Weighted Site Selection for Green Infrastructure in Portland's Johnson Creek Watershed

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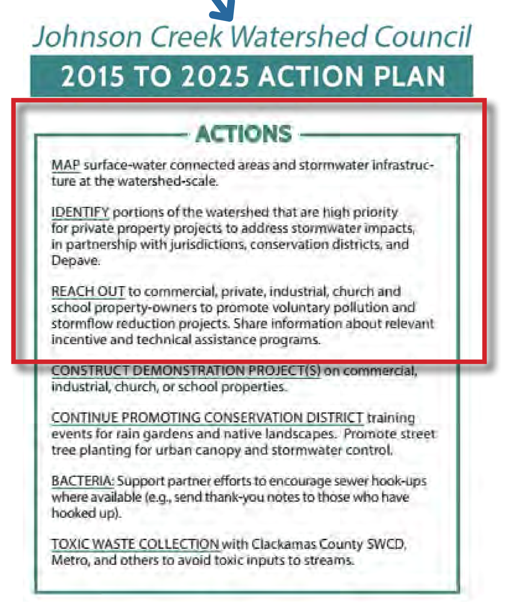
Background

Stormwater runoff presents both practical and ecological issues in urban areas, in which highly developed, impervious landcover prevents rainwater from entering the ground in a natural hydrologic cycle. Heavy rainfall leads to polluted runoff, and, due to combined stormwater and sanitary sewer systems, often results in sewage overflow into nearby water bodies, creating urban water quality issues and damaging ecosystems. The King County (Seattle) water treatment plant continues to release millions of gallons of untreated combined system sewage into Puget Sound due to damage to the treatment plant stemming from a recent flood. And despite Portland's $1.4 billion investment in the Big Pipe project to store and treat combined sewer system contents, the city still struggles with combined sewer overflows into the Willamette River during heavy rainfall events. In recent years, however, planning efforts in Portland have aimed to rely less on hard infrastructure and more on natural hydrological systems for stormwater management.


American Rivers/Lynette Batt

Green infrastructure has been identified as an effective way to 'break up' an impervious landscape, allowing stormwater to filter back into the ground near its place of contact and encourage the restoration of natural systems.

In particular, the Johnson Creek Watershed has received much attention as a priority site for better urban water management. The Johnson Creek Watershed Council released a 2015-2025 Action Plan which outlines goals to respond to development and climate change, restore wildlife habitat and water quality, and build community around Johnson Creek. One of the sections outlines several strategies to improve water quality in Johnson Creek by reducing the impact of stormwater runoff that drains directly into the surface waters of the watershed. In particular, the plan calls for identifying "portions of the watershed that are high priority for private property projects to address stormwater impacts" and reaching out to "commercial, private, industrial, church and school property owners to promote voluntary pollution and stormflow reduction projects."


Johnson Creek Watershed Council
2015 TO 2025 ACTION PLAN

ACTIONS

MAP surface-water connected areas and stormwater infrastructure at the watershed-scale.

IDENTIFY portions of the watershed that are high priority for private property projects to address stormwater impacts, in partnership with jurisdictions, conservation districts, and Depave.

REACH OUT to commercial, private, industrial, church and school property owners to promote voluntary pollution and stormflow reduction projects. Share information about relevant incentive and technical assistance programs.

CONSTRUCT DEMONSTRATION PROJECT(S) on commercial, industrial, church, or school properties.

CONTINUE PROMOTING CONSERVATION DISTRICT training events for rain gardens and native landscapes. Promote street tree planting for urban canopy and stormwater control.

BACTERIA: Support partner efforts to encourage sewer hook-up, where available (e.g., send thank-you notes to those who have hooked up).

TOXIC WASTE COLLECTION with Clackamas County SWCD, Metro, and others to avoid toxic inputs to streams.

Research questions

1. What are important factors to consider in a site suitability analysis for placement of green infrastructure?
2. What are the most suitable sites to pursue for the placement of green infrastructure in Johnson Creek Watershed?

