05/06/2011

Publication List Related to Urban Hydrology and Water Quality

Publications and abstracts are listed in reverse chronological order. A limited number of reprints are available, and can be requested by referring to the NAEW number. Use your browser's "find" feature to search for words of interest. For more information, please contact:

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Pappas, E.A., Huang, C., Bonta, J.V. 2011. Do Upslope Impervious Surfaces Impact the Run-on/Runoff Relationship? Journal of Hydrologic Engineering. 16(4):345-350. **(NAEW #472)**

Abstract:

Development of watersheds previously managed for agricultural uses for commercial and residential uses results in the replacement of pervious soil surfaces with impervious surfaces. Characteristics of runoff generated on new upslope impervious surfaces may differ from runoff generated on the predevelopment soil surface in terms of quantity, time of concentration, and sediment load. This may cause changes to the erosion regime on downslope soil surfaces. We used rainfall simulation having increasingly higher rainfall rates (20, 30, 40 mm hr-1) to generate runoff from 0.6 m2 boxes (impervious, pervious-soil). Boxes were either treated with an impervious surface (I), or filled with soil (S) 0.2 m deep, and were connected together in series of four boxes to produce different arrangements of impervious and pervious soil surfaces (0, 25, 50% impervious), and under two different antecedent soil moisture conditions. Results indicate that previously established numerical models predicting runoff characteristics as a function of runon characteristics generate very good correlations where there is 0% imperviousness, but these become insignificant as imperviousness increases. Imperviousness significantly influenced sediment regime such that previously established soil erosion predictive models cannot be simply applied to areas where runoff production occurs on surfaces having an impervious component.

Wang X., Shuster W., Pal C., Buchberger S., Bonta J., Avadhanula K. 2010. Low Impact Development Design—Integrating Suitability Analysis and Site Planning for Reduction of Post-Development Stormwater Quantity. Sustainability. 2(8):2467-2482. **(NAEW #467)**

Abstract:

A land-suitability analysis (LSA) was integrated with open-space conservation principles, based on watershed physiographic and soil characteristics, to derive a low-impact development (LID) residential plan for a three hectare site in Coshocton OH, USA. The curve number method was used to estimate total runoff depths expected from different frequency storms for: (i) the pre-development condition, (ii) a conventional design, (iii) LID design based on the LSA of same building size; and (iv) LID design based on the LSA with reduced building footprints. Post-development runoff depths for the conventional design increased by 55 percent over those for the pre-development condition. Runoff depth for the same building size LSA-LID design was only 26 percent greater than that for the pre-development condition, and 17% for the design with reduced building sizes. Results suggest that prudent use of LSA may improve prospects and functionality of low-impact development, reduce stormwater flooding volumes and, hence, lower site-development costs.

Pappas, E.A., D.R. Smith, C. Huang, W.D. Shuster, and J.V. Bonta. 2008. Impervious surface impacts to runoff and sediment discharge under laboratory rainfall simulation. Catena 72(1):146-152. (Available online at www.sciencedirect.com) **(NAEW #444)**

Abstract:

Urbanization of watersheds previously managed for agricultural uses results in hydrologic changes associated with increased flooding and erosion. Few studies have been conducted to quantify these effects under controlled conditions and standard rainfall simulation methodologies have not been previously established. In this study, a laboratory rainfall simulation procedure was developed and utilized to evaluate hydrologic and sheet erosional responses to various configurations of impervious surface cover at the small scale. Runoff and sediment losses from a sloped (5%) cascade of soil boxes having 50% impervious cover located at the top of the slope or at the bottom of the slope, or having 0% impervious cover were measured. Results indicate that the 50% upslope impervious treatment generated sediment at 3–5 times the rate of the 50% downslope impervious treatment. Upslope impervious cover resulted in initially lower water runoff rates than channel development, but this effect narrowed or reversed with continued rainfall. These results suggest that upslope impervious surfaces may represent a larger total on-site erosion risk than equivalent impervious surfaces located at lower positions along the slope, especially under high antecedent soil moisture and/or high intensity rainfall.

