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NOTE Title change

APPARENT ABSTRACTION RATES IN EPHEMERAL STREAM CHANNELS

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INTRODUCTION

Modeling flow in a broad, sandy ephemeral stream channel is complicated by the presence of transient, meandering subchannels. These erosive features affect the hydraulic properties of the channel as well as the area available for infiltration into the bed. Models which simulate erodable channels are complex, require extensive data, and are not well verified (Dawdy and Vanoni, 1986, Chang, 1984). Models which simulate stable channels, however, are widely used by scientists and engineers. The purpose of this study was to evaluate the performance of a well-tested, stable channel model when used to simulate flow in an erodable channel.

STUDY REACH

The study area is located within the Walnut Gulch Experimental Watershed near Tombstone, Arizona, and is operated by the Agricultural Research Service of the USDA. The main channel is 2.6 miles long and from 40 to 100 feet wide, with a deep sand bed and stable banks. There are four main tributaries, all equipped with flumes to measure flow into the main channel.

PREVIOUS STUDIES

There have been several studies of runoff in the ephemeral stream channels on Walnut Gulch. Keppel and Renard (1962) reported that transmission losses are influenced by antecedent moisture conditions within the channel alluvium, peak discharge at the upstream gaging station, duration of flow, channel width, and quantity and texture of the channel alluvium. They found abstraction rates ranging from 0.2 to 9 ac-ft/mi/hr in the lower reaches of Walnut Gulch. Renard and Keppel (1966) then reported on the influence of translation waves and transmission losses on the shape of the runoff hydrograph. Renard and Laursen (1975) explained the cancellation of greater downstream transmission losses by tributary inflow. Freyburg (1983) stated that, for ephemeral streams, the infiltration along the channel is a complex function of bed material, channel geometry, and hydrograph shape. Smith (1972) described the kinematic modeling of shock-type flood waves and recognized its potential as a tool for studying transmission losses in ephemeral streams.

MODEL DESCRIPTION

The model employed a four point implicit finite difference method for estimating the solution of the combined continuity and uniform flow equations ("kinematic wave") for flow area in channel segments with uniform slopes and trapezoidal cross sections (Rovey, Woolhiser and Smith, 1977). The routing equations included a transmission loss component, which for this study was approximated by a constant abstraction rate.

PROCEDURE

(1) The study reach was discretized into segments; each segment was assigned uniform properties (Fig. 1, Table 1).

(2) Seven flood events, for which intermediate inflow along the study reach could be neglected, were identified. They included two events originating from flume 8; two from flumes 9 and 15 combined; one from flumes 8,9,10 and 15; one from flumes 8,9 and 10; and one from flumes 9 and 10.

(3) Simulated hydrographs were adjusted to match the observed hydrographs by selecting an optimal bed abstraction rate for each event.

RESULTS

The optimal simulations required a range of abstraction rates from 1.0 to 6.5 iph, or 0.67 to 4.36 ac-ft/mi/hr, a subset of the range found by Keppel and Renard. The resulting simulated peak flows and flow volumes were mostly very close to the observed values (Figs. 4-9). Bed abstraction rates were plotted against corresponding values of both peak discharge and inflow volume (Figs. 2 and 3). The plots suggest a relationship between abstraction rate and the magnitude of the event.

CONCLUSIONS

There is no theoretical justification for assigning a different abstraction rate to each event, unless the range of abstraction rates can be explained by antecedent moisture conditions alone; inspection of flow records indicated this was not the case. Therefore, most of the difference must be attributed to the initial configuration of the channel and its evolution during the event, i.e., the formation of subchannels. Although our model cannot simulate these subchannels directly, it may be possible to model their effect by abandoning the explicit geometrical representation and making the area-discharge curve a function of some aspect of the flow. By constructing different area-discharge curves, the kinematic model could be used to quickly test assumptions about the relationship between channel flow, morphology, and abstraction. Until this is done, the use of a stable channel model to route flow in broad, sandy ephemeral stream channels cannot be recommended.

