UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Investigating the Optimal Locations for Outdoor Drinking Water Fountains in UBC

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Executive Summary

This research project task involved calculating the locations best suited for outdoor water fountains on the University of British Columbia Vancouver campus. A mixed method study was conducted to help identify the optimal locations through interviews, surveys and Geographic Information Systems (GIS) analysis. An online survey created for student, faculty, and staff feedback received ninety four responses. Respondents from the survey ranked the areas surrounding the Bus Loop, Sauder School of Business, and Buchanan buildings as the top three areas to install a new outdoor drinking fountain. Interviews were conducted with a UBC transportation engineer and athletic facilities director. Recommendations were also provided from the interviews. Composite maps designed to locate optimal fountain hotspots were compiled and overlaid. All feedback and information was brought together which provided specific locations across campus that would best fit outdoor drinking water fountain installation, while taking into account foot traffic, cost, main water pipes, design, interference, and potential damage. Limitations of the research were those of time constraints and a lack of available data.

This report proposes two locations for the placement of water fountains; the first, with the highest priority, located outside Buchanan, and the second located outside Sauder School of Business.

Abstract

The University of British Columbia (UBC) strives to become as sustainable a campus as possible. UBC, in collaboration with the SEEDS Sustainability program, has put forth initiatives and conducted research into more ways the campus can be a leader in the sustainability industry. There have been several SEEDS reports completed since 2010 regarding creating a more sustainable campus, specifically revolving around water usage across UBC. This report, published by us, students of Geography 371 alongside the SEEDS program aims to further that goal by reducing the amount of plastic water bottles sold on the UBC campus. To do this, the scope of the study centered around finding the most ideal locations to install new outdoor drinking water fountains around campus so that fresh, clean, and plastic-free water could be more readily available to students, faculty, staff, and members of the public. Furthermore, the report aimed to grasp the social, psychological, or physical reasons why those who primarily hydrate using single-use plastic water bottles do so. As part of our research, we created and distributed a questionnaire for students, faculty, and staff to anonymously fill out, as well as conducted interviews with relevant professionals working for different sectors of UBC. By using the Geographic Information System (GIS) statistics found in UBC's public database, we were able to overlay various pieces of data indicating where outdoor water fountains can theoretically be installed. This would correlate with the feedback given by the questionnaire and interviews giving us more detailed information on where to recommend installation points. With the conclusion of our research, UBC and the SEEDS program would have a solid grasp on the specific locations that would be best fitted for the installation of outdoor drinking fountains across the Vancouver campus while taking into account cost and usability. Additionally, we

aimed to provide further insight as to where more work needs to be done to demonstrate how tap water from outdoor fountains is a viable drinking source.

Introduction

This report is based off a roughly three-month long research project conducted by a five-member team in a Geography 371 class at the UBC Vancouver campus. At the onset of our research, we brainstormed how to go about recommending the most appropriate locations for outdoor water fountains around the UBC campus. We worked in tandem with Bud Fraser, our SEEDS coordinator, who provided us with recommendations based on our ideas. Obtaining feedback from as many students, faculty, and staff as possible seemed necessary, as we wanted to make sure that the potential fountains would have maximum usage wherever they were placed. Interviewing some key UBC staff to better understand the current water fountain usage landscape on campus also felt important. Bud helped to rework our survey and recommend some crucial people to interview. Our team reviewed past literature that was relevant to our topic, so we knew what had already been done and what to focus on based on gaps in the research. Some of our team members also began studying the GIS data based around UBC's main water pipes and population density. In the information that follows, the details of our methodology, research findings, and recommendations will be provided. While there were limitations to our research, we managed to supply SEEDS and UBC with two locations for the placement of outdoor water fountains on campus, along with a detailed methodology which can be adapted and replicated in the future.

Statement of Problem

UBC's goal to be a more sustainable campus, as stated in the Zero Waste Plan published in 2014, is to be achieved through reducing overall waste by developing better waste infrastructure and expanding waste collection points (UBC Sustainability, 2014). It is believed that mitigation of the most common waste, plastic bottles, can be achieved by increasing access to drinking water from water fountains on campus, and to promote awareness of why people should be drinking tap water. Previous SEEDS reports on reducing reliance on bottled water at UBC in 2010 indicated that they developed a marketing plan that would aim to reduce bottled water use significantly. However, because this was mainly a social media marketing and survey based project, there was not enough tangible research done for the next steps that implementing outdoor water fountains would require, for instance, data regarding viable locations based on available infrastructure.

