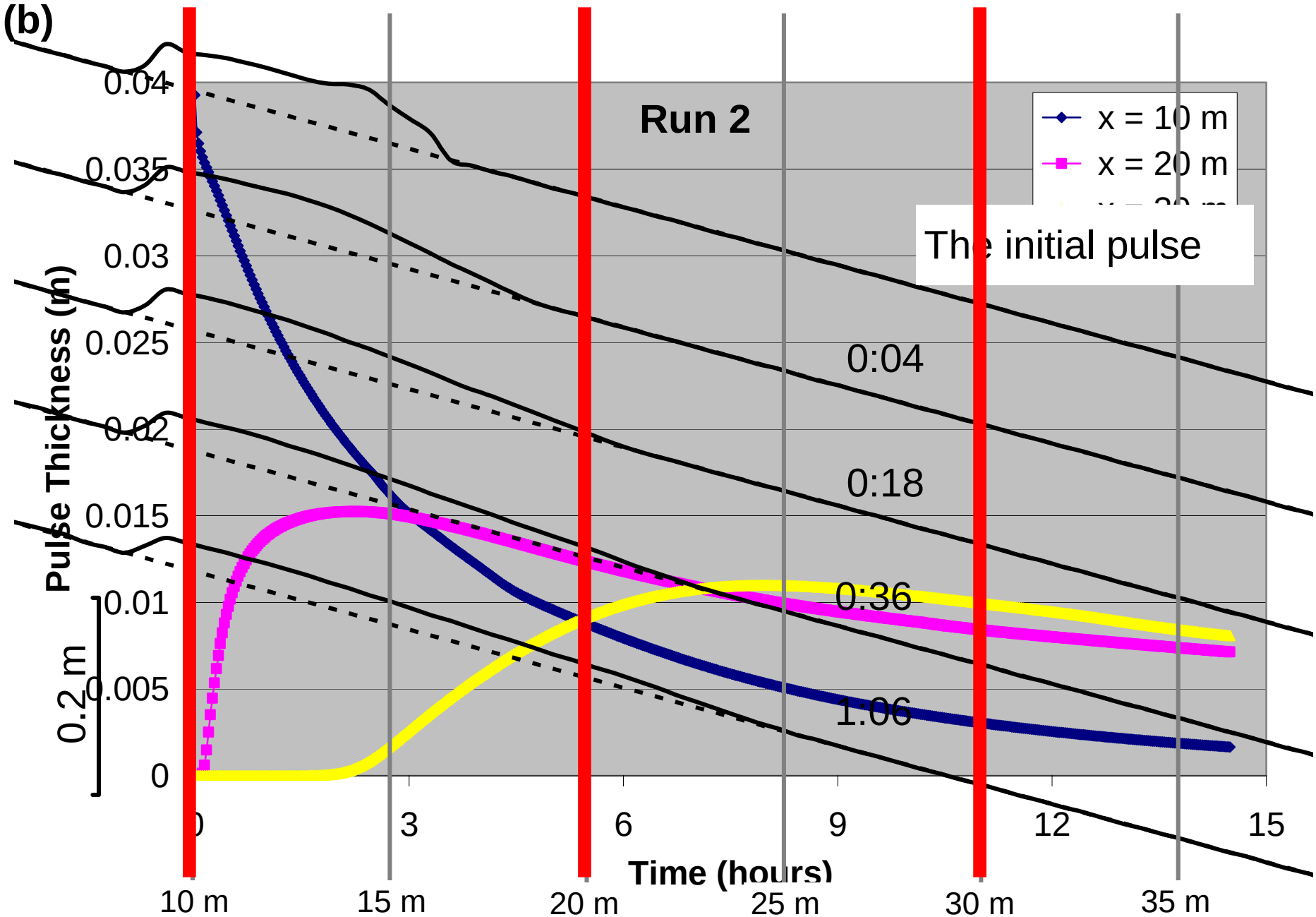
  - Cui, Y., Parker, G., Lisle, T., Gott, J., Hansler, M., Pizzuto, J.E., Allmendinger, N.E., and Reed, J., G. (2003a). Sediment pulses in mountain rivers. Part I: experiments. *Water Resources Research*, 39(9), 1239, doi: 10.1029/2002WR001803.
  - Cui, Y., Parker, G., Pizzuto, J., and Lisle, T. (2003b). Sediment pulses in mountain rivers. Part II: comparison between experiments and numerical predictions. *Water Resources Research*, 39(9), 1240, doi: 10.1029/2002WR001805.
  - Cui, Y. and Parker, G. (accepted subject to revision). Numerical model of sediment pulses and sediment supply disturbances in mountain rivers. *Journal of Hydraulic Engineering*, HY/2002/023176.