Project Objective

The purpose of this project is to identify locations within the Johnson Creek Watershed that are suitable for installation of stormwater collecting green infrastructure. This project will continue to further the City's objectives as a leader in sustainable urban development and planning, and meet specific goals identified by the Johnson Creek Watershed Council's 2015-2025 Action Plan.

Data Used

Johnson Creek Watershed Boundaries - Metro RLIS database
Slope - Metro RLIS database
Land use types - Metro RLIS database
Public/private ownerships - Portland Maps and Metro RLIS database
Hydrologic soil types - USDA/NRCS Web Soil Survey web tool
Impervious surface data - Metro RLIS database

Methods

We used a Weighted Overlay site selection method in ArcGIS to identify suitable sites.

» First, we consulted existing studies to identify common variables used in a GIS site suitability analysis for green infrastructure, and identified the following variables: slope, land use types, public/private ownership, hydrologic soil types, and impervious surface types.

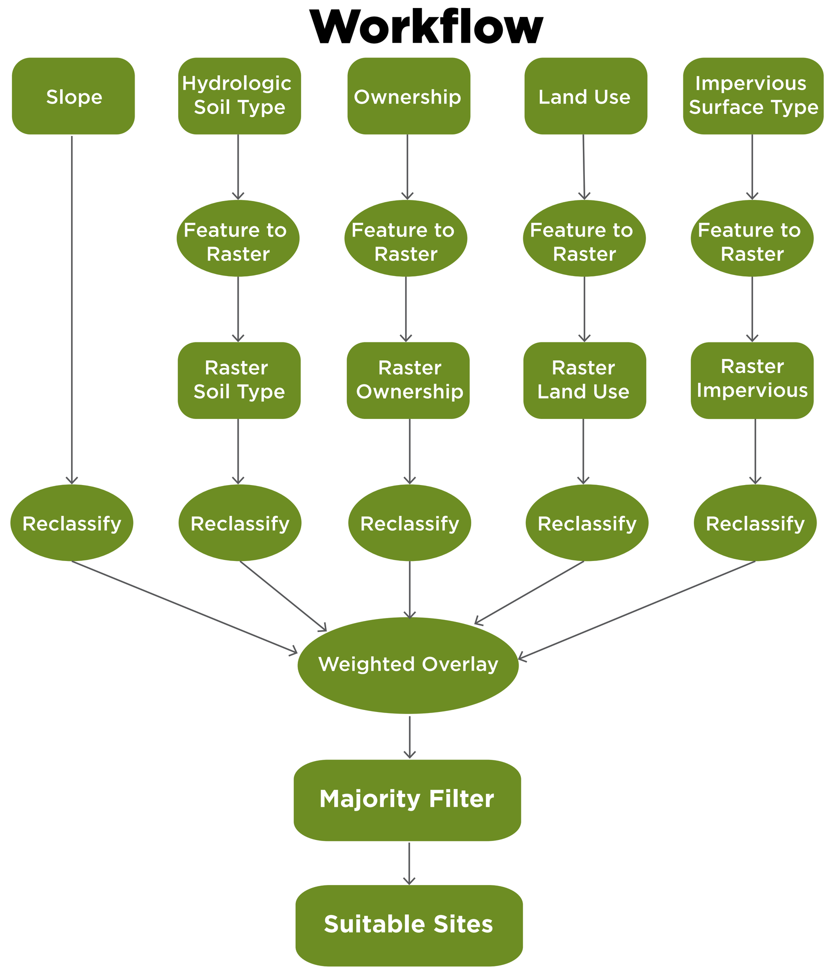
» Second, we collected the relevant data and reclassified them to a common scale of 1 through 5, simultaneously ranking the values of each attribute according to its ideal condition for the placement of green infrastructure.

» Next, after the variable layers were all converted into raster layers and ready to perform analysis, we ran the weighted overlay tool using four different weight models. Model 1 gave equal weight to each variable, Model 2 gave more weight to variables dealing with the natural environment, Model 3 gave more weight to urban and human-developed variables, and a Final Model eliminated the Impervious Surface Type variable and instead constrained the site selection to parking lots only.

