Our Water 1.1: Expanding Resilient Design through Geospatial Analytics

Developing Applied Geospatial Analytics for Assessing Green Infrastructure Performance at Urban Scales

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PERKINS+WILL

1.1 Introduction

What if our cities returned to nature? What if all of our buildings could breathe? Can you imagine a sewer system that never flooded? Is it possible to feed a city purely on urban agriculture? How can our cities return to an eco-centric equilibrium?

Let's Build Living Cities!

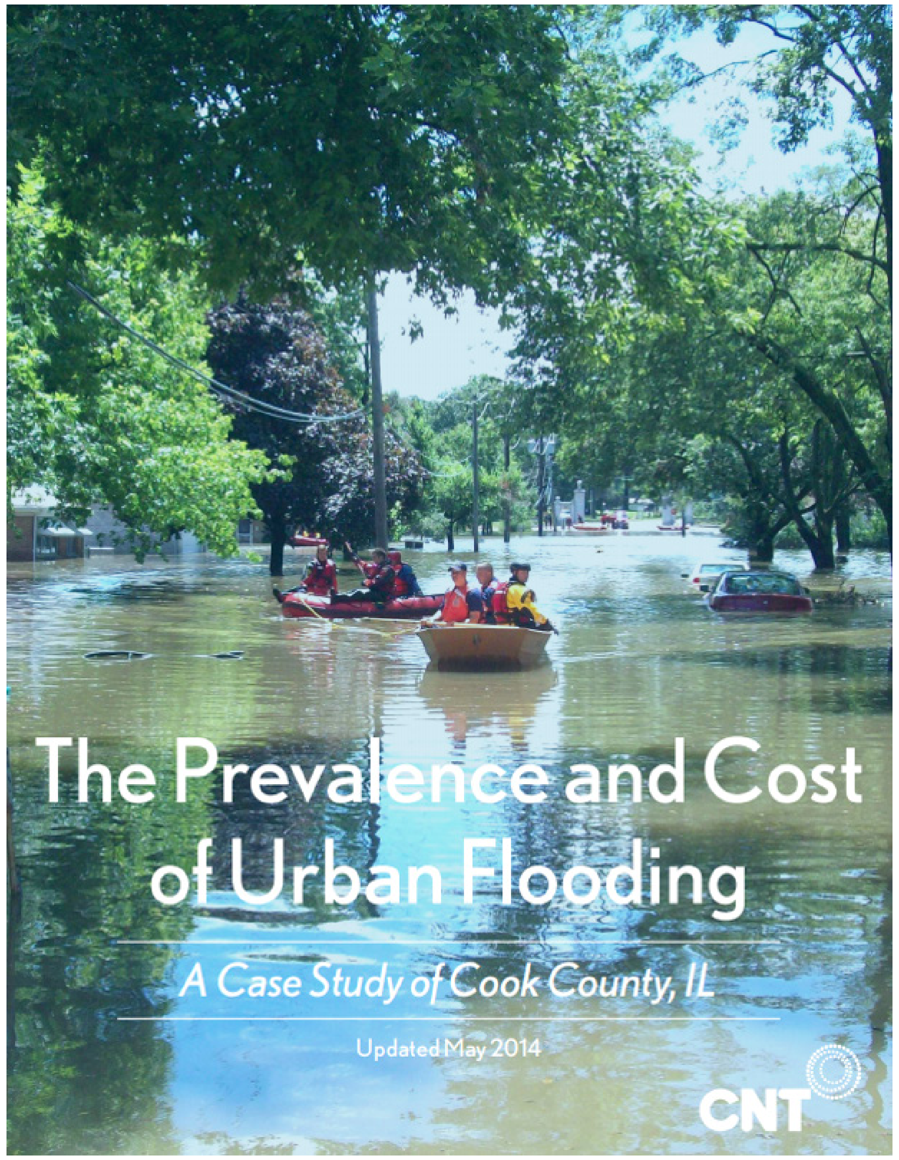
For over a century, cities have been building municipal sewer systems to handle waste and excess water. When they were first invented, overrides were put in place to divert excess water during heavy rain events. These overrides would mix raw sewage with rainwater and then eject it into local waterways. Water treatment plants have helped to reduce these occurrences, but, with urban sprawl and the growth of impervious surfaces since WWII, most American cities still utilize this ***Combined Sewer Overflow (CSO)*** today.