A substantial amount of attention is paid to the lack of outdoor water fountains around UBC academic areas and recreational facilities such as the outdoor fields, and recommendations are suggested for these areas under the basis of having high demand for accessible water but a low number of existing drinking fountains in the area (Cheng, 2014). The latest SEEDS projects conducted in 2013 and 2014 were more focused on the technical considerations of installing drinking fountains at UBC, such as infrastructural guidelines and requirements, and less on the perceptions or reasons why people may not like to drink tap water, which requires further study. Thus, the problem lies in the lack of data regarding the perceptual reasons why people may not be drinking tap water and of the locations where people desire outdoor water fountains the most.

By proposing the best locations to install new outdoor water fountains, addressing users' needs and their perceptions of tap water, we hope to tackle this issue and improve access to drinking water on campus in support of UBC's Water Action Plan.

Literature Review

Sustainability

The 34-page Zero Waste Action Plan published in 2014 outlines the many areas and means through which UBC aims to reduce overall waste, such as diverting operational waste away from landfills, improving methods of recycling on campus by developing better waste infrastructure and expanding waste collection points (UBC Sustainability, 2014). However, despite the Action Plan repeating the '3 R's of waste management – 'reduce, reuse, recycle' – multiple times, there is not much focus on reducing and reusing. As important as it is to recycle, reducing the amount of material to be recycled is even more advantageous. Not only does the recycling process for plastic water bottles use large amounts of energy (Makov et al, 2016; Gleick & Cooley, 2009), but there also appear to be limits to the efficiency of recycling plastics (Haight & Antadze, 2012). Furthermore, not all recyclables end up being diverted, and many tonnes of plastic still end up in the landfill. Between the energy used to recycle diverted plastics and the improperly disposed of plastics that end up in the landfill, working toward reducing the total amount of plastic in circulation is a laudable goal.

Perceptions

Much research has been done to determine why people hesitate to drink tap water, choosing bottled water instead. It was found that many people prefer bottled water due to preference for its taste, for the “superior” image that consuming the more expensive type of water provided (Doria, 2006), as well as for the assumed safety and quality of water not coming from a tap (Güngör-Demirci et al, 2016). This leads people to ignore the fact that chemical residue from the plastic packaging can still leak into and contaminate the water (Van den Boomen, 2010). Furthermore, previous incidents involving bacterial contamination of municipal tap water systems and Canadian ones in particular have no doubt contributed to fear that tap water is unsafe (Van den Boomen, 2010; Viscusi et al, 2015).

Gender and age

Research also concluded that factors like gender and age can affect individuals' decision-making strategies when choosing between bottled or tap water (Saylor et al, 2011). A survey targeted at Purdue University students, staff, and faculty in the United States found that women tended to drink more bottled water than men as they were more concerned about tap water quality (Saylor et al, 2011). Undergraduates were also found to drink more bottled water than graduate students, staff and faculty, implying a connection between age and type of water preference (Saylor et al, 2011). This research also found that many students were unaware of the overwhelming negative impact that plastic bottles had on the environment despite recycling processes (Saylor et al, 2011). A different survey conducted in 2012 aimed to test statements such as these, including hypotheses claiming that ethnicity impacted people's water preferences (O'Donnell & Rice, 2012). The results showed that there was no correlation between age, gender and drinking habits, whereas ethnicity did seem to have an impact on drinking habits (O'Donnell & Rice, 2012). We acknowledge that such hypotheses would depend largely on the sample of survey respondents, and so conducting similar surveys amongst the culturally and demographically diverse UBC population would help clarify such statements' validity, and help us understand how to utilise our findings in the best manner to convince people to switch to tap water.

Hygiene

A key factor in maximizing the usage of outdoor drinking fountains is their upkeep, as people will be naturally less inclined to drink from a water fountain with noticeable signs of neglect. As noted by observations conducted in Wellington, New Zealand, 47% of outdoor water fountains contained algae around the nozzle (Wilson et al., 2017) which could lead to lower water quality. Similar results were seen in Berkeley, California where only 70% of water fountains were reported to be clean (Avery & Smith, 2018). Additionally, those who intend to drink from water fountains would be less keen on doing so if the water pressure and height of the water from the fountain spout is not high enough. In Berkeley, for instance, 64% of water fountains had a spout height four inches or lower (Avery & Smith, 2018), which was believed to have contributed to reduced usage of the fountains. Someone intending to use a fountain would be much less inclined to do so if they could clearly observe that the potential for germ spreading and water contamination was high. Moreover, contaminant intrusion occurs when one or more of three main prerequisites are present in the water distribution system: “The availability of a contaminant source in the proximity of the system, a driving force (low/negative pressure), and a pathway (including submerged air valves, leak points, repair and installation sites, faulty seals and joints, and service connections)” (Mansour-Rezaei et al., 2014). Proper and consistent maintenance, as well as regular disinfection will go a long way in assuring members of the public that UBC’s fountains are clean and well taken care of (Freitas et al., 2017).

