Green Infrastructure, Ancient Rivers, and Historical Fill in Pittsburgh

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Rationale

Green infrastructure is an important strategy in efforts to minimize combined sewer overflows and flooding. It is effective in many American cities. However, Pittsburgh, PA presents unforeseen challenges for infiltration based green infrastructure due to anthropogenic soil compaction.

Approach

We examined historical and current maps to understand the soil characteristics underlying several pilot GI projects in the Pittsburgh region.

Introduction

There is a push for green infrastructure (GI) in Pittsburgh to reduce flooding and combined sewer overflows. However, the best locations for GI in the Pittsburgh region remain unclear. In examining how GI works, it is vital to understand the impact of historic land use on current function of GI. In this study, we focus on infiltration-based green infrastructure and the effect of historical soil compaction on GI's ability to divert stormwater to slower flowpaths.

Findings and Discussion

When people think about water in urban systems, they often think about impervious surfaces, things like roads or roofs that prevent natural infiltration. What is less obvious are relics of former construction that people do not realize are there. Road construction and traffic strongly compact soils. This compaction can persist for many years.

What is infiltration? How does it work?

Infiltration is the movement of rain and melted snow through the soil. Infiltrated water does not flow into sewers. The **infiltration rate** is the amount of water that can flow into the soil over a specified time. In Pittsburgh, the average infiltration rate is roughly a quarter of an inch of rain over the course of an hour.

Infiltration rates in Pittsburgh can be slower due to historical compaction of soil. These slower rates have affected several demonstration green infrastructure projects. For example, infiltration rates observed at a pilot project in Schenley Park are low, 0.08 in/hr on average. In comparison, a minimum infiltration rate of 0.1 in/hr is recommended in the Pennsylvania Best Management Practices manual. Soils in this area may have been compacted in the last century and this compaction may contribute to the slow infiltration rates.

The two infiltration trenches installed at Bartlett Meadow in 2015 had slow infiltration rates. When imagery from 1938 is consulted, roads and paths previously transected the current meadow (Figure 1). One path corresponds with a line of slow surface infiltration rates measured in the meadow in 2016 (Figure 1). While the GI was not installed directly in this path, soils in the meadow were compacted by historical activities.

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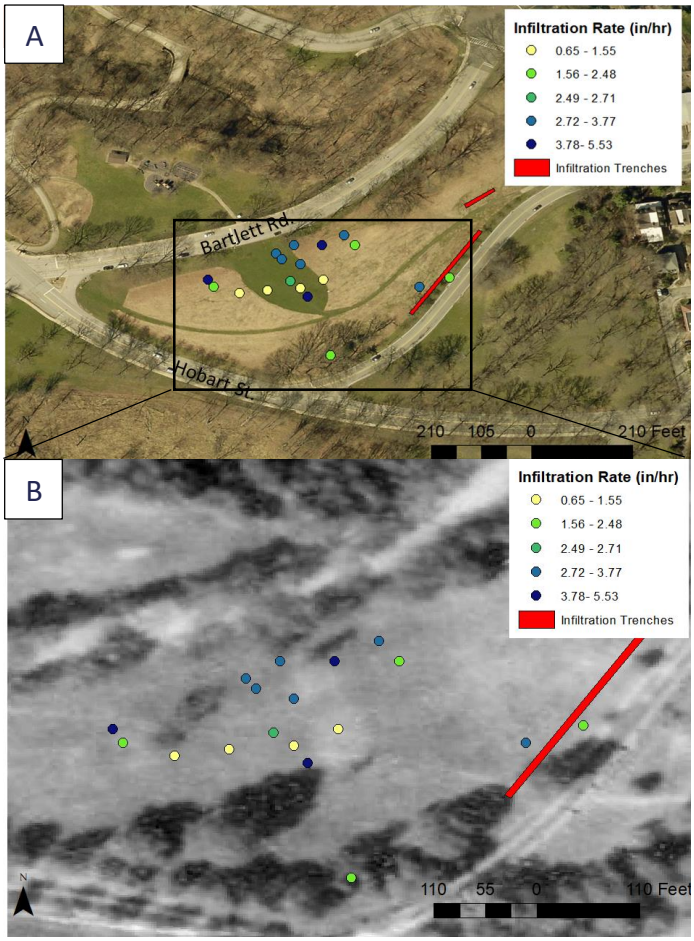

Figure 1:

Infiltration rates in Bartlett Meadow (Schenley Park) over A) imagery taken in 2017 and B) 1938. Note the line of very low infiltration rates in the center of the meadow. This line lies close to a path evident in the historic imagery.

Engineered fill can also cause low infiltration rates. Valleys are often filled to flatten areas in the region. These filled volumes are constructed by filling the area with dirt and compacting the fill material. Just as with roads, this compaction leads to low infiltration rates. For example, the rain gardens at the new Frick Environmental Center drained slower than expected when constructed. Comparison of elevations from 1927 and 2006 reveal changes in elevation characteristic of fill (Figure 2). Therefore, the rain garden was likely built on a compacted fill, and this explains part of this unexpectedly slow drainage.