Many cities today are expanding elements of their municipal sewer systems in order to reduce volumes of raw sewage that are impacting our waterways. Additional treatment plants, tunnels, reservoirs, and piping are being added in many metropolitan systems to plan for heavy rain events. These interventions are expensive and do not provide civic benefit outside of water retention during rain events. During dry days, this infrastructure goes unused.

We desperately need a solution and quickly! American cities lose billions of dollars to storm water every year. In this past year, Hurricanes Harvey, Maria, and Irma ravaged much of the southern and eastern portions of the US and intense storm systems regularly pound the midwest. Green infrastructure won't prevent the next Hurricane Harvey, but it could offer a far more resilient solution to storm surges and flash floods during intense rain events.

This submission is an expansion of the first version of Out Water, submitted in Spring of 2017. Some of the content will be redundant for those familiar with the submission, but additional details and graphics have been added along with an updated project scope.

Flash Flooding costs American cities a lot! In 2014 alone, Cook County Illinois suffered $733 million in flood damages, amounting to 181k total claims. These figures will continue to rise with climate change.



1.2 This is a Problem We can Solve

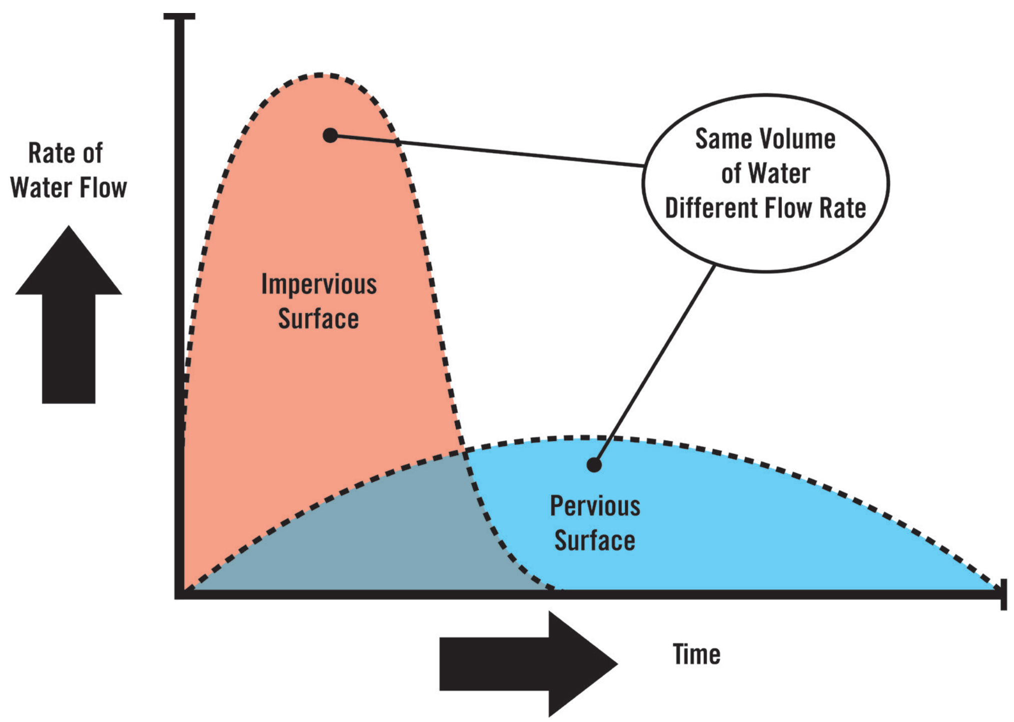
The source of our problem is in our understanding of water and city performance. This is one part "design" one part "policy" - we need an elegantly engineered solution AND a mindset shift.