Accessibility

While hygiene and the perceptions towards drinking tap water are important, the design and aesthetic is also an essential part of the research: although the term aesthetic is typically interpreted as relating to beauty, it is more complex and can influence consumers’ behaviour, lifestyles and attitudes. Studies have concluded that aesthetic factors are of importance when creating a sustainable product - that is, one that will not go out of use before it is expected to and so will not contribute to the waste of material, energy and economic resources (Zafarmand et al, 2003). This research has shown that there are 7 key factors ensuring a product’s sustainability: these include aesthetic durability, logicality and functionality, upgradeability and modularity, as well as retaining local aesthetic and cultural identity, to name a few. These sustainable attributes will be important to keep in mind when considering how to ensure the outdoor water fountains will still be used regularly even when they are no longer brand-new and immediately noticeable, as a key feature of sustainable products is that they prioritize function and durability over being attractive or exceedingly innovative (Zafarmand et al, 2003). Not only might they help make UBC a more sustainable campus, the presence of water fountains could have unintentional benefits as well, such as encouraging users to drink water instead of buying unhealthy sugary drinks (Wilson et al., 2017). This could potentially and indirectly help to promote a healthier lifestyle on campus, as well as save students' money (Wilson et al., 2017; Park et al, 2009).

The placement of fountains

Research conducted on the UBC campus has produced notable findings regarding the placement of drinking water fountains (Cheng, 2014; Tran et al., 2012). These studies have suggested areas in need of fountains with criteria such as having a high amount of foot traffic, a high ratio of users per water fountain, high levels of trace heavy metals in the water within acceptable levels, or areas with no drinking water fountains nearby (Cheng, 2014; Tran et al., 2012). While this provides a starting point for our investigation, fulfilling any one of these criteria warrants the recommendation of the placement of a water fountain, which seems impractical from the viewpoint of a client with a limited budget. These studies demonstrate the consideration of reasonable criteria which we can build upon, although highlighting the need for a more systematic approach in selecting locations for drinking fountains. The desired approach would entail being able to consider the multiple factors to be taken into account while being able to produce a list of locations ranked by priority.

Reducing sales versus providing adequate access

Another notable point is the ambiguous balance between providing access to drinking water versus reducing the sales of bottled water. A substantial amount of attention is paid to the lack of water fountains around UBC recreational facilities such as the outdoor fields, and recommendations are suggested for these areas under the basis of having high demand for water but a low number of existing drinking fountains in the area (Cheng, 2014). Although the sales of bottled water in these locations are nonexistent, and athletes utilizing the facilities often bring their own reusable water bottles, the placement of water fountains in these areas would likely not offset a large number of bottled water sales. While it is possible for the lack of water fountains in these areas to influence bottled water sales in another part of campus, it is still likely that a water fountain placed close to a food vendor selling bottled water would have a greater impact on bottled water sales due to the immediate and obvious choice of alternatives. The criteria and rationale used by the previous researchers is therefore ambiguous and must therefore be explored more thoroughly for an in-depth analysis of priorities (Cheng, 2014; Tran et al., 2012).

If we draw from the theories of Henri Lefebvre, we may be more inclined to position fountains to compete with food vendors. In his work, 'The Production of Space', he argues that the urban environment is fabricated in order to serve a capitalist order where our convictions are largely shaped by a selfish and profit-oriented rationale, and we must therefore take back ownership of this heavily regulated space (Lefebvre, 1991). From this perspective, the goal of our project will also come into conflict with some of UBC's economic goals of profiting from beverage sales, and to therefore position water fountains in spaces where they create competition with food vendors would be a form of reclaiming space against the capitalist system.

Methodology

We first gathered data from our surveys and interviews with the hope of finding key considerations to the placement of outdoor drinking water fountains. We used the information gathered to determine the most important factors for placement (proximity to food outlets, foot traffic in the area, demand by surveyed population) and assigned different weights to each factor. Factors which we deemed more important were given a larger weight and vice versa.

We then used ArcGIS to overlay the data layers on top of each other to find the areas which scored the highest by calculating using the assigned weights for each factor. Finally, once determining the highest scoring areas, we used street-level photographs to propose locations to place the outdoor drinking water fountains.