» Finally, we used the Majority Filter Tool to simplify the resulting raster and identify more unified areas.

The summary figure and table identifies each variable used in this analysis, its ideal conditions for green infrastructure, the flow of data processing, and the respective weights given to each variable in a series of Weighted Overlay models.

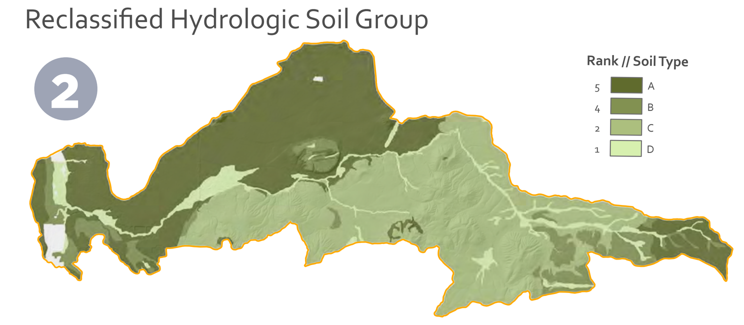
Workflow



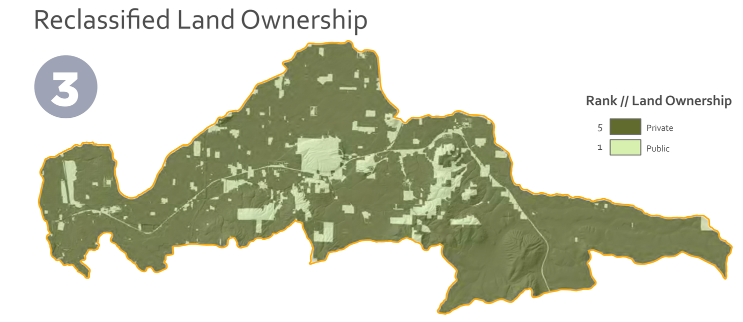
Variable	Ideal conditions for green infrastructure	Original data type	Final data type	Range of assigned values	Model 1 Weight	Model 2 (Natural Context) weight	Model 3 (Urban Context) weight	Final model: Parking lot constraint
Slope	2-5%	Continuous Raster	Categorical Raster	5,4,3,2,1	20%	35%	15%	**25%**
Hydrologic Soil Type	Well-drained	Vector Polygons	Categorical Raster	5,4,2,1	20%	35%	15%	**25%**
Ownership	JCWC Goal to focus on Private land	Vector Polygons	Categorical Raster	5,1	20%	10%	25%	**25%**
Land Use	JCWC Goal to focus on Commercial & Industrial Land	Vector Polygons	Categorical Raster	5,4,3,2,1	20%	10%	20%	**25%**
Impervious Surface Type	Parking Lots	Vector Polygons	Categorical Raster	5,4,3,1	20%	10%	25%	
				Total:	100%	100%	100%	100%