The City as a Sponge

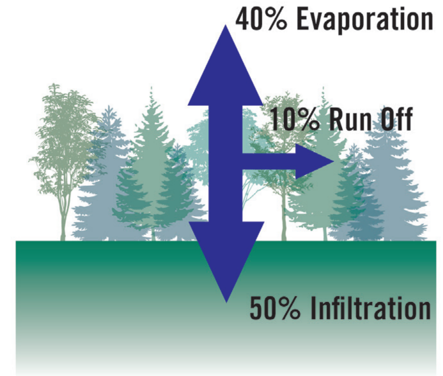
City design has, for centuries, revolved around designing hardscape. These spaces have their place, but they come at a cost. Impervious surfaces don't allow rain water to pass through them and infiltrate the soil and recharge our ground water.

Instead of allowing nature to do it's job, we have engineered sewer systems to manage stormwater (a convey and store approach to storm water).

In order to solve this problem, cities need to return to a place of passive storm water retention (a soak-and-store on site approach). This can be achieved through many green infrastructure interventions, including green roofs, bioswales, pocket parks, rain barrels, and rain cisterns.



Land Infiltration and Discharge Flow Rate Diagram - Ideal Situation in Blue

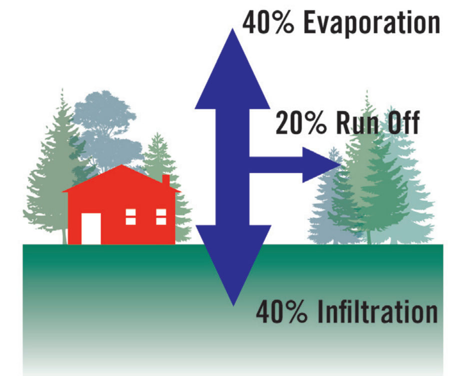


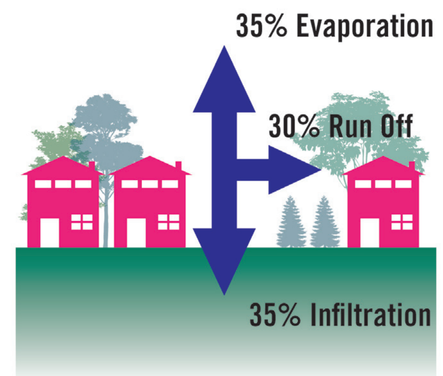
Unaltered Land

Nature is a wonderful adaptive force. In a conventional temperate forest (think the forests of Oregon or the Smokey Mountains) most precipitation is captured immediately by porous soils. This moisture is then either transfered to ground water, plant life, or evaporated. A small portion (about 10%) runs off to nearby streams or lakes.

Rural Development

Most rural development performs much like the above unaltered land. With the exception of rural farm landscapes, these spaces minimize impervious surfaces. Flooding still occurs on localized spaces, often due to highway or road developments, which can discharge large amounts of storm water into local streams and cause them to swell.



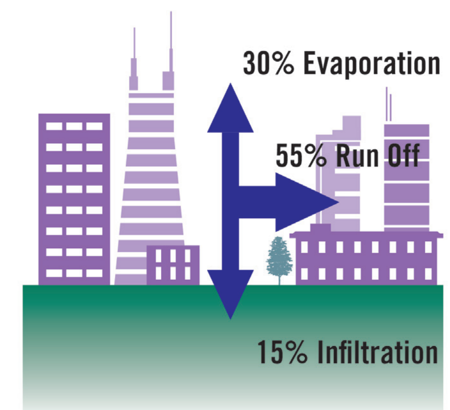


Suburban Development

Suburban spaces struggle on localized scales, but can stress the entire hydrological cycle of counties. Suburban developments pool water at the lowest point of topography, causing intense localized flooding. These spaces may appear integrated with nature compared to urban settings, but the stark contrast between developed and non-developed land means natural spaces have to bear disproportionate volumes of water. This contributes to run off.