Survey

We distributed our online survey to students, faculty and members of staff at UBC Vancouver, and asked respondents about the motivations for their drinking water habits, preferences regarding water consumption, as well as demographic. Depending on their answers, they could be asked up to 9 of the questions (Figure 1).

Survey Results

We received a total of 94 responses to our survey. From our first question asking how respondents primarily chose to rehydrate on campus (Figure 2), we found that only 1 of our respondents consumed bottled water to rehydrate. 3 did not drink water on campus, and 5 preferred to consume other beverages instead. 23 individuals used drinking water fountains, and 62 brought their own refillable bottles.

If the respondent had answered that they brought refillable bottles or used water fountains, the next question they were directed to asked about their motivations for doing so. Of the respondents who used refillable bottles (Figure 3), the majority of responses indicated awareness that it was better for the environment (41), with some explaining their choice being due to habit (40), convenience (37), being conscious of the price of bottled water (26), and preference for taste (10).

Respondents who primarily drank from water fountains (Figure 4) selected answers reflecting that they did so out of habit (13), convenience (11), concern for the price of bottled water (10), or out of being conscious that it was better for the environment (8).

We then asked respondents about their demographics - specifically, whether they were undergraduates, graduate students, faculty or staff and if they were domestic students or from outside of Canada. This was done in order to find out if there was a correlation between their demographic and water drinking habits, as had been concluded by researchers conducting a study at Purdue University in the United States (Saylor et al, 2011).

Of the 21 undergraduate respondents (Figure 5), 14 used refillable water bottles to rehydrate, 4 drank from water fountains, 1 bought bottled water and 2 did not consume water regularly. Of the 33 responses from graduate students, 24 used refillable bottles, 8 drank from water fountains, and 1 consumed other beverages instead of water. We received 12 responses from UBC faculty, and of those, 8 respondents used refillable bottles, 3 drank from water fountains and 1 consumed beverages other than water. Of the 20 responses from UBC staff, 14 brought refillable bottles, 4 drank from water fountains, and 2 consumed other beverages instead.

We received 26 responses from domestic students (Figure 6). Of these, 19 used refillable bottles to rehydrate, 4 drank from water fountains, 1 bought bottled water and 2 did not drink water on campus. Of the 28 responses from international students, 19 brought refillable bottles, 8 drank from water fountains and 1 consumed beverages other than water.

We then asked respondents how long they have been at UBC Vancouver, as well as whether they lived on or off campus, again to see if there was a correlation between their demographics and their water consumption habits.

Of the 13 respondents who had spent less than a year at UBC (Figure 7), 10 used refillable bottles, 2 drank from water fountains and 1 consumed other beverages than water. 11 respondents had spent 1 to 2 years at UBC, and of these, 8 brought refillable bottles, 1 bought bottled water and 2 did not drink water to rehydrate. 12 respondents had spent 2 to 3 years at UBC, and of these, 10 brought refillable bottles while 2 drank from water fountains. 11 respondents had spent 3 to 4 years at UBC, with 5 of them using refillable bottles, and 6 drinking from water fountains. Of the 39 responses from individuals who had spent more than 4 years at UBC, 27 indicated that they brought refillable bottles to rehydrate; 9 drank from water fountains, and 3 consumed other beverages in place of water.

We received 69 responses from individuals who lived off-campus (Figure 8), and of these, 48 brought refillable bottles, 15 used water fountains, 2 did not consume water on campus, and 4 drank other beverages instead of water. Of the 17 responses from those who lived on-campus, 12 brought refillable bottles, 4 drank from water fountains, and 1 bought bottled water to rehydrate.

The 1 respondent who had answered the first question by selecting that they preferred buying bottled water on campus was then asked for their motivation as to why, in order to understand their preference. They stated that they enjoyed the taste of bottled water more than tap water, and cited convenience as a factor in buying bottled water on campus instead of bringing a refillable bottle along (Table 1).

The 8 individuals who had responded that they primarily bought other beverages such as coffee or soda to rehydrate or that they did not drink water on campus were also asked about their motivations as to why. 4 respondents cited that it was inconvenient to find drinkable water on campus; 2 indicated that their preference was regarding taste; 1 cited concerns about the hygiene of UBC's tap water, and 1 respondent simply did not consume water on campus (Table 2).

The respondents who had indicated that they either bought bottled water or did not drink water on campus were asked what might make them switch to consuming a reusable source of tap water in order for us to understand if they had previous convictions regarding tap water that future studies may be able to address more in-depth. 1 respondent stated that they would do so if accessibility to drinking water fountains on campus was improved by adding more fountains, and 1 other indicated that better-tasting tap water would help them make the switch (Table 3).