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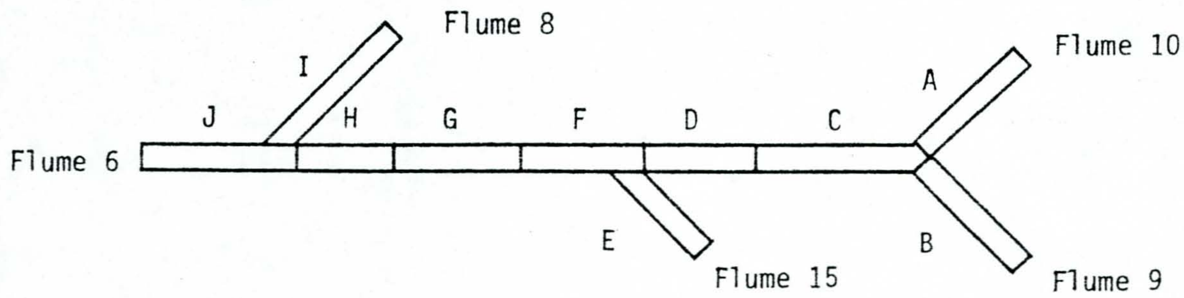

Figure 1. Schematic of Model Representation.

Table 1. Properties of Channel Segments.

Segment	Length (ft)	Width (ft)	Slope
A	524	30	.0113
B	271	20	.0113
C	4617	40	.0113
D	1707	65	.0099
E	339	20	.0090
F	2527	65	.0151
G	1988	40	.0105
H	1331	100	.0117
I	2722	45	.0136
J	1675	100	.0112

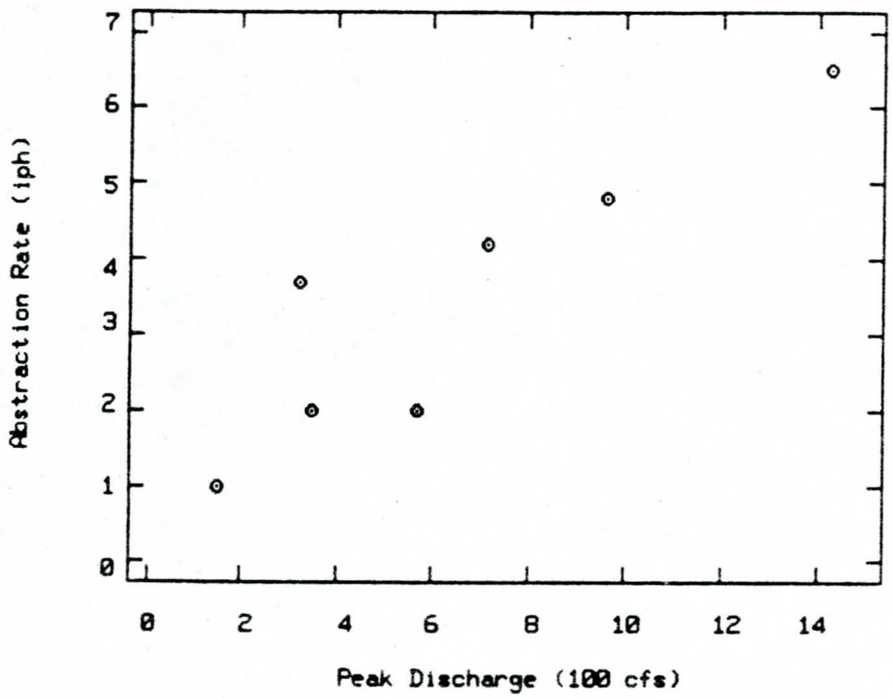

Figure 2. Abstraction versus peak discharge.