Urban Development

Cities struggle so much with rain water, primarily, because most of their land cover consists of rooftops and pavement. These systems are predicated on the quick and efficient conveyance of water away from where it falls. This is largely due to the fact that water has no where to go when it falls on pavement except to a low point. As such, sewers are integral to ensuring flooding does not happen, although these systems often struggle to keep up.



1.3 The Process

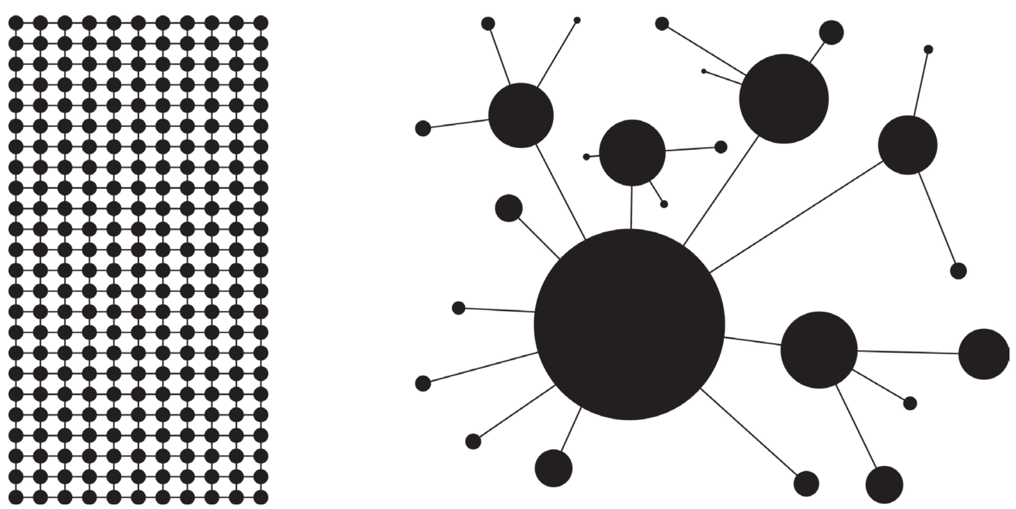
Where do we start?

Green infrastructure has gained a lot of traction as an innovative approach to civic design in the past few decades. Policy makers, designers, scientists, engineers alike are slowly embracing it as a tool to address problems within cities surrounding stormwater management, but consistently run into issues providing convincing data supporting its performance and benefits. Furthermore, cost estimation and building retrofits / adaptations create barriers of uncertainty. Ultimately, this gap of information and understanding can prevent clients and designers from considering green options as opposed to traditional options.