Lastly, we asked respondents to select a minimum of 2 locations where they would want a new outdoor drinking water fountain to be installed (Table 4). We provided a list of pre-selected locations, as well as gave them the option to suggest their own. The majority of respondents chose the Bus loop, UBC Sauder School of Business and Buchanan buildings as areas where they would most want a new water fountain to be built, with 60, 50 and 45 selections for those locations respectively. 18 respondents chose the area near the UBC Engineering buildings, and 10 selected Thunderbird Park. We received 4 responses highlighting the Nest, 3 for an area along Main Mall, 3 near Walter C. Koerner Library, 2 near the bookstore, 2 near to the Orchard Commons residence, 1 near the Geography building, 1 near the entrance to Wreck Beach, and 1 response selecting the UBC Rose Garden as a location. 4 respondents indicated that they had no interest in new outdoor drinking fountains, and 1 suggested that new fixtures might be unnecessary.

Survey Analysis

From the results of the survey, we can see that UBC Vancouver students, staff and faculty surveyed generally seemed to be aware of the impact that bottled water consumption has on the environment and that has influenced their bringing refillable bottles or utilizing drinking water fountains. Habit, convenience, and saving money by not consuming expensive bottled water were also cited as reasons for this.

We can see from the demographic of the individuals surveyed that there is no clear correlation between age and drinking habits, as had been concluded in existing literature (Saylor et al, 2011) - instead, we found refillable bottled water usage to be prevalent amongst our respondents regardless of the number of years they had spent at UBC, or whether they were undergraduates, graduate students, staff or faculty. However, we acknowledge that these results could be skewed due to our limited sample size of respondents.

We did learn that lack of accessibility to drinking water sources, issues of taste preference as well as concern for the hygiene and safety of UBC's tap water system were factors influencing the respondents who did not consume tap water on campus. These are accepted as some of the main reasons why students generally prefer bottled water (Choate et al, 2018), and it is clear that future studies could look into addressing these concerns in order to help promote the drinkability of tap water on campus in the future.

Additionally, we gained valuable insight as to which areas on campus had the most demand for new outdoor water fountains, and we were able to use this information in applying our GIS methodology to determine exact locations to best place new fountain fixtures.

Interview

The interview portion of our methodology consisted of two semi-structured interviews with Krista Falkner (Campus Transportation Engineer) and Dan Cooper (Associate Director of Athletic Facilities) about the need for fountains on campus and in Thunderbird Park with regards to cost and placement recommendations. We first interviewed Krista Falkner, who works with all modes of transportation in the UBC public realm, including both pedestrian and vehicular traffic of all kinds. We wished to gather information regarding the key obstacles for placement of potential fountains, information regarding the ongoing construction plans at UBC, and other perspectives she may have to offer on our proposal. With our other interviewee, Dan Cooper, our aim was to get a sense of the need for more available public water in and around Thunderbird Park. We hoped to further understand how people who use the space tend to hydrate and whether or not the installation of additional outdoor water fountains would be beneficial to athletes and others using these facilities. Furthermore, we wanted to know if water fountain installation here was realistic given our list of criteria for placing fountains in a specific area.

Interview with Krista Falkner

Krista encouraged us to think about how the placement of the potential water fountain would affect the surrounding dynamic landscape of the campus. For example, positioning fountains near trees and street furniture such as benches and signs would help to better protect not only the fountain, but the user of the fountain as well from vehicles or cyclists in the area. She also suggested placing fountains near existing pathways instead of constructing them further from a walkway, which would involve extra cost by requiring extra pathways to be built. However, she also highlighted that we should consider the user's position while utilizing the fountain and avoid placing it in areas where the fountain or the user utilizing the fountain will block the path for other pedestrians. Krista also indicated that cost was a major factor in the approval of such a project, and such considerations would have to be made to ensure costs were kept as low as possible.

Appearance-wise, Krista said that the fountains should blend into the surrounding environment as much as possible and not appear foreign. She also noted the possibility of approaching existing construction projects to discuss the placement of outdoor drinking fountains. This would reduce the costs associated with installation because fountains could be built during the construction phase, and not added after the completion of the project, reducing the need for re-digging and rehabilitation of the constructed landscape.

Figure (10) shows projects that are currently under construction with their locations; Biological Sciences Building, Gage South Student Residence and Diesel Bus Transit Exchange, Hebb Seismic Upgrade and Landscape Renewal, and MacInnes Field Parkade are ongoing constructions. Furthermore, current applications that are still being processed and construction has not yet begun are need to be considered for the future research consideration. Overall, Krista's expertise provided us with new perspectives to optimal locations for outdoor water fountains that we would not have foreseen.