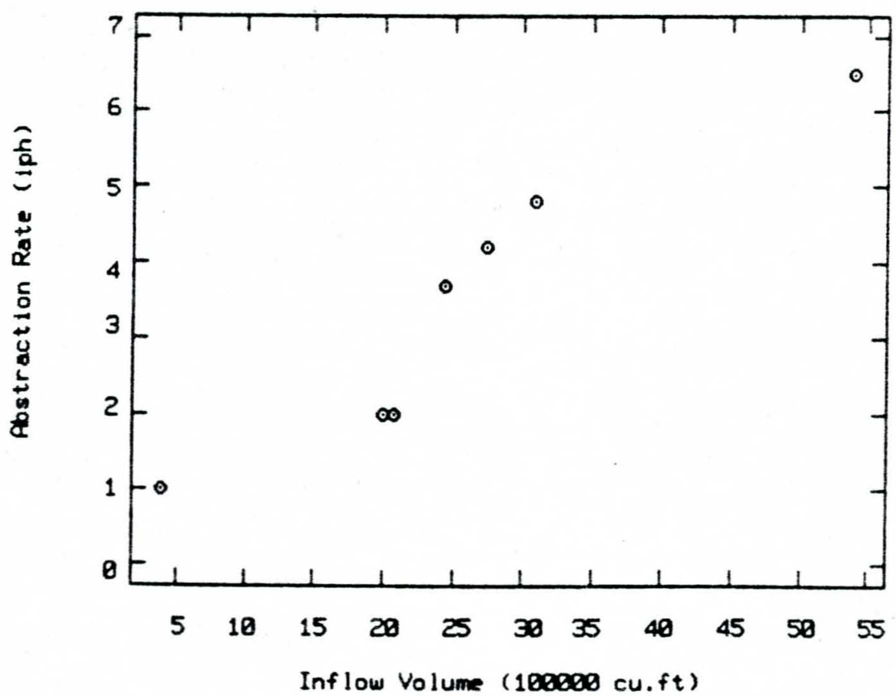

Figure 3. Abstraction versus inflow volume.

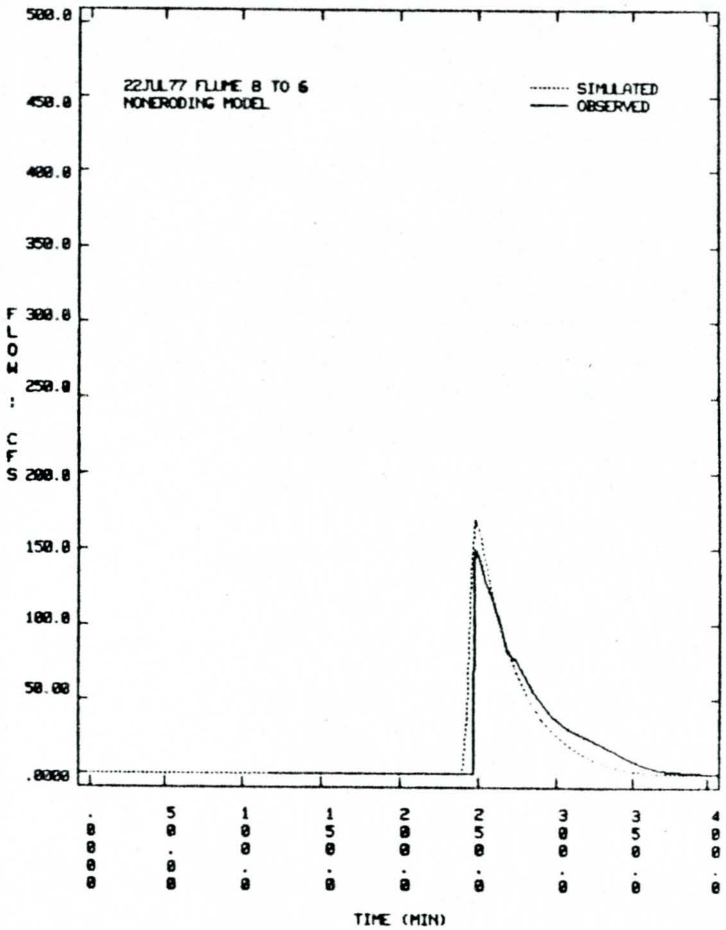

Figure 4. Event with 1.0 iph abstraction.