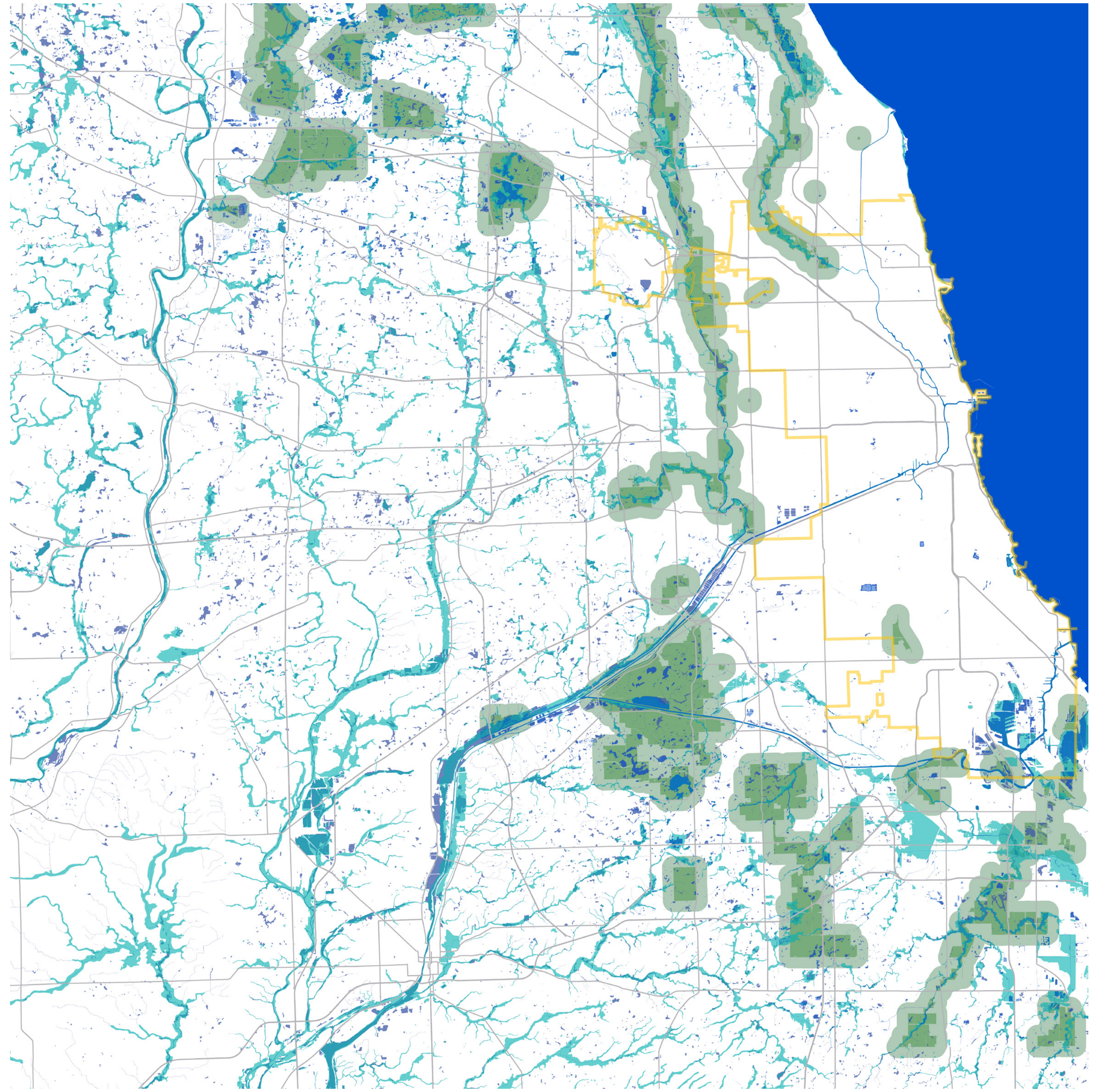
Some engineering solutions companies have been able to generate performance metrics for green infrastructure, which help paint a more complete picture of potential outcomes. One such firm, ***OMNI Ecosystems***, has collaborated with Perkins + Will on a few projects in the Chicago Office and across the country at various scales and applications. As such, their performance metrics have been applied to actual projects with proven success.

Such performance metrics aren't easy to come by, and are often confusing or difficult to apply in design analysis. OMNI's metrics for their proprietary materials and media represent a solid foundation for estimating green infrastructure performance, but the bigger question of, "Does this make a difference for the city?" still lingers.

Soak and Store **Convey and Store**



Soak and store offers a "sponge" approach to storm water management, creating an integrated web, with fewer opportunities for system overload or failure, and more overall flow capacity



Cook County Regional Hydrology Map - Flood Plains, Waterways, Forest Preserves and Buffer

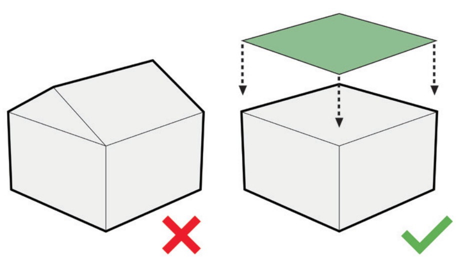
1.4 Process

Capturing a Workflow

Using OMNI's metrics and standards for building pre-requisites, a process has been developed, which can generate rough estimates for applications of their technology to buildings across Chicago using ***ESRI ArcGIS***. This process / package is called ***Our Water***, which translates to whatever project it is applied to (i.e. Our Water: Chicago). Below is a graphic representation of how Our Water is executed currently.

