Identifying Floodwater Storage along Johnson Creek

Nate White and Thea Kindschuh

21 March, 2017

Abstract

Building flood resilience into our communities is a continual, imperative task. With climate change increasing the likelihood, frequency, and severity of flood events, it is important to find and secure floodplain storage that will preserve and cater to the retention of quality natural areas while mitigating damage to residences and urban areas abutting streams. This project sought to expand upon the wealth of current research and planning around flood mitigation in the urbanized portion of the Johnson Creek Watershed in Portland, OR, and to create and utilize an accessible model to determine further potential floodwater storage and riparian habitat restoration areas in this watershed. Through simple Geographic Information Systems (GIS) analytics, we identified the Barbara Welch study area upstream from the existing Foster Floodplain as a potential floodwater storage area. Going forward, our analytic processes can be developed into a replicable GIS model for identifying further floodwater storage sites in the watershed.

Introduction

Nestled in the confluence of the Columbia and Willamette Rivers, Portland has long understood the benefits and consequences of living in a riparian environment. The city experienced a significant flood in 1996 during which many rivers of northwestern Oregon and southwest Washington experienced the worst flooding in 30 years, with the Columbia and

Willamette Rivers rising as much as 10–20 feet above flood stage. Eight deaths were directly attributed to the floods, over 30,000 residents were forced from their homes, and damage approached 500 million dollars[1]. While the area has not seen a flood of such magnitude since, Portland residents and planning agencies are anticipating increased flooding and striving to prepare for the fifty-year flood, during which Johnson Creek can be anticipated to rise 15.2 feet.[2]

The Johnson Creek basin is located in northwestern Oregon on the eastern side of the Portland metropolitan area in Multnomah and Clackamas Counties. Johnson Creek is about 24 miles long and has a surface-water drainage basin that covers an area of 54 miles[3]. The Johnson Creek FEMA Floodplain extends outside the stream bed and incorporates areas that flood due to groundwater swells as well as resulting from high stream levels, meaning the hundreds of families living along Johnson Creek[4] are living in danger and liability. In fact, research into discrepancies around flood insurance rate inconsistencies and the equity issues affecting families living in the floodplain is currently being conducted[5], and inspired us to find other potential floodplain storage areas that can provide flood mitigation relief.

---

[1] Colle, Brian A.; Mass, Clifford F. (1999), "The 5–9 February 1996 Flooding Event over the Pacific Northwest: Sensitivity Studies and Evaluation of the MM5 Precipitation Forecasts", *Monthly Weather Review*, **128** (3): 593–617, Bibcode: 2000MWRv..128..593C, doi:10.1175/1520-0493(2000)128<0593:tffeot>2.0.co;2.
[2] Stonewall, Adam. (2017) United States Geographic Survey, Interview.
[3] Lee, Karl K. and Daniel T. Snyder. (2009), "Hydrology of the Johnson Creek Basin, Oregon", USGS. https://pubs.usgs.gov/sir/2009/5123/pdf/sir20095123.pdf
[4] Thonis, Wayne. (2007), "Johnson Creek Watershed Population Density (by 2000 Census Block Group)", JCWC. http://jcwc.org/wp-content/uploads/2012/03/population-density.pdf
[5] Rathfelder, Amy. "Students Talk FEMA Insurance with Homeowners in Johnson Creek Floodplain." Sustainability. Institute for Sustainable Solutions - Portland State University, 6 Feb. 2017. Web. 21 Mar. 2017. <https://www.pdx.edu/sustainability/solutions-blog/students-talk-fema-insurance-with-homeowners-in-johnson-creek-floodplain>.