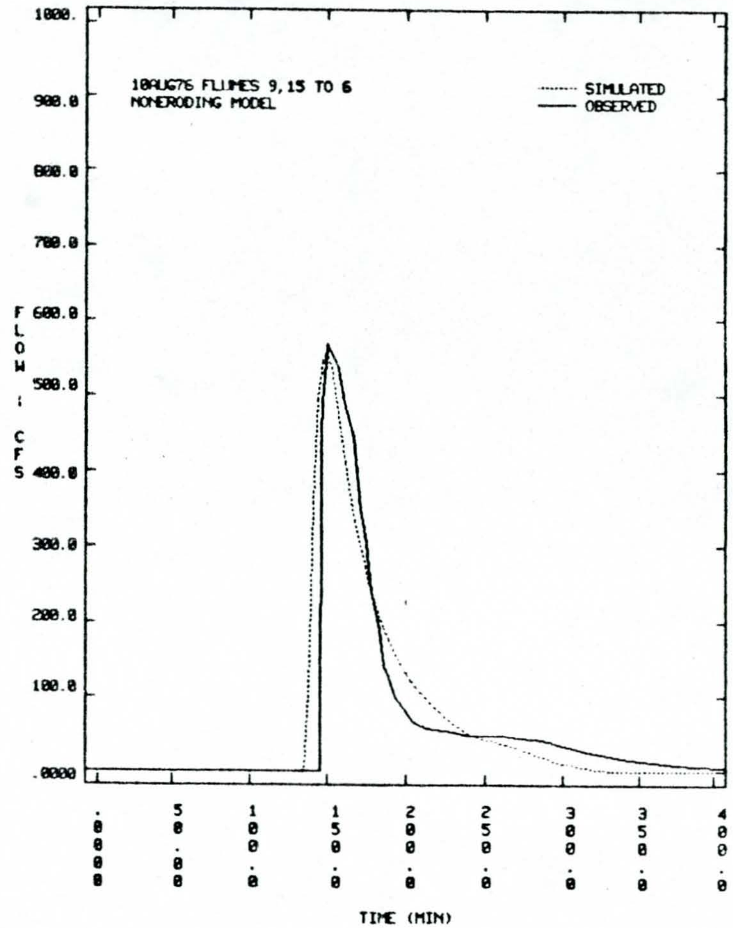

Figure 5. Event with 2.0 iph abstraction.