Bonta, J.V. 2006. Effects of urbanization of undisturbed watersheds on

hydrology and water quality research plan, instrumentation, and baseline watershed conditions. USDA-Agricultural Research Service, North Appalachian Experimental Watershed, Coshocton, OH. Sept. 2006, (**NAEW #433)**

Abstract:

Although urbanization has a major impact on watershed hydrology, there have not been many studies to quantify how basic hydrological relationships are altered by the addition of impervious surface under controlled conditions. The USDA-Agricultural Research Service and USEPA jointly initiated a pilot program to study the impacts of simulated impervious surfaces on hydrology, sediment, and water quality in small experimental watersheds located at the North Appalachian Experimental Watershed (NAEW), Coshocton OH. This report outlines the research plan and instrumentation for using four experimental watersheds (0.57 ha to 3.09 ha) subjected to natural precipitation and weather, and contains an analysis of baseline watershed conditions prior to installing imperviousness. These upland watersheds have a grass cover and swale areas that concentrate watershed runoff with no incised stream channel. Percent imperviousness is planned from 0% to as much as 40% under two spatial arrangements of imperviousness - stream-channel-connected and stream-channel-disconnected imperviousness. This report concentrates on hydrological analysis of data. Preliminary indoor laboratory rainfall simulation efforts are also presented. An analysis of weather during the project, runoff volumes and peak flow rates, infiltration, soil-water content, curve number, and precipitation and stream-water chemistry is presented for the undisturbed conditions. Curve numbers for the undisturbed sites ranged from 64 to 75. The recent (3+ years) weather tended to be wetter and warmer than average, with some months having record precipitation and air temperature. Exploratory data investigations revealed weak correlations between infiltration data and soil characteristics, and were affected by spatial variability of soil hydraulic properties. The results suggest that the correlations could be used as a first approximation of Horton infiltration parameters if this model was used. They also provide a measure of the variability that can be expected. Also, analysis of soil-water content data suggested that variability of soil water in the soil profile may play a role in runoff generation, but more data are required. Duration curves of soil-water data suggest that they can be used to quantify both macroporosity and smaller pore spaces. These results may be useful in existing models, and may give guidance on developing new algorithms for future models if soil-water content data could be easily collected to help parameterize new algorithms. Water-chemistry from the four sites was different. Concentration-discharge regressions for several constituents on these small watersheds were statistically significant, but the relations were characterized by much variability, however, the trends were apparent. Frequency distributions of chemical constituents for both discrete and composite stream samples can be used to compare future land treatments consisting of increased imperviousness. The historic data sets at the NAEW have proven invaluable for evaluating baseline data because they contain the response of the watershed to a wide variety of weather experience. Baseline data analyses presented in this report can be used for comparisons when imperviousness is increased in the future on these four sites.

Shuster, W.D., J.V. Bonta, H. Thurston, E.A. Warnemuende, and D.R. Smith. 2005. Impacts of impervious surface on watershed hydrology: a review. Urban Water Journal 2(4):263-275. (Available in PDF file.) **(NAEW #426).**

Abstract:

Increased impervious surface area is a consequence of urbanization, with correspondent and significant effects on the hydrologic cycle. It is intuitive that an increased proportion of impervious surface brings with it shorter lag times between onset of precipitation and subsequently higher runoff peaks and total volume of runoff in receiving waters. Yet, documentation on quantitative relationships between the extent and type of impervious area and these hydrologic factors remains dispersed across several disciplines. We present a literature review on this subject to better understand and synthesize distinctions among different types of impermeable surface and their relative impacts, and describe the manner in which these surfaces are assessed for their putative impacts on landscape hydrology.

Shuster, W.D., Y. Zhang, J.V. Bonta, H. Thurston, and E.A. Warnemuende. 2004. Comprehensive research and impacts of management of imperviousness on watershed hydrology. Proceedings of 2004 CIGR International Conference, Beijing, China. Oct. 11-14, 2004. **(NAEW # 413)**

Abstract:

Impervious surface is one of the primary agents of hydrologic change in urbanizing watersheds, and its impacts on hydrologic cycles and terrestrial ecological regimes are multifold. The mechanisms through which these impacts are manifested are not well understood, hampering effective management of these impacts. Here at the USEPA National Risk Management Research Laboratory, Sustainable Environments Branch, we are concerned with promoting multidisciplinary approaches to sustainable environmental management systems through the integration of hydrologic, ecological, economic, and legal perspectives. One way that we articulate this mission is through the examination of storm water runoff regimes in urban ecosystems and how these might be better managed. We have identified two areas of focus, the first is in-situ assessment of the alteration of hydrologic cycle in response to urbanization; and secondly systemic, low-cost participatory approaches to managing storm water runoff at the watershed scale. There are few or no studies that we are aware of which determine the underlying mechanisms and extent of these impacts over the course of landscape alteration through the incremental addition of impervious surfaces over time. The USDA-ARS and USEPA-ORD-NRMRL have initiated a pilot program to study the impacts of different extents and geometries of simulated impervious surface on 1.5 ha experimental watersheds located at the North Appalachian Experimental Watershed, Coshocton, OH (USA). As a complement to the experimental investigation of fundamental processes in urban hydrology, we explore distributed stormwater management practices that may mitigate the deleterious impacts of stormwater flows in a previously developed 150