As mechanism to mitigate the effects of flooding in urbanized areas, Portland utilizes a Natural Area Acquisition Strategy[6] wherein the City of Portland purchases properties within identified high priority natural areas through a willing seller program wherein they pay fair-market value to residents who volunteer to sell their property. The strategy prioritizes acquisition based on ecological criteria to create protected systems of natural areas consisting of green ribbons along major waterways and feature large natural area parks and preserves, with citywide conservation priorities focusing on protecting large, intact areas; protecting sites with exceptional biodiversity values; improving connectivity within a regional system of natural areas; and buffering current natural areas. Watershed-specific priorities include identifying large, contiguous habitat; riparian buffers; wetlands, especially those connected with other water bodies; natural streams, springs, and headwater areas; sites in good ecological condition; known nesting or roosting sites for species of concern; property adjacent to existing park property or serving as a connection; regional trail connections; opportunities for environmental education or nature-based recreation; and property threatened with development. This strategy was utilized in the expansion and conversion of the Foster Floodplain, where sixty private properties were purchased to restore 63 acres of wetland floodwater storage. The effort proved effective during the floods of 2012 and 2015, and efforts are in place to continue the expansion and restoration of the area for flood mitigation, habitat restoration, and cultural

[6] Portland Parks and Recreation. (2006), “Natural Area Acquisition Strategy”, https://www.portlandoregon.gov/parks/article/130583

heritage.[7] In order to protect families living in the 100-year floodplain, it is recommended that the Foster Floodplain needs to expand to accommodate 125 acre-feet of floodwater storage[8].

Methodology

Because of the ongoing need for expanded floodwater storage along the Johnson Creek Floodplain, we sought to identify potential wetland restoration areas for future consideration utilizing the priorities set forth in the Natural Areas Acquisition Strategy. According to the USGS, floodplain modelling in this region is complicated due to the inconsistency of weather events and the temporal variation therein, as well as issues along Johnson Creek especially regarding groundwater swells and their effect on flooding. Because of these factors, every flood is different, exhibiting more as a unique “snowflake” event than the steady-flood “bathtub” model utilized by FEMA that assume floodwaters will fill an area linearly. However, modelling this variation is very complex, and unsteadied modelling is relatively new. Due to the complexity of this flood pattern modelling, we sought to utilize accessible data and a simple methodology to identify areas for future consideration.

We began looking at recent research into pre-urbanization streams derived from hydrologic and geographic data as well as historic depictions, which identified Johnson Creek as one of the last remaining free-flowing historic streams in the Portland area, offering an excellent opportunity for restoration and conservation efforts[9]. We then used the 100-year FEMA Floodplain Map of the Johnson Creek Watershed, which encompasses an average of

---

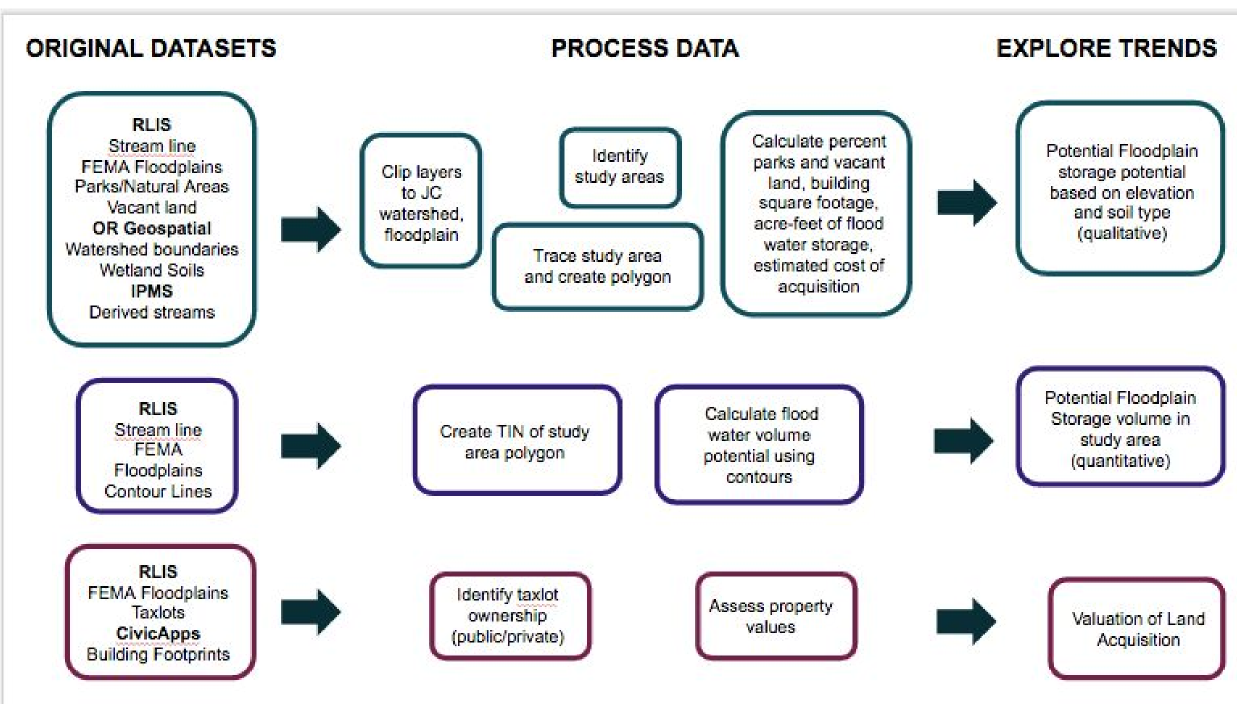
[7] Johnson Creek Watershed Council, 2015 - 2025 Action Plan (2015). http://jcwc.org/wp-content/uploads/2015/06/JCWC-Action-Plan-10.4_small.pdf