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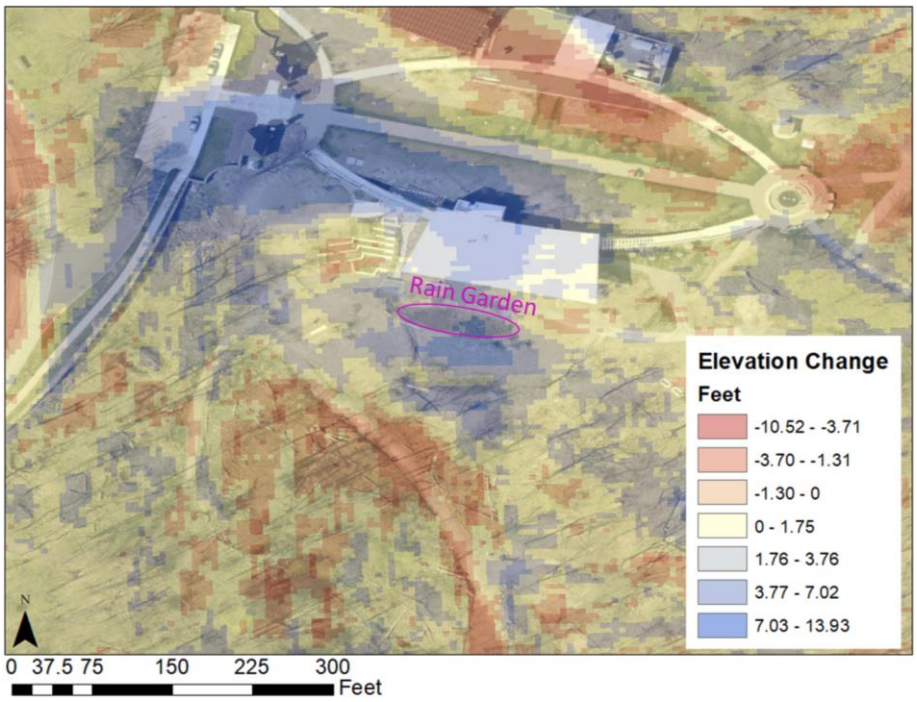
Figure 2:

Change in elevation in areas around the Frick Environmental Center between 1927 and 2006. This map was prepared by comparing historical contour mapping (1927) and modern LiDAR data (2006). Blue represents an increase in elevation, red represents a decrease. Red likely results from erosion or areas were fill dirt was borrowed from. Note, most of the blue corresponds with the current footprint of the Frick Environmental Center.



Opportunities for Infiltration

The migration of the Monongahela and Allegheny rivers during continental glacial retreats resulted in several paleo-channels tens of thousands of years ago. Valleys have deposits of sand and gravel that can infiltrate water at much higher rates than most of Pittsburgh's clay soils. This paleo-channel is easily recognizable from elevation data (Figure 3) and is the location of some of the densest residential developments in Pittsburgh. Numerous green infrastructure projects have been installed in these areas. While there are no reported infiltration rates for these projects, the paleochannels are likely to work well for infiltration-based GI and therefore are a promising location for future GI.

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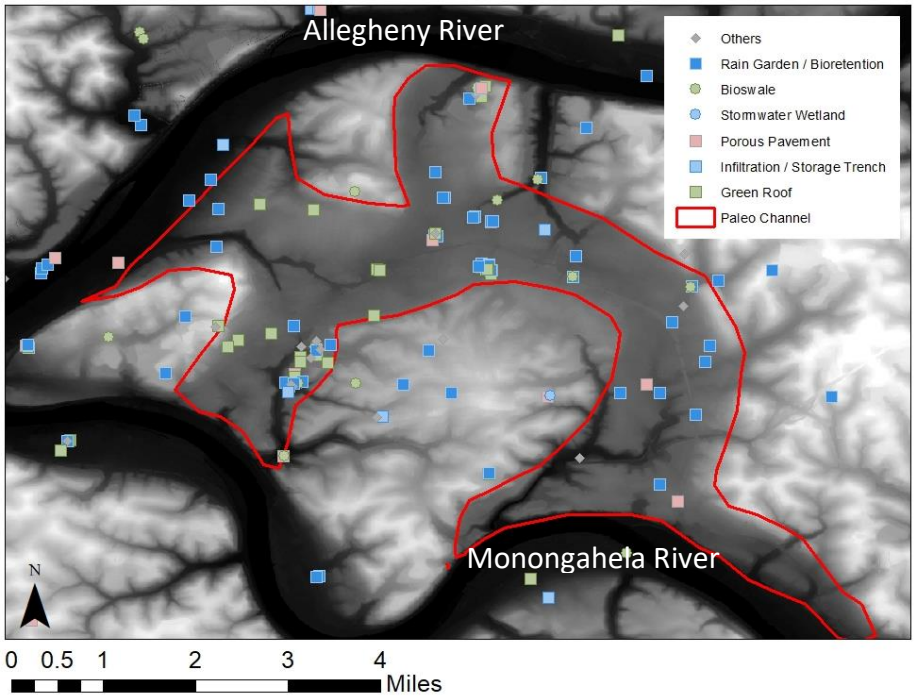
Figure 3:
Location of paleo-channel and existing GI projects in Pittsburgh. Symbols show the locations of green infrastructure recorded in the Allegheny County Green Infrastructure Atlas. White areas are higher areas and black areas are lower areas.



Implications

- In the evaluation of sites for green infrastructure, historic activities that compact soil, like old roads and filled areas should be avoided or carefully accommodated. This compaction likely has affected the performance of some demonstration GI projects in Pittsburgh.
- In contrast, areas overlying the paleo-channel are likely superior for future infiltration-based GI projects due to the sand and gravel deposits common in these ancient riverbeds. While the dense property holdings can complicate infrastructure projects here, these areas are natural future sites for GI projects.

Historical land use practices may have compacted soil underlying monitored green infrastructure projects resulting in lower than expected infiltration rates. Other regions in the city, particularly the paleochannel, may be better suited for future projects.

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