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Impacts of Grade Control Structure Installations on Hydrology and Sediment Transport as an Adaptive Management Strategy

Research Bulletin
S&T Project 1751

Mission Issue

Improved understanding of the hydrologic impact of GCS installations on stormflow, infiltration, erosion, sediment transport, and local microclimate to reduce peak flows, erosion, sediment transport, and temperature and increase water availability leads to effective water resource and reservoir management for long-term resource planning.

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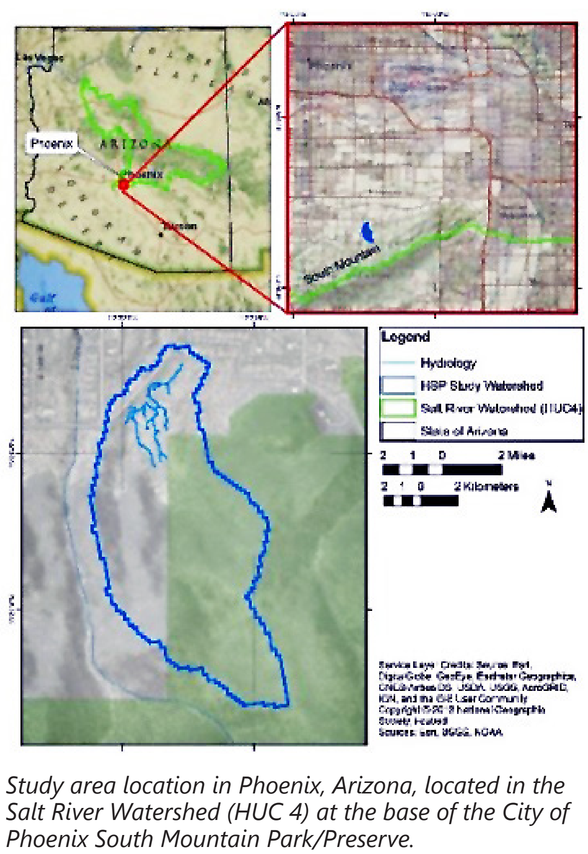
Problem

There is limited hydrologic research demonstrating that Grade Control Structure (GCS) installations reduce stormflow peaks, sediment transport, and microclimate temperatures and increase infiltration, soil moisture, and local water resources in arid lands. Measuring stream flow in ephemeral channels is challenging and monitoring over the long-term can be expensive. Restoration practitioners suggest GCS as an adaptive management strategy, but need quantitative studies to address significant legal and institutional barriers.

Solution

The Study was designed to assess hydrologic conditions pre- and post-GCS installations at the Boy Scouts of America (BSA), Heard Scout Pueblo located at the base of South Mountain Park in Phoenix, Arizona, USA. The Study drainage flows through the BSA facilities and campgrounds before exiting into a residential neighborhood, where flooding has been identified as a problem. This research builds on the work of others to collect hydrologic and sediment transport data, document how GCS installations alter the hydrologic cycle, and address potential impacts on safety, downstream surface water-rights appropriations, the environment and society.



Study area location in Phoenix, Arizona, located in the Salt River Watershed (HUC 4) at the base of the City of Phoenix South Mountain Park/Preserve.

"The careful redundancy of data acquisition, exemplified in the details of this study, is invaluable when studying dryland hydrology."

Laura M. Norman, Ph.D.
Supervisory
Research Physical Scientist,
U.S. Geological Survey,
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More Information

https://www.usbr.gov/research/projects/detail.cfm?id=1751

Application and Results

Innovative monitoring equipment was installed in the study drainage. This included a large-scale particle image velocimetry video camera and pressure transducers (to calculate discharge); digital terrain models, sediment samplers and sediment chains (to measure erosion and deposition); soil moisture sensors in monitoring wells (to document infiltration and potential recharge); and weather stations (to track temperature and relative humidity). Four small Unmanned Aircraft System (sUAS) surveys, a Terrestrial Land Survey, and a standard Land Survey were completed to monitor changes in cross-sections and geomorphology. Second, a two-dimensional (2D) mobile-bed hydraulics and sediment transport model for river systems was applied to predict sources and sinks of water and sediment yield, and predict impacts of GCS installations throughout the drainage. Third, GCSs were physically installed throughout the study area by a civil and environmental engineering consulting firm. Finally, results from the pre- and post-GCS installations monitoring were documented and compared.

Despite drought conditions, small storm flow events provided enough data to model and analyze surface water conditions. Model analyses predicted the slight reduction and delay in peak flows for small events, consistent with the literature. The data collected for this Study agreed with model predictions and documented these effects, giving confidence for future modelling efforts. While data collection did not portray impacts on rainfall-runoff response from the installation of GCS, this is attributed to the dry antecedent conditions. The structures did reduce flashiness of peak flows though (which should limit erosion). The model estimates that the structures could increase the infiltration approximately 15% over time, slightly larger than average infiltration increases documented previously. Collected microclimate data demonstrate that GCS installations create roughly a three-degree microclimate cooling effect for at least two days following rainfall events, as compared with the untreated sites.

Future Plans

The existing comprehensive monitoring program provides a good opportunity to continue stormwater monitoring and potentially collect data under wetter climatic conditions. While this study has ended, the Flood Control District of Maricopa County, in coordination with the U.S. Geological Survey and the BSA, will include the site in their regional monitoring network and will continue to collect data to assess how GCS installations may be used in regional stormwater management. More research is warranted to explore the microclimate cooling results and use of green infrastructure to manage stormflows, critical in water-limited, arid, and semiarid ecosystems.

Grade Control Structure #1 looking upstream, March 13, 2020. (Bureau of Reclamation photo, Phoenix Area Office, Deborah Tosline)