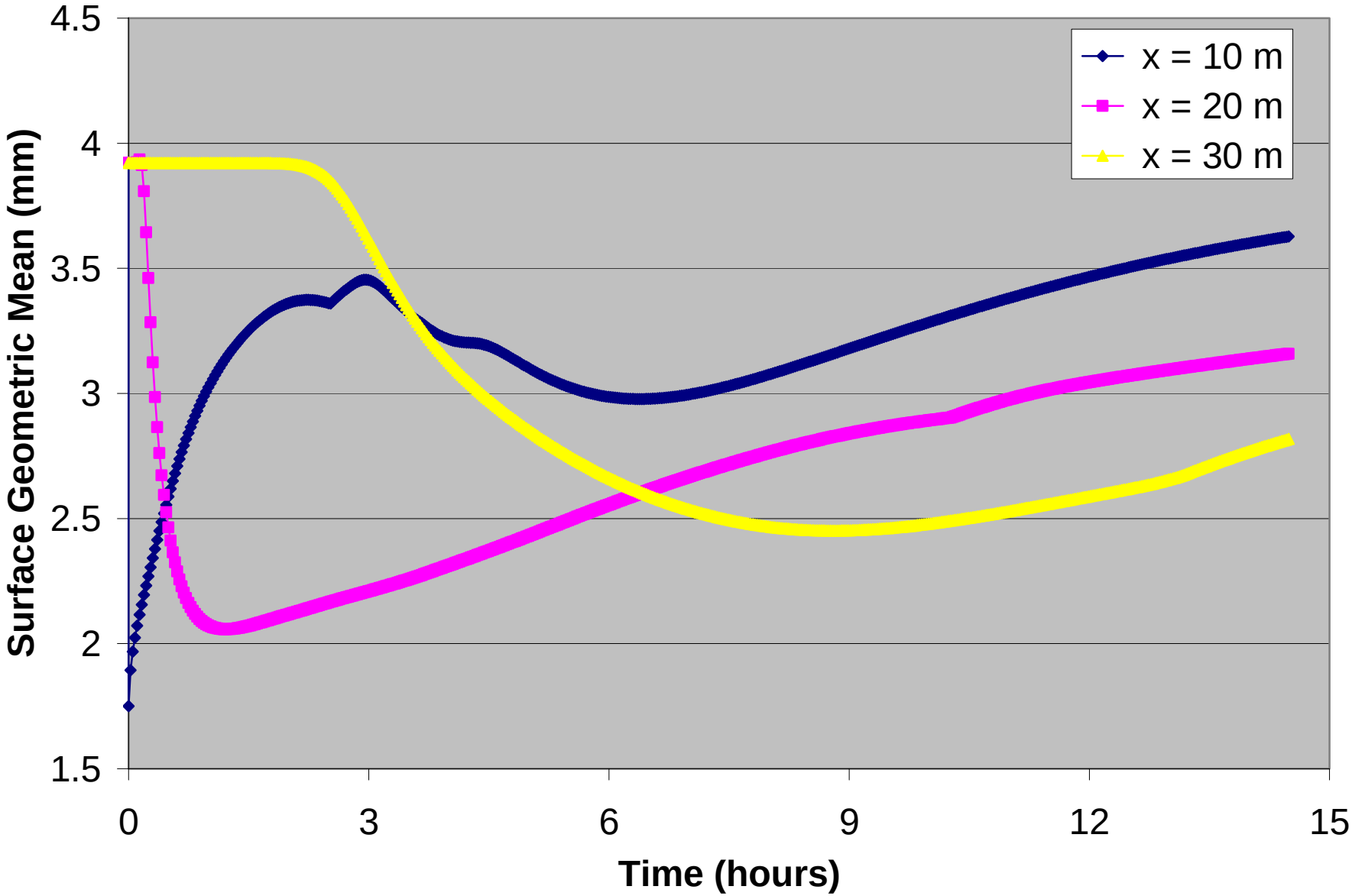
Cui et al. 2003a



Cui et al. 2003b