hectare residential neighborhood where impervious surface impacts are typically left unmitigated. Here, we use an urban watershed as a pilot study to determine whether parcel-level Best Management Practices (BMPs; e.g., rain gardens) can be implemented throughout the residential areas, and on the basis of an economic incentive program, which itself centers on trading detention responsibility among parcel holders to achieve a preset watershed-level cap on runoff. We have implemented an before-after/control-impact experimental design and initiated hydrologic and ecological monitoring at five stations distributed across the various land uses and impacted areas to determine whether the placement of BMPs at the parcel level in the residential area have effected an improvement in hydrologic and ecological status for tributaries draining urbanized areas of the watershed. We present a basic description of experimental approach for these projects followed by a summary of field data and discussion of preliminary modeling results.

Bonta, J.V., W. Shuster, E. Warnemuende, H. Thurston, D. Smith, M. Goss, and H. Cabezas. 2003. Quantification of urbanization in experimental watersheds. First Interagency Conference on Research in the Watersheds. Oct. 27-30, 2003, Benson, AZ. pp. 355-364. **(NAEW #392)**

Abstract:

Although urbanization has a major impact on watershed hydrology, there have not been many studies to quantify how basic hydrological relationships are altered by the addition of impervious surface under controlled conditions. The USDA-ARS and USEPA have jointly initiated a pilot program to study the impacts of simulated impervious surfaces on hydrology, sediment, and water quality in small experimental watersheds located at the North Appalachian Experimental Watershed, Coshocton OH. This paper outlines the approach and rationale for using rainfall simulation, experimental watersheds subjected to natural precipitation and weather, and modeling for a multiyear project. Percent imperviousness is planned from 0% to 40% under two spatial arrangements of imperviousness - stream-channel-connected and stream-channel-disconnected imperviousness. The results from laboratory rainfall simulation will help guide the implementation of impervious surfaces in the watersheds. Preliminary evaluation of the Coshocton baseline runoff data shows that, during the time of constant land use since 1975, annual runoff depths are similar and runoff regimes have been constant. Results from this study are applicable to the development of urban hydrology analyses, hydrology and water-quality models, design and testing of urban best-management practices, and environmental management.

Warnemuende, E.A., W. Shuser, D.R. Smith, and J. Bonta. 2003. Methodology for determining effects of extent and geometry of impervious surface on hydrologic balance. First Interagency Conference on Research in the Watersheds. Oct. 27-30, 2003, Benson, AZ. pp. 89-95. **(NAEW #394)**

Abstract:

Urbanization of watersheds previously managed for agricultural uses results in

hydrologic changes associated with increased flooding, erosion, and surface water degradation. Few studies have been conducted to quantify these effects under controlled conditions and standard rainfall simulation methodologies have not been established. In this project, the feasibility of rainfall simulation methods to evaluate hydrologic and erosional responses to various impervious treatments is examined. In addition, a modular segmented soil box design is developed in order to quantify the hydrologic, erosional, and water quality impacts of specific urban land use configurations, including the impacts of land uses of areas hydrologically connected to impervious areas. Hydrologic, nutrient, and pesticide data from runoff under rainfall simulation will be collected and analyzed. Treatments will include the following distributions of imperviousness at the 20%, 30%, and 40% total impervious area level: effective impervious elements each 1.25%, 5%, and 20% of total hydrologic area, non effective impervious elements each 1.25%, 5%, and 20% of total hydrologic area. In addition, potential urban and turf best management practices will be evaluated. In conjunction with this study, a field study will be conducted at the North Appalachian Experimental Watershed near Coshocton, OH by members of the USDA-ARS and USEPA. The field study will investigate impervious surface effects at the small watershed scale.