Interview with Dan Cooper

Dan Cooper informed us of the progress made thus far in making water more accessible in Thunderbird Park and the surrounding area. The recent installation of the outdoor water fountain in the park marked the first and only outdoor water fountain in the area (another outdoor water fountain will be installed in MacInnes Field following the completion of construction, although this is an area separate from the park). He also presented us with a map of Thunderbird Park which indicated potential sites for more outdoor water fountains (Map 14). These locations were selected based on a list of criteria which Dan informed us need to be considered.

When installing an outdoor water fountain, Dan stressed the consideration of the water main locations, the source of the water, and the cost of implementation. The location of the water mains is something our research team already knew we need to consider. Proximity to buildings is also something to consider, as fountains closer to the the water source will require less frequent cleaning and maintenance due to less stagnant water needing to be flushed out. The source of the water for the fountains cannot come from the irrigation already in place, since it is not consumption-grade. This was something we had not considered and made locations closer to buildings more recommendable as well. The map of potential sites for fountains that Dan gave us took into consideration cost as well - certain locations were perhaps more desirable than others but would be far more expensive to implement. We then considered if placing one very expensive but more ideally located fountain would better suit the park as compared to two more cost-effective but less ideally located fountains.

In conclusion to our interview with Dan, he offered some alternatives to outdoor water fountain installation. The indoor facilities in the park already contain water fountains and if all existing indoor fountains could be retrofitted with a water bottle filler, this could offset the demand for an outdoor fountain. Ensuring there is a water fountain with a bottle filler alongside the vending machines could make people think twice about purchasing an unhealthy beverage instead of free water as well. Finally, we discussed the possibility of purchasing or renting a water wagon to supply water for big events going on in the park which could be filled when needed. This would be cheaper, require less maintenance and still reduce the amount of plastic bottles being sold and used.

GIS Methodology

We learned from our interviews that the most important factors for determining the placement of outdoor drinking fountains is the demand for the fountains and the cost. We sought to identify the areas with the highest demand for water using maps of foot traffic around the UBC campus to locate the most popular and frequently-used streets and sidewalks; however, existing maps did not cover key areas in UBC, such as the Bus Loop, so we were not able to utilize that dataset. While conducting our own research, we inquired about foot traffic data with UBC Campus and Community Planning, a UBC systems analyst, and the UBC GIS librarian on existing foot traffic data at UBC Vancouver; this inquiry revealed that there there was no existing GIS data layer available. Therefore, we decided to use the size of each faculty divided amongst each faculty building to determine the average population of each building as a measure of population density. From this general dataset, we could determine hotspots around campus and hence identify areas which would see high volumes of foot traffic.

We also incorporated the results from our survey question, “Where do you think is an ideal location for new outdoor drinking water fountains?”, as this also represents locations which had demand for drinking fountains, and could therefore bolster our results.

Cost was the other major factor highlighted by our interviewees, and to find locations which had minimal cost of installation, we decided to search only for areas which were above or very close to a main water pipe. This was to reduce the costs associated with digging up the ground and laying new water pipes for the drinking fountain, which could end up being extremely expensive due to the cost of utilizing heavy machinery.

Gathering GIS data (Table 4)

For our GIS analysis, we first gathered data online (buildings polygons, water mains network, existing water fountains) and through creating them ourselves (population density, population density hotspot, food outlets, survey suggested locations, interview suggested locations). ‘Table 5’ shows the type and source of the data we used.

GIS Process

To create our ‘UBC population density hotspots’ map (Map 3), we divided the student population of each faculty by the number of each faculty’s buildings. This gave us the average number of students in each building, illustrated by ‘Map 2’. We then showed this data as circles of varying size, representing the building’s population, above each building. We then determined the hotspots of population by eye and saved it as a usable format for our GIS analysis.

To create our ‘UBC food outlets’ map (Map 5) and ‘UBC existing drinking water fountains’ maps (Map 8), we used Google Maps. For ‘UBC food outlets’, we searched the UBC campus for cafes and restaurants, saved them and converted them into data points to place onto GIS maps. For ‘UBC existing drinking water fountains’, we found a dataset from a previous study which recorded water fountains and outlets in UBC in 2013, and likewise converted it into data points to place onto GIS. We then created a buffer of 50 metres and 25 metres around these two datasets to act as the effective range.

To create the ‘Preferred locations from survey results’ map (Map 6) and ‘Preferred locations from interview results’ map (Map 7), we simply created the data layers ourselves. For ‘Map 6’, we looked at the top three most suggested locations to place an outdoor drinking water fountain and illustrated them on ArcGIS. For ‘Map 7’, we obtained suggestions of locations from previous studies through Dan Cooper, and we illustrated them on ArcGIS.