Based on data from Cui et al. 2003b



Based on data from Cui et al. 2003b

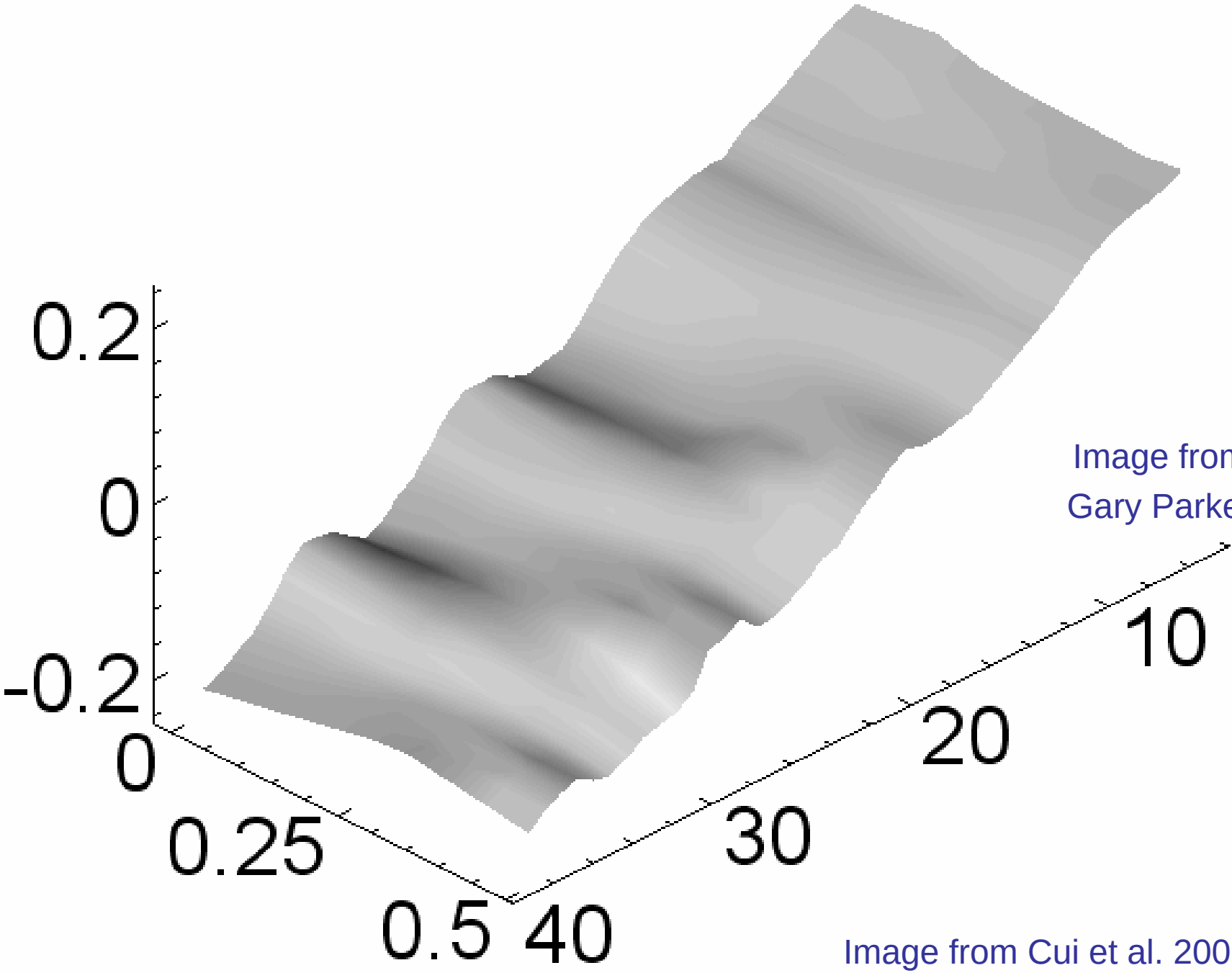
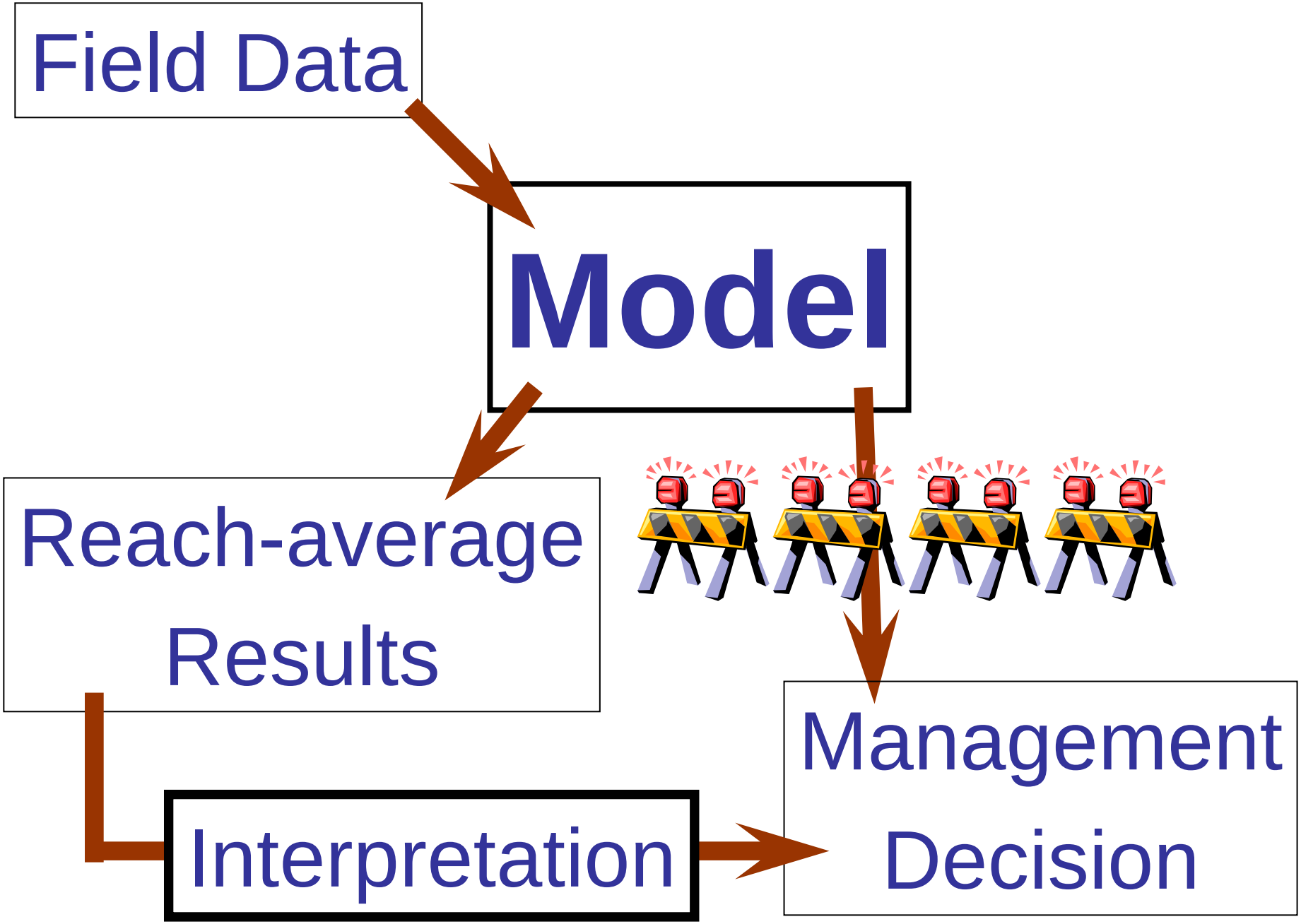