[8] Law, Steve, (2016). “An end to Lents flooding?“ Portland Tribune. http://portlandtribune.com/pt/9-news/332995-210655-an-end-to-lents-flooding

[9] Morris, Randy. (2017) Portland Institute of Metropolitan Studies Interview, “Derived Streams.”

multiple flood patterns in a steady model to produce an overcompensated floodplain designation area to protect and inform residents of potential risks. Using the Metro Regional Council's GIS data for Multnomah County via Metro's Regional Land Information System (RLIS), parks and natural areas were overlayed for a rough estimation of good connectivity potential; wetland soil types along the floodplain to identify good wetland restoration potential and floodwater storage efficacy[10]; and building footprints for an estimation of the burden of removal. Once identified, our study area was analyzed for potential floodwater storage capacity using a 3D Triangulated Irregular Network (TIN) model and 10 meter contour lines, and a land acquisition valuation was established for an estimated cost of acquisition. This workflow is illustrated in Figure 1, with data and sources included.

Figure 1: Workflow and Data Sources



[10] State of Washington Department of Ecology, "Functions and Values of Wetlands". http://www.ecy.wa.gov/programs/sea/wetlands/functions.html

Initially, we chose to focus on the urbanized portion of the Johnson Creek watershed west of SE 158th Drive to the Willamette River due to increased development pressures on remaining open space and vacant land in this corridor that is putting restoration efforts at risk; this urbanized area having a high risk of damage to existing development within the floodplain; and the presence of a high amount of impervious surfaces that prevent floodwater storage and increase the risk for flood damage. Our initial study area is shown in Appendix A. The full extent study area highlighted three potential areas of consideration: the Foster Floodplain, the Luther Road area, and the Barbara Welch study area.

Results

Further literature review supported our identification of these areas, as Foster Floodplain has an ongoing restoration strategy in place and Luther Road was the site of a restoration project as well, which while limited in its floodwater retention capacity due to heightened stream velocity at this site, still offers significant habitat benefit.[11] Utilizing this information, we delved deeper into the third study area, referred to hereafter as "Barbara Welch". Stream Site flow monitors from the United States Geologic Survey (USGS) in Portland identified Barbara Welch as good potential floodplain storage due to the high productivity - volume of water flow - measured in the area versus the lower productivity at the confluence of Johnson Creek to the Willamette, suggesting upstream flood mitigation would be effective in protecting downstream urbanized areas, a strategy recommended by the Foster Road Flood

[11] Bureau of Environmental Services, City of Portland (2013), "Luther Road Habitat Restoration Project". https://www.portlandoregon.gov/bes/article/429283