Reclassified Slope

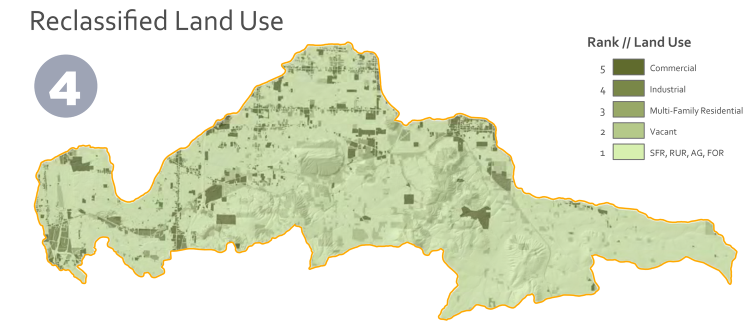
Reclassified Hydrologic Soil Group



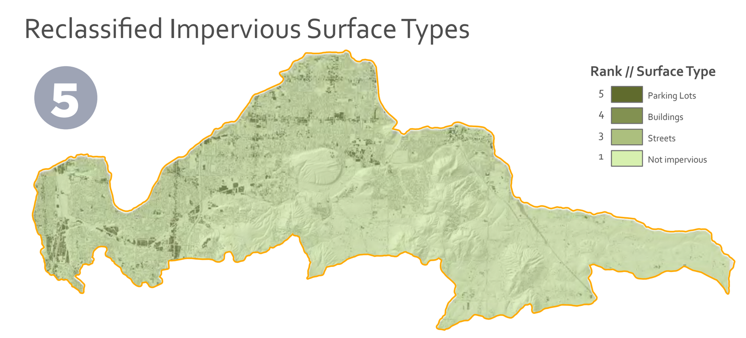
Reclassified Land Ownership



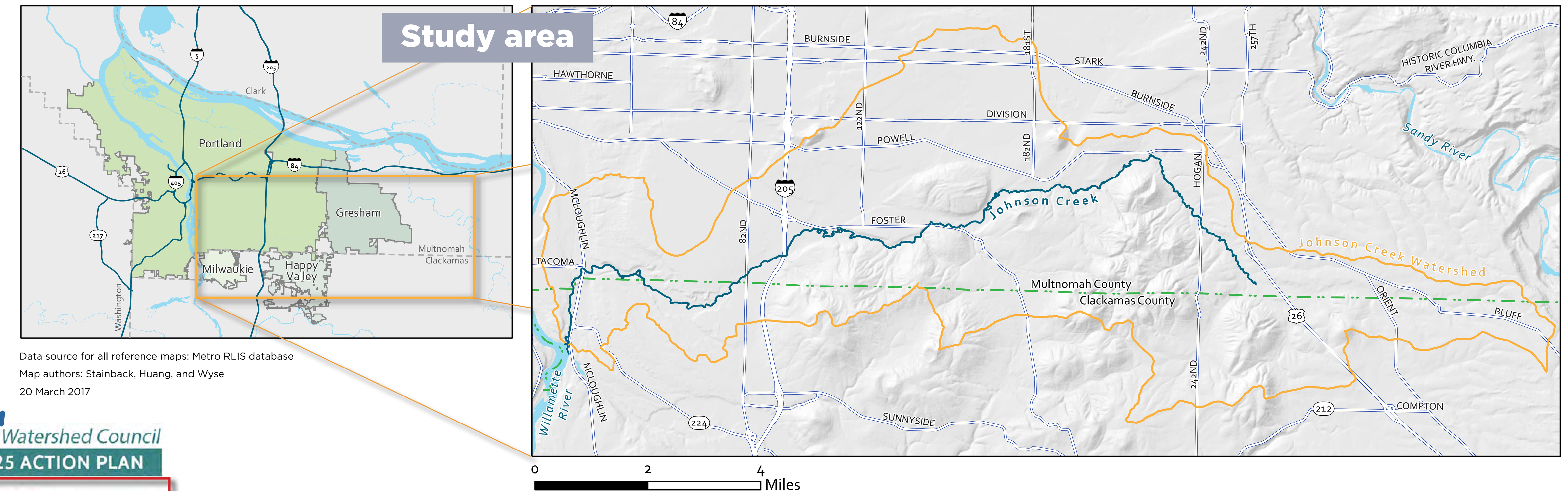
Reclassified Land Use



Reclassified Impervious Surface Types

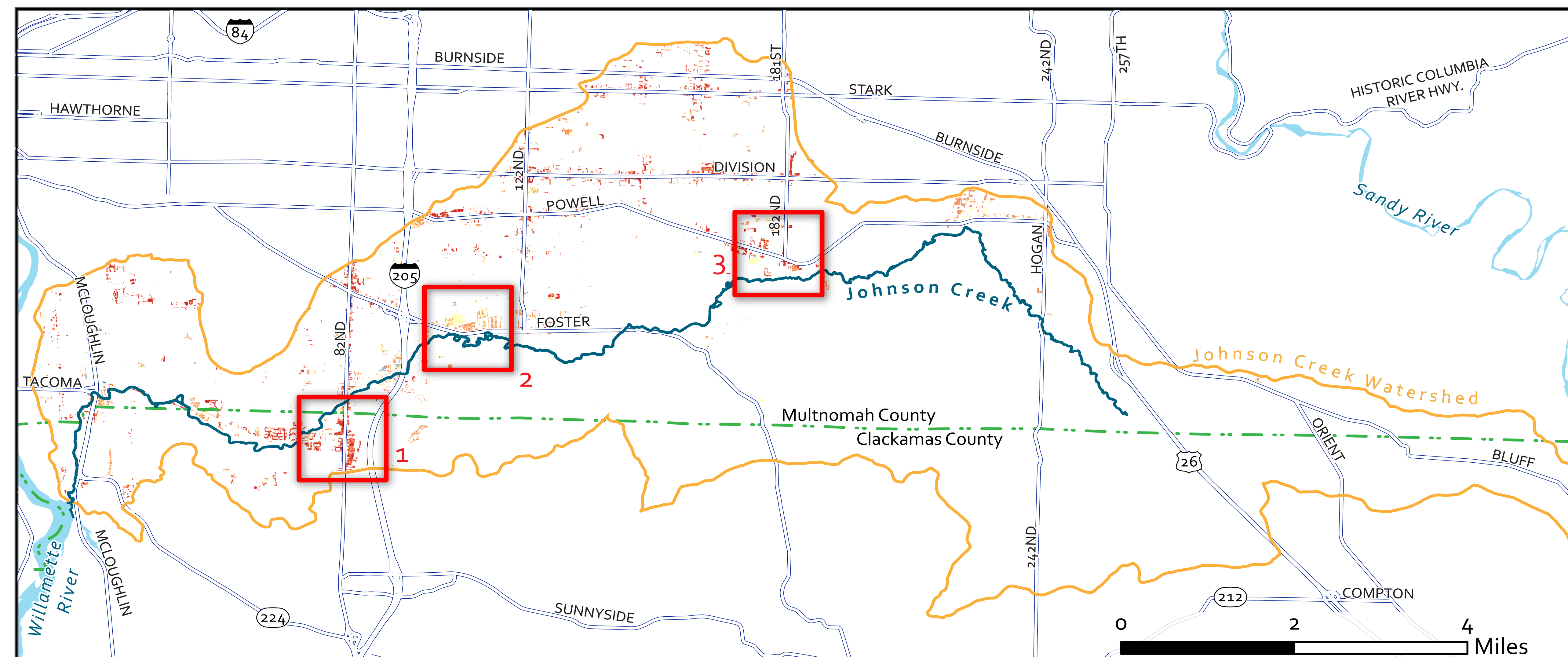


Study area

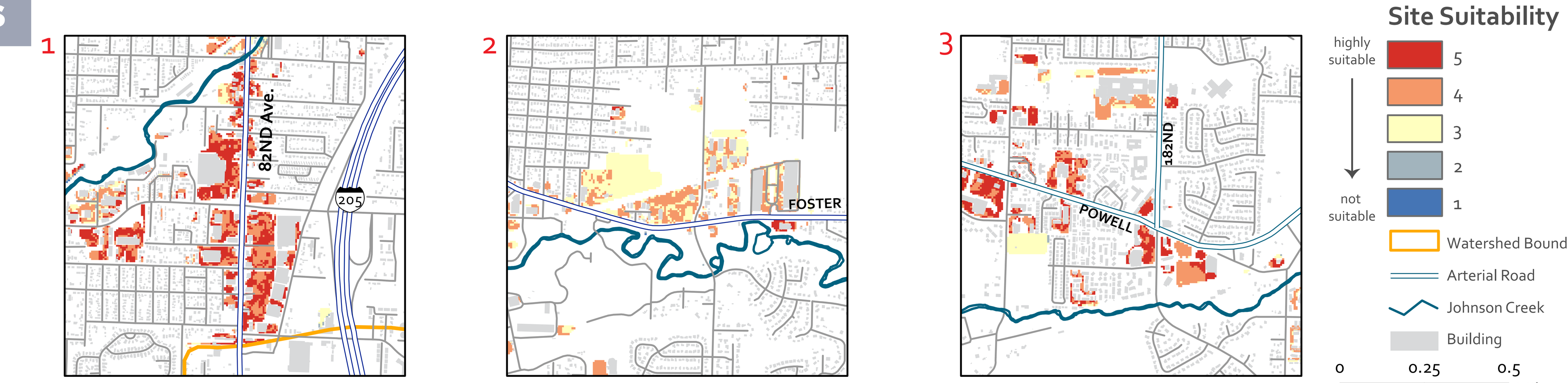


Data source for all reference maps: Metro RLIS database
Map authors: Stainback, Huang, and Wyse
20 March 2017

Flickr user Aaron Volkening



Final selected sites



Results and discussion

We initially performed the analysis for all parcels within the Johnson Creek Watershed with the expectation that the weighted site selection tool would identify and rank the privately-owned parking lots, which we prioritized for this study due to their potential to best meet the Johnson Creek Watershed Council's needs. However, the results identified all parking lots as highly suitable, while any other land use types were given a lower result class. We then limited our analysis extent to only include the parking lots, and gave the remaining four criteria equal weights of 25%. Although the result still identifies most of the areas considered as highly suitable, the result included a more clear filtered rank among all the parking lots. Thus, we determined it as a better result than the other weighted methods.