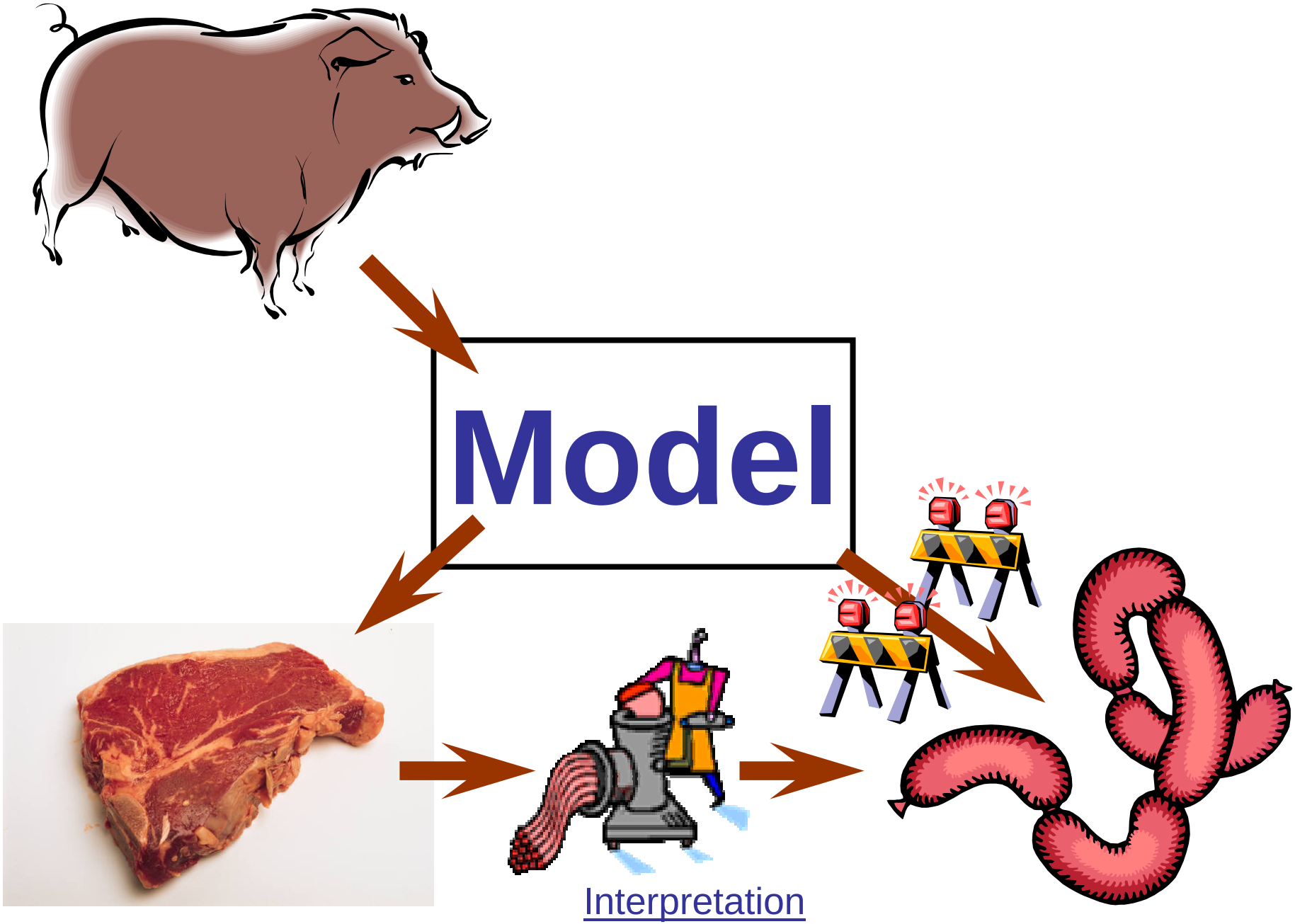
Image from Gary Parker

Image from Cui et al. 2003(a)

What are we eyeing for in the future?

- To develop something built upon the sediment pulse model;
- To attempt to interpret results within the model and provide an indexed evaluation about potential benefit, i.e.,
  - the extent of the beneficial reach;
  - how long will the augmented gravel last;
  - how often it should be done;
  - ...


Field Data
Model
Reach-average Results
Interpretation
Management Decision


Model
Interpretation

Summary

- Application of simple bedload transport equations can provide certain useful information for a gravel augmentation project – but be cautious;
- Existing gravel pulse model can provide insight in understanding of the consequences of gravel augmentation but its result can only be interpreted on a reach-average basis, which is coarser than the preferred resolution for a gravel augmentation project (i.e., habitat-scale);
- Better tools are on the way that will be built upon the gravel pulse model, findings from CALFED funded flume experiments, and experiences from field practitioners.