Mitigation Strategy[12]. Optimal floodwater storage areas will have this high productivity and low velocity, meaning a large volume of water is passing through at a slower speed. That Barbara Welch matches these qualifications make it a good candidate for upstream flood mitigation, as the productivity is high enough to have a substantial impact downstream and the velocity is low enough that the water will be controllable. Additionally, any flood mitigation projects in the area are required to provide enough flood storage to ensure that discharges and flooding are not increased downstream, and while the Foster Floodplain addresses smaller flood events, Foster Road bisects the area and still presents complications during flood events. Upstream mitigation, then, would help remediate this. Lower velocity in this area due to the relative lack of channelization and surrounding intact riparian forest (as opposed to the channelized, grassland area of Luther Road) allows for more effective floodwater storage efforts as slow-moving water can be better meandered into surrounding riparian wetlands.

To further analyse the potential efficacy of Barbara Welch as a floodplain storage and wetland restoration site, we ran a 3D TIN analysis of the study area for polygon volume. We determined that based on the steady model of the FEMA floodplain and the 15.2 foot water level rise predicted by the fifty-year flood, the Barbara Welch study area could hold 219 acre-feet of floodwater, more than the 125 acre-feet stated as necessary for the Foster Floodplain area[13]. We then calculated the percent parks and natural areas and vacant land (Appendix B) to assess the potential connectivity between existing open space. Percentage of wetland soils were also calculated to be present in a relatively high amount in our study area, suggesting a high potential for effective floodwater absorption (Appendix C). Land and building

---

[12] FOSTER CORRIDOR INVESTMENT STRATEGY: Foster Road Flood Mitigation Strategy (2013), http://www.pdc.us/Libraries/Lents_Action_Plan/Lents_Action_Plan_-_Appendix_12_pdf.sflb.ashx
[13] Law, Steve,

acquisition costs were calculated using private and public taxlots and building footprints (Appendix D) with an estimated cost of $12,405,880, which is nearly twice as more than the $12-15,000,000 cost estimated for the Foster Floodplain which removed twice as many homes for the same amount of money. As a result, the cost per acre of acquisition in Barbara Welch ($188,884/acre) was twice as much as the target cost outlined in the Natural Area Acquisition Strategy ($96,365/acre, Appendix E). If desired, this approach could be used to capture individual properties that could meet the dollar per acre target outlined in the Natural Area Acquisition Strategy.

Limitations

Our project sought to identify further areas for floodwater storage and wetland restoration consideration as well as present a replicable, simplified model for future floodplain storage identification efforts. While successful, our model presents a number of limitations around detail of floodplain accuracy and land valuation. The Barbara Welch study area was identified based on the existing FEMA floodplain map, which represents an overcompensated boundary due to using historical averages of extreme flood events. Additionally, the 125 acre-foot storage capacity need was the amount of flood storage identified for the Foster Floodplain area, which we extrapolated as still necessary for our upstream study area. Further, our flood storage calculations for Barbara Welch assume that any floodwaters will be arbitrarily confined to our study area, where in reality, floodwaters will “leak” beyond the artificial boundaries we created for our analysis. For this reason, backyard floodplain adaptation strategies may be helpful for neighbors surrounding the area, as well as continued efforts to contain and treat stormwater runoff through Portland's myriad stormwater management efforts. The utilization of steadied flood modelling and overall simplification of soil analysis to only include wetland soils in our consideration are broad simplifications as well, but this was intended in our vision for a simple and replicable model.

Our land valuation acted upon a number of limitations as well, as the costs for acquisition laid out in previous reports did not go into significant detail around specific calculations, and no outside budgetary accounting was available for specific project costs. Our model also assumed lands designated "public" were owned by the city and therefore did not need to be purchased; that the tax valuation provided in the taxlots layer was effectively representative of the lot market value; and that vacant land was indeed vacant, which is not necessarily the case[14]. We also found that the taxlots did not account for all the buildings in the study area, nor were owners listed for every lot, meaning we could not determine whether the lot was privately or publicly owned. We also only focused on the costs of acquiring the land, and did not calculate any costs of building removal, converting the land to wetlands, and other restoration efforts.