We then consulted the Johnson Creek Watershed Council's 2015-2025 Action Plan. The Action Plan identifies areas that drain into the surface streams (rather than areas that drain into the sewer system) as high priority for water quality mitigation measures. Thus, comparing the results of our analysis with the Council's boundary identifying areas that drain directly into surface streams, we were able to identify several key areas that are the most suitable for the placement of green infrastructure (see map above).

These priority areas lie along 82nd Ave. on the border between Multnomah and Clackamas Counties (1), a cluster located along Foster Blvd. between I-205 and 122nd Ave. (2), and a cluster oriented around the intersection of Powell Blvd. and 182nd Ave (3). Initial verifications using Google Earth Pro were used to confirm the suitability of these sites. These are all highly impervious clusters of commercial parking lots that fall within the boundary of areas that drain to the surface waters of the Johnson Creek Watershed. A fourth potential site along Powell Blvd. and Main Ave. was identified, but not included in the analysis due to the presence of East Gresham Park, which may provide a natural buffer between the impervious areas identified and Johnson Creek. However, further analysis must be performed to confirm whether or not the park is equipped with the infrastructure necessary to absorb runoff from impervious areas nearby.

There were also some potential sites that were missing from our analysis due to incomplete data (the USDA soils dataset does not include a hydrological soil classification for areas that are categorized as 100% urban; therefore the final weighted overlay tool did not include these sites in the analysis). Among these was the McLoughlin Industrial Park. While this area is not included in our results, its proximity to both Johnson Creek and its confluence at the Willamette River merits further inspection for opportunities to manage runoff through green infrastructure approaches.

Conclusion

With projected population growth in the greater Portland region, urban infill and development will likely increase within the Johnson Creek Watershed and lead to a higher ratio of impervious landcover and higher risks of flooding and water quality issues. Implementing a system of green infrastructure for stormwater management is a sustainable and effective approach to manage these current and future challenges.

While there were limitations to our study including time constraints and lack of certain data (notably, an existing green infrastructure inventory, and a complete spatial database of the sewer network within the watershed), our analysis provides a starting point for the Johnson Creek Watershed Council to use for further inquiry. An important next step should include site visits to the priority areas identified, to verify the results and gain a better understanding of each site's context.

Sources
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