Any city with GIS data for its buildings can execute the work process for Our Water; the minimum data fields required are buried in GIS shape layers. Additional data layers can be factored in to increase the overall performance of the analytics involved.

Through this process, >300,000 Hamilton County buildings and their data were converted to .csv format, where various formulas were applied through a series of binaries and statistics to assess feasibility of a roof hosting a green roof retrofit. Currently this function exists in Excel. In total, the initial application of Our Water took a week, but now has an established workflow, which speeds the process up.

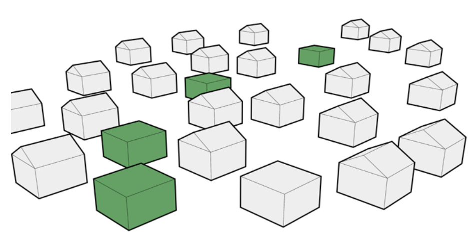


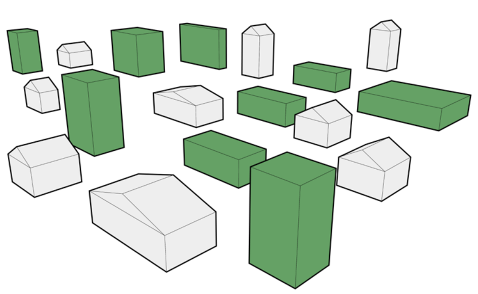
Green Roof Application

The primary requirement of a green roof is a flat roof. A flat roof offers a good base for building a deep media option with diverse planting offerings.

Sum of Flat Roofs

Counting the number of applicable buildings offers a quantifiable outcome. The sum of flat roofs over a region equals the applicable space for green roofs.





Complex Geometry

In reality, building complexity make "counting" structures challenging, not to mention, there are a lot of buildings. Our Water addresses these issues using statistics as it's backbone.

Results

Below is a table of the completed Our Water analysis, units are in gallons. Using OMNI's numbers and formulas, between 19-23% of building area in Hamilton County qualified. The maximum retention of this building area is 668,000 gallons of water. This is about 30% of the total sewer volume for the city.

That volume of water could dramatically reduce flooding at localized levels as well as provide urban agriculture opportunities across the city.

Viable Building Area

Percent of Total Building Area

Media Depth

19% Method	By Group Method	
146,657,718	176,385,165	Total Sq Ft
19.0%	22.9%	
3 Inch Deep		
139,324,832	167,565,907	Minimum Saturati
58,663,087	70,554,066	Typical Saturation
8 Inch Deep		
371,044,026	446,254,468	Minimum Saturati
156,923,758	188,732,127	Typical Saturation
12 Inch Deep		
555,832,750	668,499,777	Minimum Saturati
234,652,348	282,216,264	Typical Saturation

* Data for Cincinnati 2017

Volume in Gallons

Analysis Results for Hamilton County

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1.5 Project Proposal

Why is this important?

This innovation incubator, if funded, would focus on expanding Our Water to summarize multiple cities. As of right now, this process has been successfully executed for Cincinnati (Hamilton County) and Chicago. Perkins + Will would dramatically benefit from having results for other cities we regularly do business in, as this information can better inform design solutions within our projects.

These results would be packaged and summarized for consumption across the firm in the form of a blog and ideally a white paper (time permitting). Additional graphic content would also be integrated into the package to better expand the impact Our Water can have for marketing and research surrounding water.