Conclusions

While expanding the existing floodplain storage capacity in the urbanized portion of the Johnson Creek watershed to reduce flooding risks and costs may seem obvious or redundant due to successful pre-existing projects like the Foster Floodplain, the incorporation of the Barbara Welch study area into the city's flood mitigation strategies is still of significant value

---

[14] City of Portland Bureau of Planning and Sustainability, (2012) "Buildable Lands Inventory". https://www.portlandoregon.gov/bps/article/408236

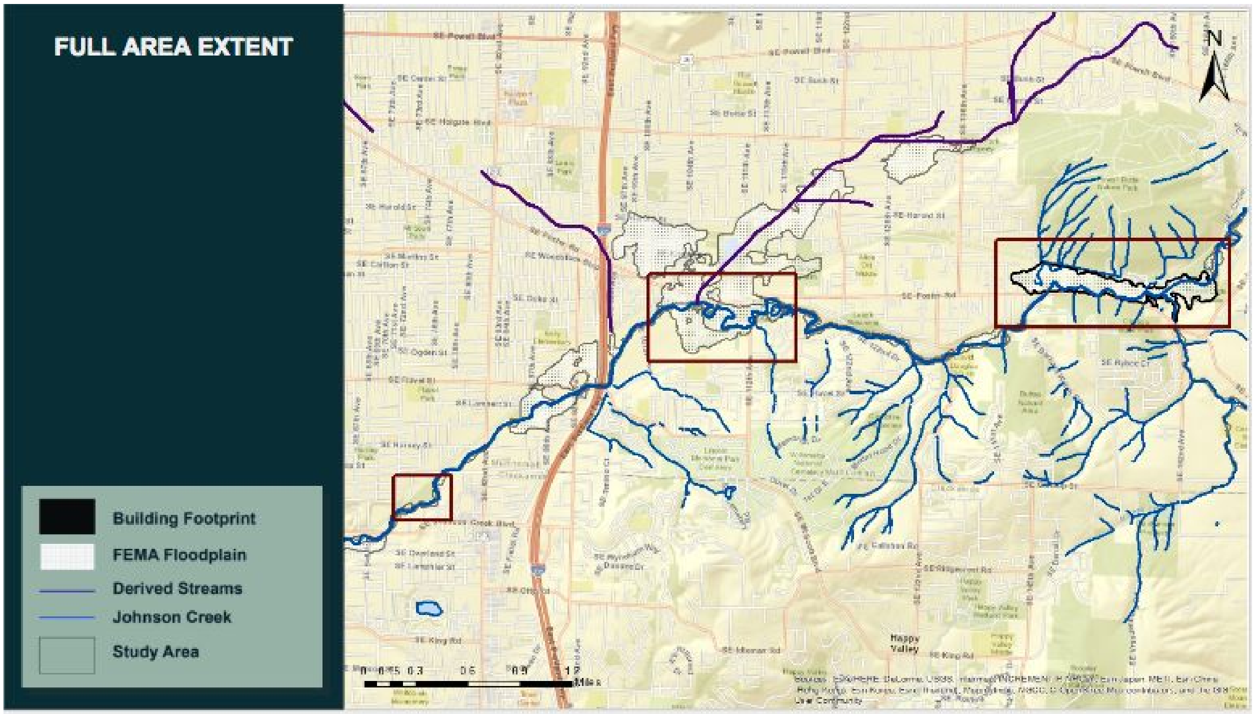
because of its alignment with the city's conservation strategy. Barbara Welch addresses a number of environmental, economic, and social criteria outlined by the city: Barbara Welch has high connectivity to existing open space and parks; the low gradient stream velocity and intact riparian forest lends itself well to successful upstream flood water storage and healthy, slow, meandering water movement; and upstream flood storage reduces economic and social costs (i.e. property damage, displacement, and expensive flood insurance premiums) caused by flooding in downstream urbanized areas.

