Reedy Creek: A Stream Science and Spatial Statistics Approach

Jared Goldbach Ehmer & Andrew Loesch

Department of Geography and the Environment and Environmental Studies Program, University of Richmond

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Introduction

In 2009, the U.S. Environmental Protection Agency (EPA) issued updated rules regarding Total Maximum Daily Load (TMDL) levels for three primary pollutants in the Chesapeake Bay: nitrogen, phosphorus, and total suspended sediment (TSS). The EPA required Richmond to draft Watershed Implementation Plans (WIPs) detailing individual pollution reduction goals and specific actions required to achieve those goals. The City of Richmond intended to complete stream restoration projects on five urban streams, including Reedy Creek. The City of Richmond commissioned Timmons Group to complete erosion analyses and recommend stream sections for restoration. The following (1) examines the relationship between spatial stream statistics and Land Cover Management practices over the current scenario and the alternative planned scenarios using the spatial statistics program iTree Hydro and (2) contains a short literature review of the relevant literature in the stream restoration field today, and connects current theories and analyses to Reedy Creek's local context.

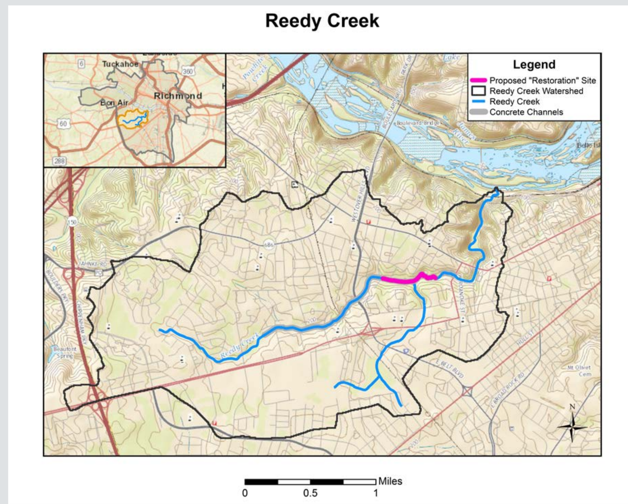

Figure 1: Overview of Reedy Creek and Watershed

Spatial Statistics

iTree Hydro is a simulation tool that analyzes how land cover influences the volume and quality of runoff. It can analyze historical or future hydrological events and allow the user to contrast runoff volume and quality from existing Land Cover (referred to as the Base Case) with runoff from the Alternative Case Land Cover. Basin Characteristics were calculated using USGS's StreamStats Tool, NLCD Canopy Cover (Figure 2), and NLCD Land Cover (Figure 3). iTree Hydro takes hourly weather data from the past nine years, combines it with elevation data for the watershed, and models the impact on the landscape given the values provided from the Basin Characteristics. Streamflow (Figure 4), runoff (Figure 5), pollution (Figure 6), and erosion (Figures 4 and 6) were modeled under the 'Base Case' (present landscape conditions) and the 'Alternative Case' (hypothetical landscape conditions). The explored Alternative Case involves a proposed 10% Land Cover Change from Developed land to Shrub land – the replacement of impermeable surfaces with shrubbery. This is a common percentile goal for extended Land Cover Change and particularly obtainable over the Richmond city-scale (Lambin et al. 2001). Under this proposed Alternative Case, modeled streamflow, runoff, pollution, and erosion are all reduced. Particularly higher percentile reductions appear across the board during severe weather events – floods are felt lesser in magnitude and rapidity due to the buffering effect and permeability of the new shrub land (Figures 4 – 6). The solid bars represent the Base Case and the hashed bars represent the Alternative Case – there are reductions across the board under the Alternative Case. A reduction of impervious land cover like this Alternative Case displays is one potential way to achieve the individual pollution reduction goals without performing a Stream Restoration on a creek that may not even meaningfully reduce the primary pollutants headed towards the Chesapeake Bay.