Weighting methodology (Table 5)

Demand for the fountains was crucial, as highlighted by our interviewees, and we therefore decided to make it the most important factor in the decision-making process. We used the ‘population density hotspots’ and ‘preferred locations from survey’ layers to represent this, as ‘population density hotspots’ illustrate the areas with the largest daily student populations, and ‘preferred locations from survey’ represents where we have recorded a demand for water fountains through our online survey. ‘Population density hotspots’ was given a weight of *0.30*, and ‘preferred locations from survey’ was given a weight of *0.25*.

Our interviewee had suggested locations which they had been considering for the placement of water fountains, and based on his expertise in the area, we decided that his opinion was deserving of a weight of *0.20*, assigning it to ‘preferred locations from interview’.

The water fountain being in a location within 50m of a food outlet is placed at the same weight as it being in a location suggested by the interviews. We believe this is also a factor in determining the demand for water fountains, however it is not as important as being in a population hotspot or being in a location suggested by the surveys. We therefore assigned it with a weight of *0.20*.

We concluded that the fountain being in a location which is not within 25m of an existing drinking fountain is the least important factor. Although it would help us provide access to drinking water to a wider area, having water fountains which fall within a 25m range of each other would not be a major problem, and they would still likely see use.

Results of proposed areas

We then combined the datasets outlined above, calculated their scores using our determined weights (Map 9) and located the areas which scored the highest (Map 10). Finally, while targeting the areas with the top calculated score (0.80) at Buchanan and Sauder, we proposed the placement of water fountains in several precise locations in these areas (Map 11 and 12).

Proposed locations

All proposed locations are in high population areas and are situated close to street lights to ensure they are illuminated at night. They are also located on the grass to avoid users standing and blocking existing pathways while utilizing the fountains. This also allows us to avoid the costs associated with digging up and repaving the pathways during installation of the fountains. The locations therefore vary only by their relative protection from vehicles, proximity to the main water pipes, and to trees, which result in additional costs from the need for root hydrovacing during installation. However, a disadvantage of all locations is that they are not under cover, providing little to no protection against rain.

Proposed locations at Buchanan (Map 11, figure 11 to 13)

Location 1 (figure 11) and 3 (figure 13) are the closest to main water pipes, while location 2 (figure 12) is slightly further. Location 2 and 3 are located near trees and would likely require root hydrovacing during construction. Because we have placed a higher priority on the cost of installation and therefore emphasize the proximity to main water pipes, location 1 and 3 are preferred over location 2. Additionally, location 1 is preferred over location 3 as it it will not require root hydrovacing, and it is therefore the best location for placement at Buchanan.

Proposed locations at Sauder (Map 12, figure 14 to 19)

Location 1 (figure 14) and 6 (figure 19) are the closest to main water pipes. However, location 1 is not protected by street furniture and holds the risk of inhibiting emergency services if situated too close to the fire hydrant. Locations 2 (figure 15), 3 (figure 16), and 4 (figure 17) are further from the main water pipes, but are relatively safe as they are protected by trees, street furniture and lamp posts, which discourage vehicles and cyclists from crossing the grass. Location 5 (figure 18) is further from main water pipes and is also situated at the edge of the grass section, making it more susceptible to conflict from pedestrians, cyclists and vehicles. Because we have placed a higher priority on the cost of installation, and therefore emphasize the proximity to the main water pipes over the protection of fountains by street furniture and trees, location 1 and 6 are preferred over 2, 3, 4 and 5. Finally, location 6 is superior to location 1 because of its location allowing it to be relatively protected from vehicles.

Recommended locations

We have finalized two locations for the placement of outdoor drinking water fountains in UBC, being location 1 at Buchanan (Figure 11) and location 6 at Sauder (Figure 19). These locations are in areas with high population, within an area highlighted by our survey results, within 50m of a food outlet, and are at least 25m away from an existing fountain. Furthermore, both locations are located very close to main water pipes, are above grass to reduce costs, and are in places that are relatively protected from vehicles. However, since Buchanan location 1 is likely not as close to tree roots as Sauder location 6, we will recommend that Buchanan location 1 is placed at a higher priority.

Significance of proposed research and recommended actions

This study proposes two locations for the placement of outdoor drinking water fountains on the UBC campus. Based on our research, these locations are the most ideal and would likely see great use while being inexpensive to install. We would therefore recommend the installation of water fountains in these two locations, with a higher priority being placed on the location at Buchanan.