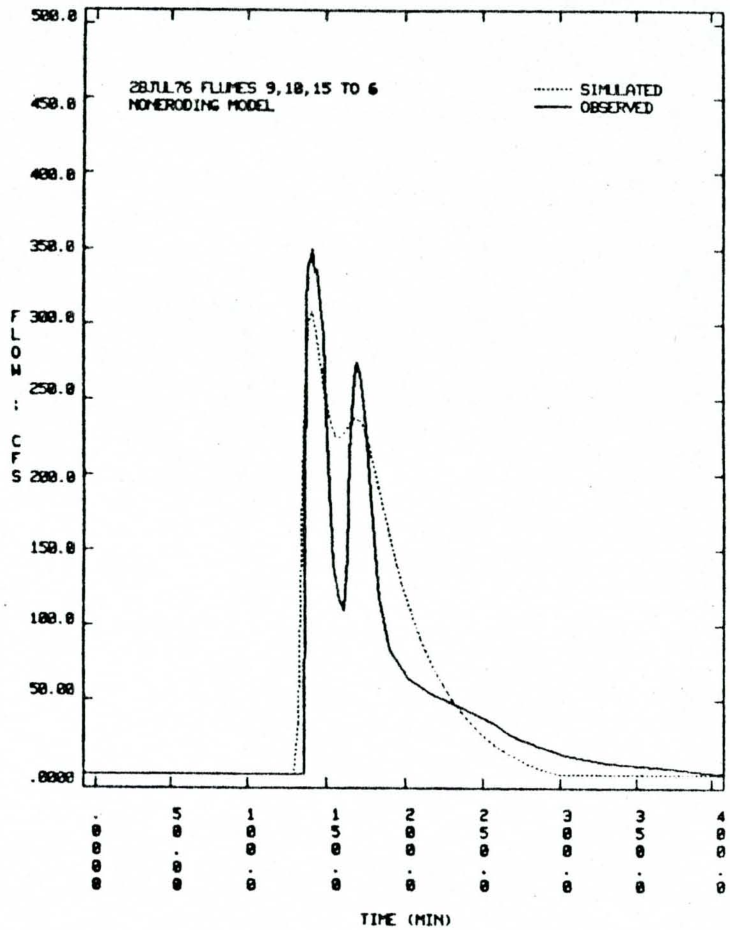

Figure 6. Event with 2.0 iph abstraction.

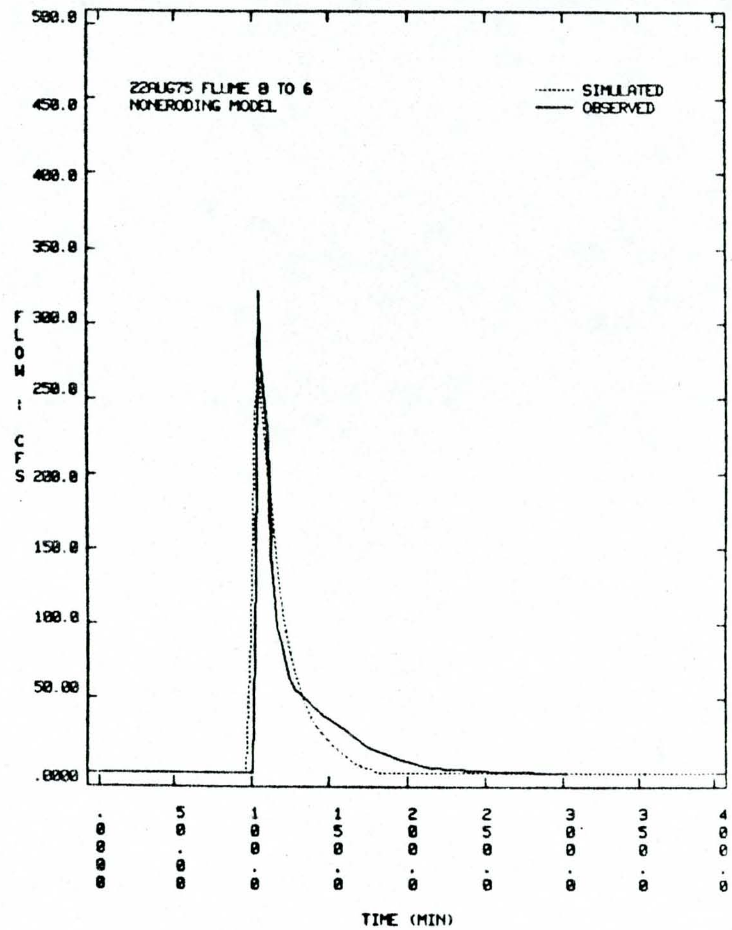

Figure 7. Event with 3.7 iph abstraction.

