Assessing the Influence of Sediment Loads on the Surface Velocities of Flash Floods

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Introduction

Flash floods are a common ecological disaster often coming in quick causing damage to both man-made structures and natural ones. Studying various aspects of these flash floods can help mitigate damage from these floods. One of the key factors influencing the behavior of flash floods is the amount of sediment carried by these floods. Sediment can alter characteristics of the surface velocity of the flow, which is important to understanding the impact of floods and designing safety measures. This research aims to investigate how varying sediment concentrations affect the surface velocity of flash floods. We compute surface velocities using video recordings of several flash floods at a sediment observatory in central New Mexico. We compare these velocities with bedload flux measured by sediment samplers at this site to assess the impact of higher bedload flux on surface velocity. These types of comparisons can improve predictive models and develop better strategies for managing the risks associated with flash floods.

Methods

- LSPIV: Large-Scale Particle Image Velocimetry (LSPIV). LSPIV analysis consists of recording a video of a flood and analyzing each frame for changes in the water surface. Individual particle tracking produces an array of surface velocity vectors. These vectors can be used to calculate average surface velocity of flash floods.
- Fudaa: The editing software Fudaa was used to condense and articulate the findings into usable velocity vector data.
- Samplers: Sediment collection in the basin was acquired using three Reid-type in-channel samplers which were embedded into the river bed equal distance apart. Samplers are metal boxes 3 feet into the ground with metal slats to close the box. Sediment collections occurred 12-24 hours after the flood and would be refilled with water upon return to the river floor in order to keep sediment levels from spiking.
- Web link for LSPIV software: https://www.iahr.org/library/infor?pid=19562

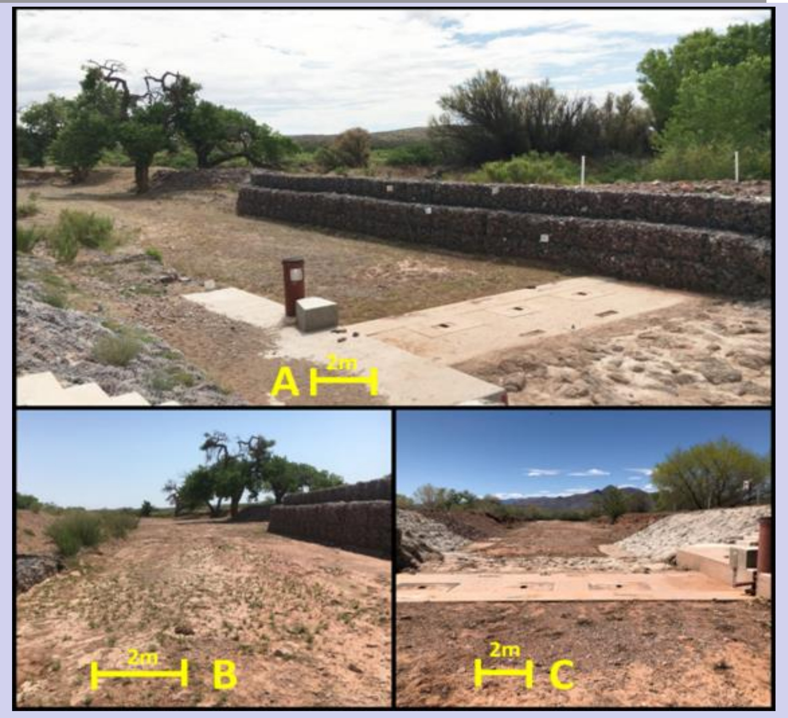


Figure 1: Photos of constructed Pinos site in oblique view (A), looking upstream (B) and looking downstream (C sideview

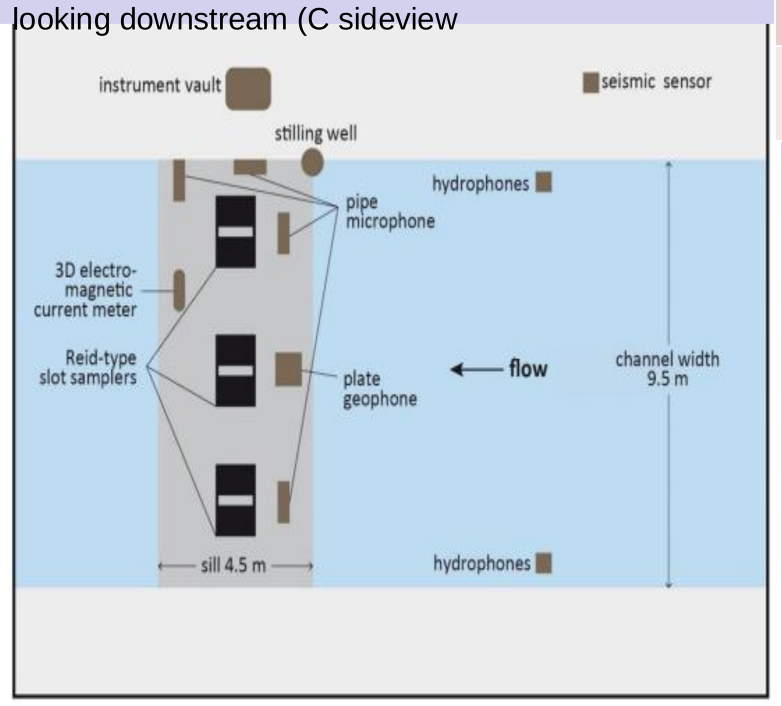


Figure 2: Overhead view of the mechanics of the site

1. Date
2. Peak height of the flood
3. Time flood data was recorded

Bedload and Velocity

The table is divided into three sections, each corresponding to a specific area of the flood site. For each section, the table lists the date of the flood, the peak height of the flood, and the times when measurements were recorded. Data collection began at minute 0. At these times, surface velocity, measured using Large-Scale Particle Image Velocimetry (LSPIV), and bedload flux were recorded. The surface velocity data were obtained using LSPIV, while bedload flux was averaged over a 5-minute period surrounding the time of the video measurements.