Maps and Charts

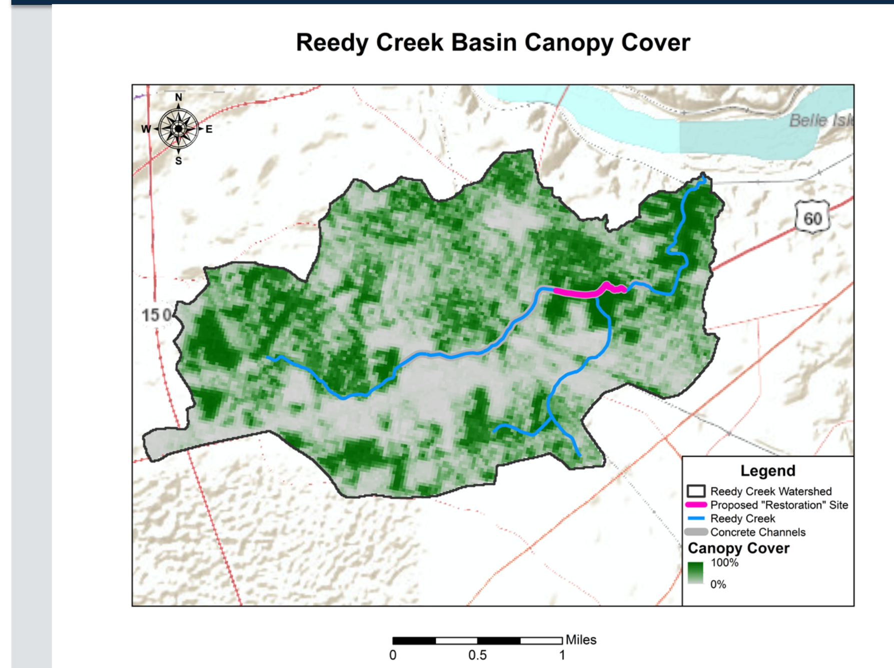

Figure 2: Canopy Cover over Reedy Creek Watershed

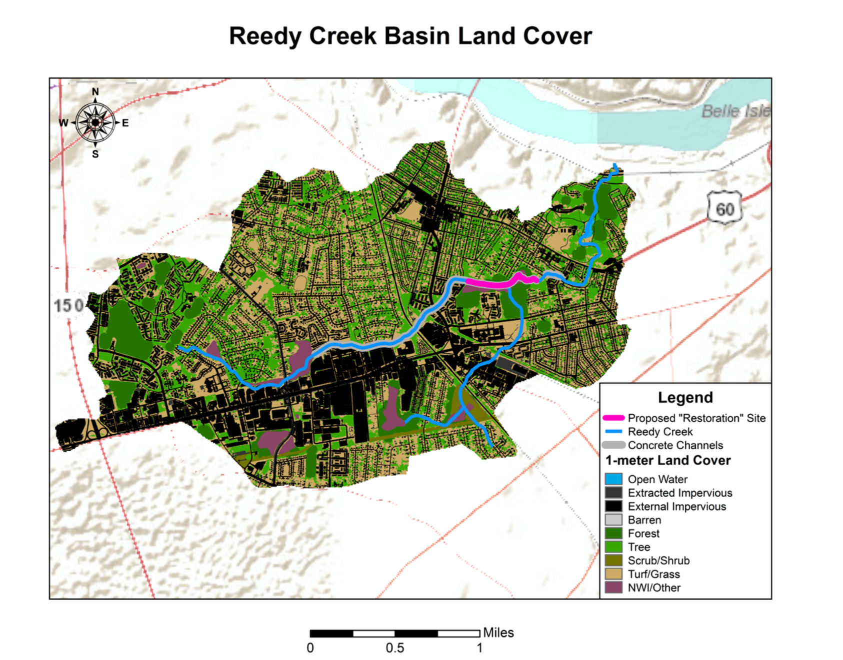

Figure 3: Land Cover over Reedy Creek Watershed

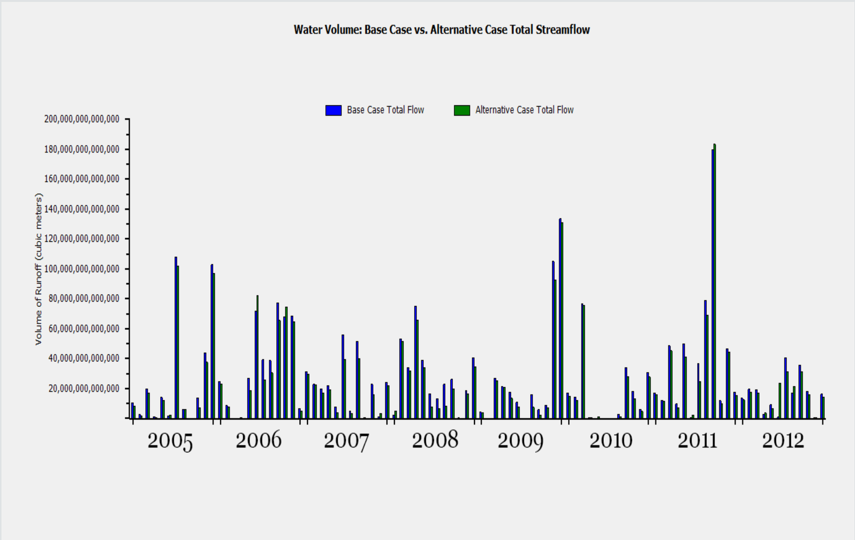

Figure 4: Base Case vs. Alternative Case Predicted Streamflow

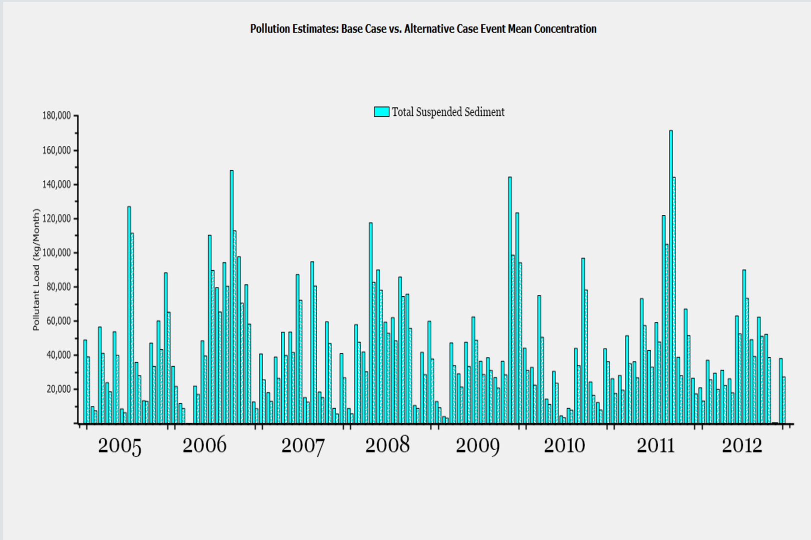

Figure 5: Base Case vs. Alternative Case Total Suspended Sediment

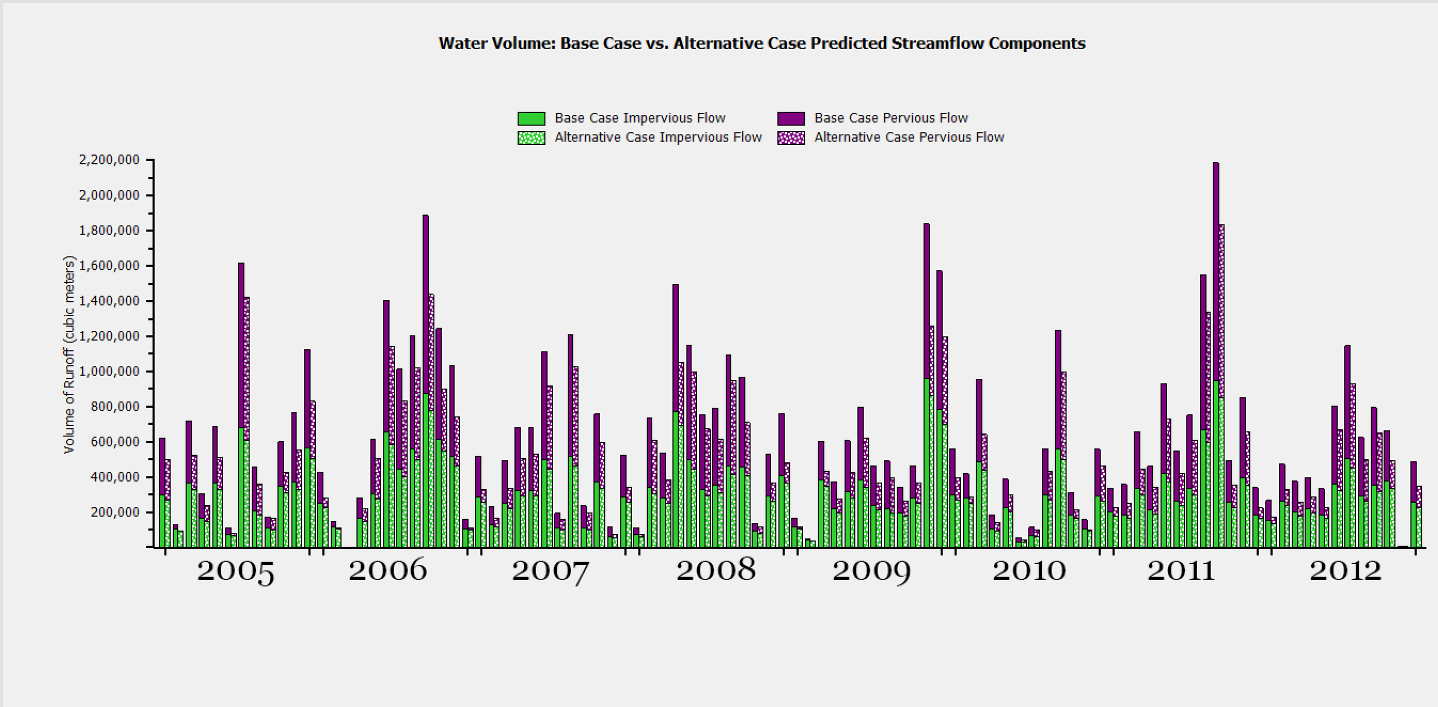

Figure 6: Base Case vs. Alternative Case Pervious and Impervious Flow

Stream Restoration Design & Risks

As stream restoration generally lacks scientific literature both for development and review for consensus on metrics of success, the Reedy Creek Restoration Project proposal finds itself in an evolving tradition. Roni and Beechie of the National Marine Fisheries propose a comprehensive, multi-step process for stream restoration design and execution to combat the startling lack of stream restoration technique literature. Several goals of the Reedy Creek proposal fail to successfully evaluate the multiscalar nature of stream restoration and biological, chemical, and physical risks associated with the individual steps throughout the process using this template.