We also found that parcels within Barbara Welch study area are identified as "High Value" Habitat Conservation Priority Areas[15], and are consistent with a number of positive ecological factors observed in our literature review. Because of this consistency, we can conclude that our simplified GIS model overlaying existing, accessible data for the FEMA floodplain, parks and natural areas, wetland soils, and the built environment provide a structured model to reach similar conclusions as much more in-depth, complex models. This suggests that smaller jurisdictions with fewer resources can still take steps toward wetland restoration and floodplain planning using our simplified approach. With public funds becoming even scarcer, this sort of analysis may be key toward continuing the important urban ecological restoration work being done in the region.

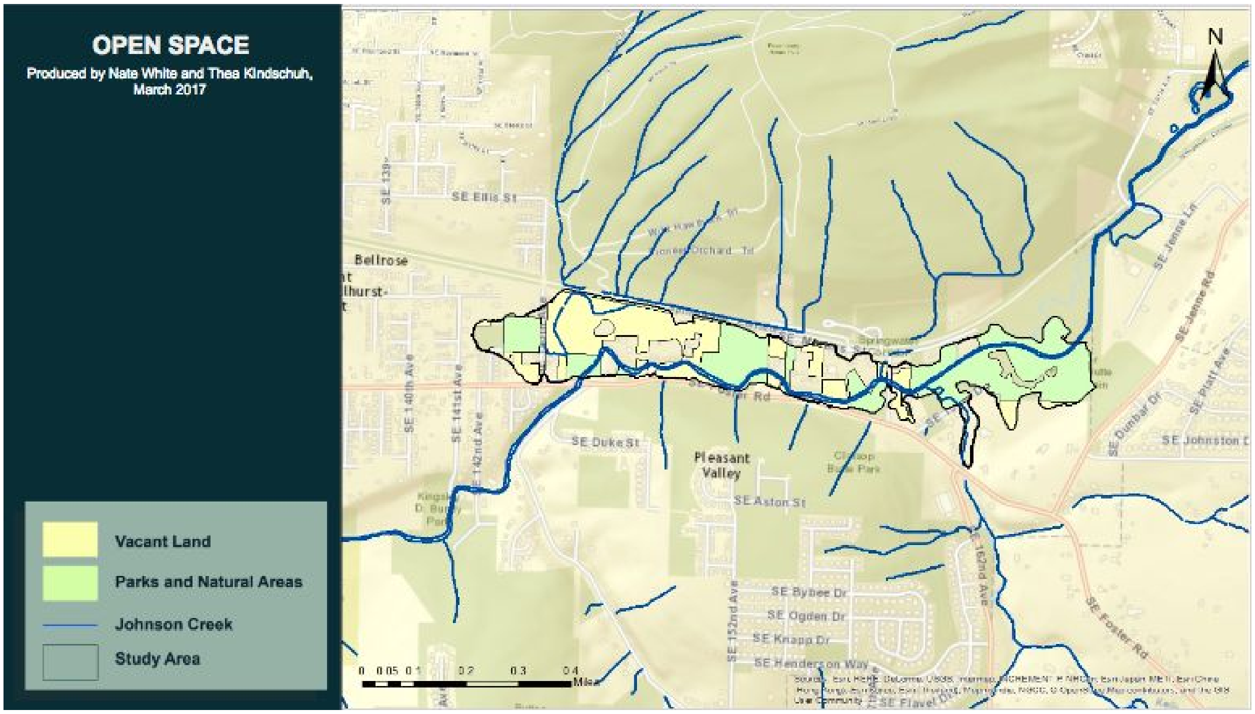
---

[15]The Intertwine, "Regional Conservation Strategy."
http://www.regionalconservationstrategy.org/page/documentation