2022-07-06 5.46cm Min 19	Section 1	Section 2	Section 3
Flood Velocity m/s	0.216	0.051	0.001
Bedload Flux kg/m/s	0.161	0.033	0.032

2022-08-20 12.8cm Min 20	Section 1	Section 2	Section 3
Flood Velocity m/s	0.388	1.31	1.703
Bedload Flux kg/m/s	0.691	2.086	2.615

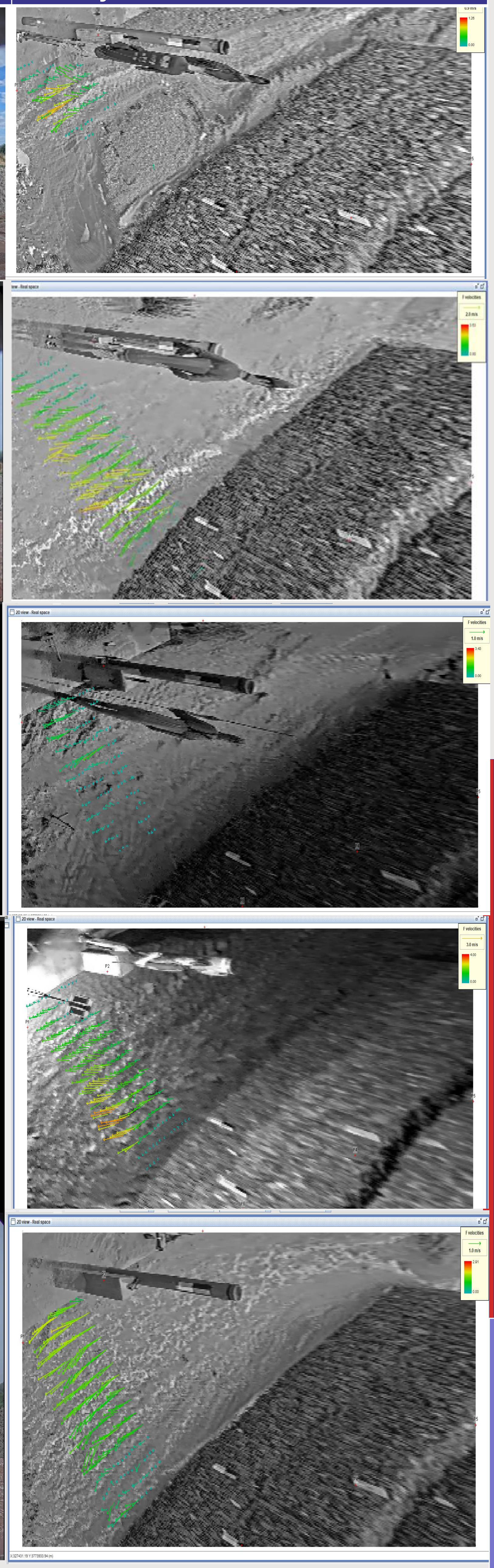
2021-07-02 30.7cm Min 20	Section 1	Section 2	Section 3
Flood Velocity m/s	0.181	0.238	0.106
Bedload Flux kg/m/s	3.357	8.076	6.257

2023-08-26 43.2cm Min 29	Section 1	Section 2	Section 3
Flood Velocity m/s	0.079	1.322	0.826
Bedload Flux kg/m/s	3.259	3.958	0.703

2021-07-23 95.5 cm Min 29	Section 1	Section 2	Section 3
Flood Velocity m/s	1.185	1.239	0.368
Bedload Flux kg/m/s	2.172	3.366	2.310

Still Image: These are images taken from the camera on site.

Transformed Image: Images changed by orthorectification to calculate flood velocity.



Abstract

Studying the effect of sediment load on surface velocity during flash floods is crucial for understanding erosional processes and enhancing aquatic safety. The collection of data on ephemeral streams can be difficult; the use of handheld velocity meters requires close proximity to swift moving water. However, the use of video and digital software allows for remote, safe data collection. In this study, we analyzed two years of video camera footage of floods during 2022-2024 from the Arroyo de los Pinos, a Rio Grande tributary in central New Mexico. We compared water surface velocity with bedload sediment transport rates, across flow depths ranging from 15 to 65 cm. Sediment data was collected in Reid-type in-channel samplers. Surface velocity data was collected from video camera footage that was analyzed using Large Scale Particle Image Velocimetry (LSPIV) software (FudaaLSPIV). This open-source program analyzes each frame of a video and uses individual particle tracking to calculate surface flood velocity, allowing for safe and remote flood velocity analysis. We predict that our findings will indicate that higher sediment loads correlate with decreased surface velocity during flash floods of similar water levels, because of the additional roughness and momentum transfer or drag due to the mobile bed sediment. The results will provide valuable insights for the interpretation of surface velocity data, which is useful for flood risk management and erosion control strategies.

Conclusion

The evidence shows that flood velocity significantly influences sediment deposition in tributaries. Faster floodwaters, with their high potential energy, keep sediment suspended, resulting in minimal deposition as sediments are transported over long distances without settling. While on the other side, slower floods lack the energy to transport sediments efficiently, leading to limited carrying capacity and low overall deposition, as they cannot move larger sediment particles. Medium-speed floods, however, possess enough energy to transport sediments while also allowing them to settle, leading to high amounts of sediment deposition. This balance makes medium-speed floods the most efficient at depositing sediments compared to faster and slower floods.

Acknowledgments

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