Using Roni and Beechie's metrics, the original Reedy Creek proposal raises some concerns. The initial project only displays concern for biological, chemical, and physical processes on a regional scale by adhering to federal regulations to reduce sediment and pollutants in the Chesapeake Bay, ignoring city and local scales. In addition to attempting to restore portions of the stream with already healthy soils, the project does not provide a dedicated plan to prevent erosion after its completion. The project fails to address the increased vulnerability of streams to infiltration by invasive species, such as English Ivy or Blackhaw viburnum, during restoration and the potential loss of habitat or habitat quality (Bond and Lake 2003).

Common invasive species near Reedy Creek:

Left: Blackhaw viburnum (*Viburnum prunifolium*)

Right: English Ivy (*Hedera helix*)

As the stream restoration project, using these metrics, may create an unhealthy environment at several local and stream scales, evaluation of alternatives may provide a compromise beneficial to the Chesapeake Bay and Richmond. Perhaps the simplest alternative solution, reduction of impervious surfaces in basins and watersheds contributing to the James River, provides significant local benefits during our preliminary analysis. Streamflow velocity and runoff of both water and pollutants are reduced as a result of water's increased exposure to landscapes capable of slowing and absorbing water into the water table, as well as cycling nutrients.

Acknowledgements & Citations

Beechie, T. and P., Roni. 2009. *Stream and Watershed Restoration*. John Wiley & Sons.

Bond, N., and S. Lake. 2003. Local habitat restoration in streams: Constraints on the effectiveness of restoration for stream biota. *Ecological Management & Restoration* 4 (3):193–198. http://onlinelibrary.wiley.com/doi/10.1046/j.1442-8903.2003.00156.x/full.

Davey, Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and Casey Trees. 2017. iTree Software Package Suite. US Department of Agriculture - Forest Service 6.1.16.

Environmental Systems Research Institute (ESRI). 2016. ArcGIS Software Suite. Environmental Systems Research Institute 10.4.1.

Lambin, Eric F., B. L. Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John W. Bruce, Oliver T. Coomes, et al. 2001. "The Causes of Land-use and Land-Cover Change: Moving Beyond the Myths." Global Environmental Change 11 (4): 261-269.

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