This package offers us the capacity to integrate quality green infrastructure research and metrics directly into the design process at early massing or master planning stages. As such, it becomes a powerful advocacy tool for green alternatives, resilient design, and sustainable approaches to storm water. This process can be a powerful first step in conveying potential benefits and feasibility for clients, cities, universities, and developers. With further integration to tools already being developed by other parts of the firm (Mass Metrics, Hazel, C+S Base Plan Analysis) Our Water can add to a suite of tools to improve our site plan analysis capacities.

Deliverables?

If funded the work flow of Our Water would be applied to New York City along with a few other key P+W markets (i.e. Atlanta, Los Angeles, and perhaps others). In order to complete this process 30 to 40 hours of billable time will be required, but no pay stipend, as Perkins + Will already has all the necessary resources currently.

In addition, 20 to 30 hours would be dedicated to developing a white paper, possibly co-authoring with OMNI ecosystems, with the intention being to publish in the P+W research Journal.

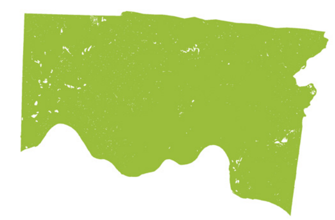
Future Applications

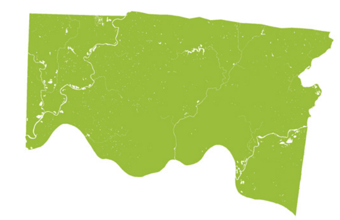
Our Water presents a lot of opportunities for future applications and innovations. Below is a quick list of phasing for development:

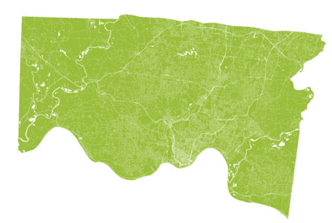
1. Develop and execute process (***completed***)
2. Chart / map workflow (***completed***)
3. Visual Context of space (see below) (***future endeavor)***
4. Convert workflow into GIS plugin (***future endeavor***)
5. Add additional modules to assess: (***future endeavor***)
    a. Permeable pavement performance
    b. Bioswale performance
    c. Additional green infrastructure technologies
6. Adapt data output to a dashboard (***future endeavor***)

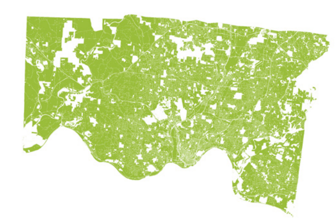
Hamilton County - What are We Doing with Our Space?


Land Area


Land Area Minus Lakes


Land Area Minus Lakes and Rivers


Land Area Minus Lakes, Rivers, and Pavement


Land Area Minus Lakes, Rivers, Pavement, and Parks


Land Area Minus Lakes, Rivers, Pavement, Parks, and Buildings

1.6 Previous Research

About the Researcher

Tom Seiple currently serves as an Analyst for Perkins + Will. He has experience as a Community Planner, but has skills in computational analytics as well. His undergraduate work in Environmental Science along with previous work experience as a researcher for the EPA, the University of Cincinnati, and Proctor and Gamble lend to detailed assessment of structured and unstructured data. Pairing those skills together he has served in many research labs and task forces across the firm, along with building work-flows, and furthering sustainable practices through policy design.

Tom has previously participated in P+W's Innovation Incubator program with his previous effort for Our Water. His master's thesis focused on mapping under-utilized spaces in Cincinnati to recreate a century old parks master plan, where the idea was first concieved. In 2015 he helped generate an economic impact analysis for a rails to trails project using GIS analytics paired with econometrics. At Perkins + Will Tom has contributed to a regional framework for Chicago titled Connected Chicago as a GIS specialist. He has also actively participated in various stages of data analytics with Process Lab and participated at various project scales and stages as a mapping / geospatial specialist. He is currently seeking his RELi AP through the firm and is the primary data architect of Indicator, the CI space analytics tool.