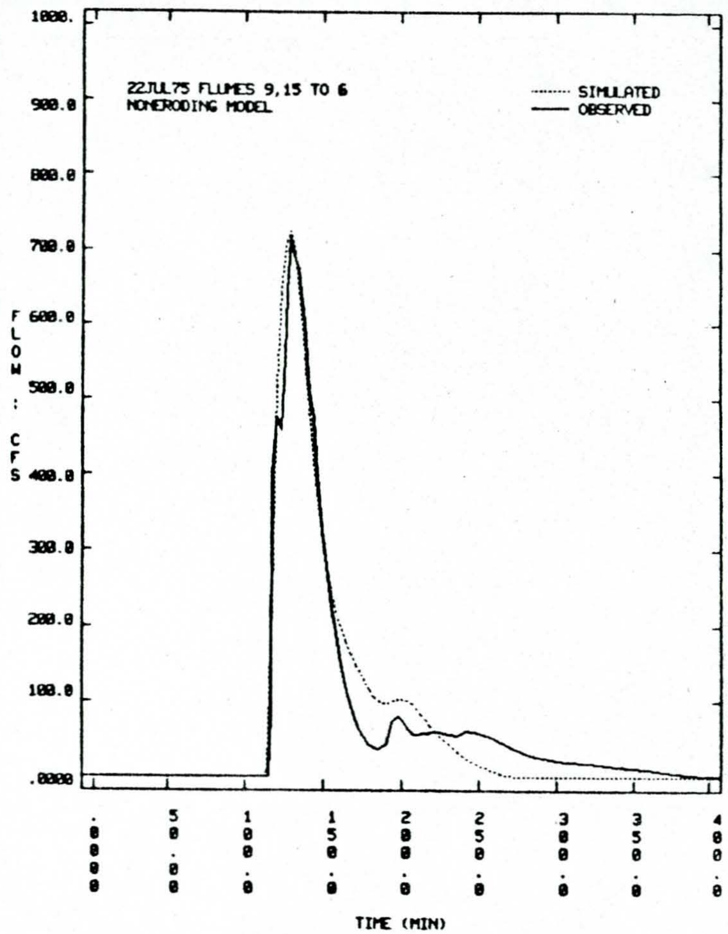

Figure 8. Event with 4.2 iph abstraction.

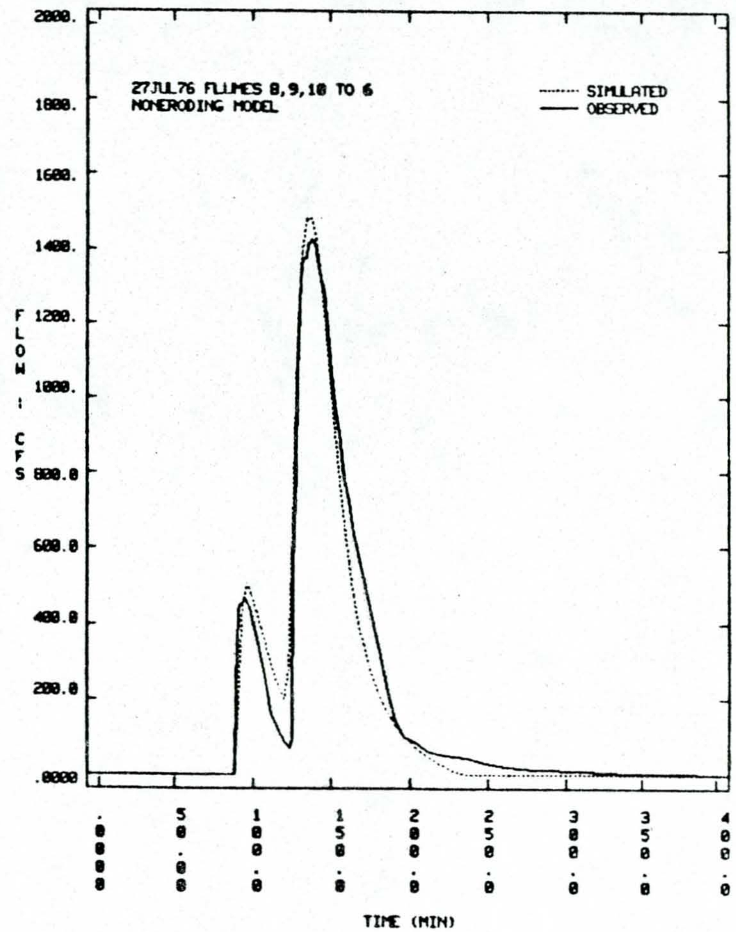

Figure 9. Event with 6.5 iph abstraction.