Appendix A: Initial Study Area, Full Area Extent

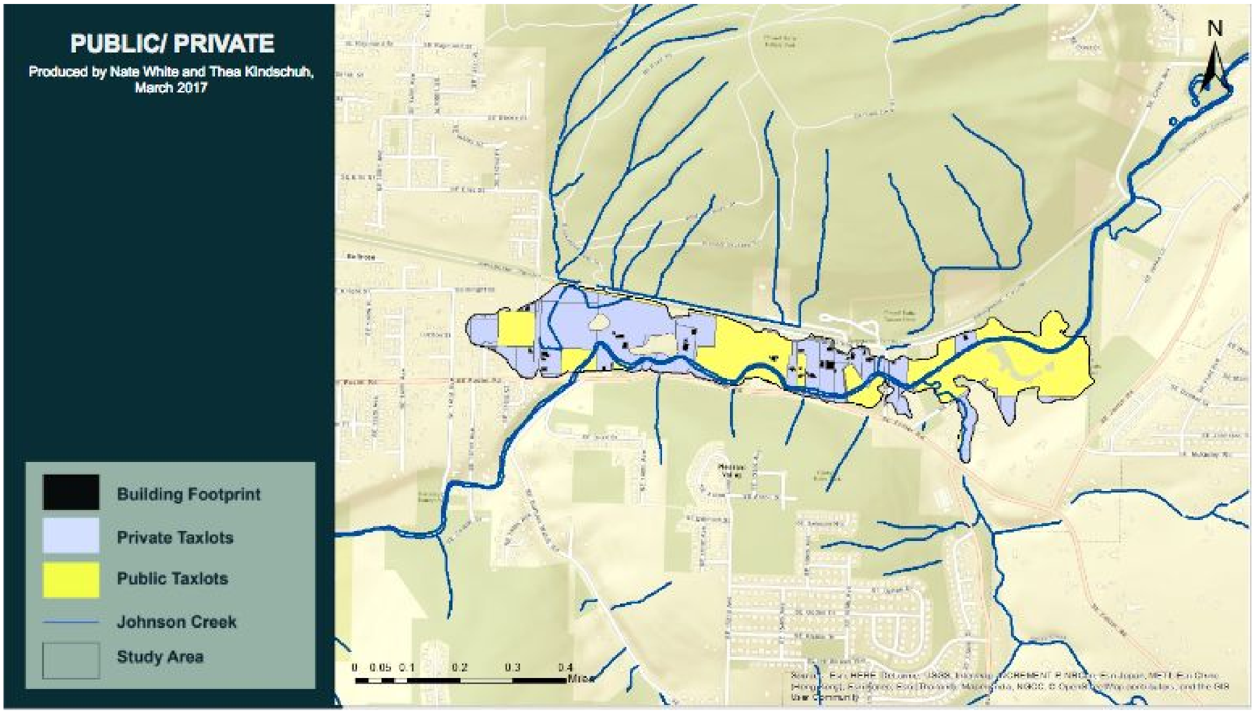


Appendix B: Open Space Availability in the Barbara Welch Study Area



Appendix C: Wetland Soils in the Barbara Welch Study Area

Appendix D: Public and Private Land and Building Footprints in the Barbara Welch Study Area



Appendix E: Evaluative criteria for prioritizing potential floodplain storage

Covariate	**Measure/ Calculation**
Study area acreage	**Barbara Welch: 3,813,248 sq ft = 87.45 acres** Taxlots (Private) = - GIS acres = 65.68 acres Taxlots (Public) = - GIS acres = 82.36 acres
# buildings in study area	# total buildings in BW study area = 35 # total buildings in taxlots = 32 - # public buildings = 2 - # private buildings = 30
Property values	**Private taxlot value (land + building value):** $12,405,880 **$/acre** Private taxlot value/Private Taxlots GIS acres = $12,405,880/65.68 acres = $188,884/acre <u>Target (per Natural Area Acquisition Strategy):</u> $80,000/acre (target) = 2006 dollars $96,365/acre (target) = 2017 dollars
% vacant land	100(Sq ft vacant land/ total) 1,171,541/ 3,813,248 = 30.7%
% parks/natural areas	100(sq ft parks/ total) 1,628,455/ 3,813,248 = 42.7% Combined parks/ vacant land = 73.43% of study area
% wetland soils	100(Sq ft wetland soils/ total) 2,155,989/ 3,813,248 = 56.5%
Acre-feet of storage capacity	TIN volume calculation 15 ft above 230 ft contour → 245 ft contour 9,549,872 ft cubed = 219 acre-feet