While only two locations were proposed, the methodology we used to arrive at these locations outlines a guide for drinking fountain placement. Future studies can continue to find the best locations in the next highest-scoring areas in our results (Map 9), or instead utilize our datasets and methodology while adapting the data (updating datasets) and criteria (adjusting the importance of different factors regarding fountain placement) to create results that are more accurate and reliable.

Discussion

Limitations

Both our survey and interview results had a small sample size of respondents, which cannot fully represent the population statistics of UBC Vancouver. Arranging interviews with individuals who could have provided more feedback regarding drinking habits at UBC would have been beneficial to our research. Additionally, in our survey, we did not inquire as to the specific faculty of our respondents - doing this would have provided us with a clearer understanding of the popular location choices for water fountain placement. Our survey could have been altered to ask for secondary sources of hydration as opposed to only asking primarily. This question may have confused or mislead some people's' responses, as they may primarily use a refillable water bottle but still buy plastic water bottles multiple times a week. We also could have phrased our selection of responses more adequately to gain the best idea of the water consumption statistics of our respondents.

There were some variables our research team were unable to take into account. For instance, water consumption will inevitably go up as the days get warmer in the summer. Likewise, during the winter months water demand would likely drop. With this in mind, foot traffic would increase around certain areas around UBC in the summer months (e.g. the Wreck Beach entrance) while other areas on campus get less busy with fewer students enrolled in classes during the summer months. A lack of available water may lead to not only more plastic water bottle usage, but an increase in waste as well. We asked ourselves if these variables are worth considering when taking into account water fountain location recommendations.

We were also unable to conduct a study of foot traffic in UBC due to limitations in time, and instead had to rely on assumptions made from the population density of buildings. This led to limitations in the accuracy of the data, as some areas may appear to have low populations (such as faculties with a large number of buildings) when in reality it is not the case. It is also likely that students of a single faculty are not evenly spread out across the faculty's buildings, and oftentimes classes of one faculty are held in a different faculty's building, which is not captured by the dataset.

Future Research Recommendations

More research can be conducted to improve the accuracy and reliability of our results. As mentioned, installation locations ensuring maximum usage is a priority, so gathering current foot traffic data across campus is needed. This should be obtained while taking into account shifts in foot traffic during different seasons of the year. This would allow us to find the sidewalks and pathways that are the most utilized on campus, and use that to guide our decision-making. Having a quantified dataset on foot traffic would also allow greater precision in the scoring, as each pathway will have a different number of people using it. We can then calculate the best location for fountains by considering the exact number of people utilizing the pathway, as opposed to the binary of "whether or not the pathway is popular or not".

While our initial survey got a satisfactory amount of feedback, obtaining more answers from a wider range of students would give the research more credibility and allow us to draw more conclusive results.

Future research could also explore the possibility of proposing drinking fountains in buildings currently under construction or pending approval for construction. This would reduce the costs associated with installation because fountains could be built during the construction phase, and not added after the completion of the project, reducing the need for re-digging and rehabilitation of the constructed landscape.

Another direction for future research would be to explore the possibility of existing drinking fountains as opposed to installing new ones. This option could provide benefit while also being a fraction of the cost, as a bulk of the infrastructure is already in place. We would therefore recommend obtaining quotes on the cost to retrofit the water fountains inside the athletic facilities in Thunderbird Park, as suggested by Dan Cooper.

We also recommend weighing the effectiveness of water wagons used for past events with regards to plastic bottle usage. If this is not possible, renting water wagons on a trial basis and comparing their usage to plastic bottles sold would be helpful. Conducting surveys at these events to get feedback from attendees on how they feel about the use of water wagons would be useful.

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Appendix A

#	Questions
1	How do you primarily re-hydrate on campus?
2	(Answered: Reusable bottles) Nice job! Where do you currently fill your water bottles?
3	(Answered: Reusable bottles) What motivated you to bring a refillable water bottle?
4	(Answered: Drinking fountain) What motivated you to drink from drinking water fountains?
5	(Answered: Buy bottled water) Why do you prefer to buy bottled water instead of using a refillable water bottle / drinking from the water fountain?
6	(Answered: Don't drink water / buy other beverage) Why don't you drink water on campus?
7	(Answered: Don't drink water / buy other beverage) What would make you switch to reusable tap water?
8	Where do you think is an ideal location for new outdoor water fountains?
9	What is your status at UBC?
10	(Answered: Undergraduate / Graduate) Are you a domestic or international student?
11	How long have you been at UBC?
12	Do you live on or off campus?
13	Do you have a physical disability?

Figure 1. Survey Questions

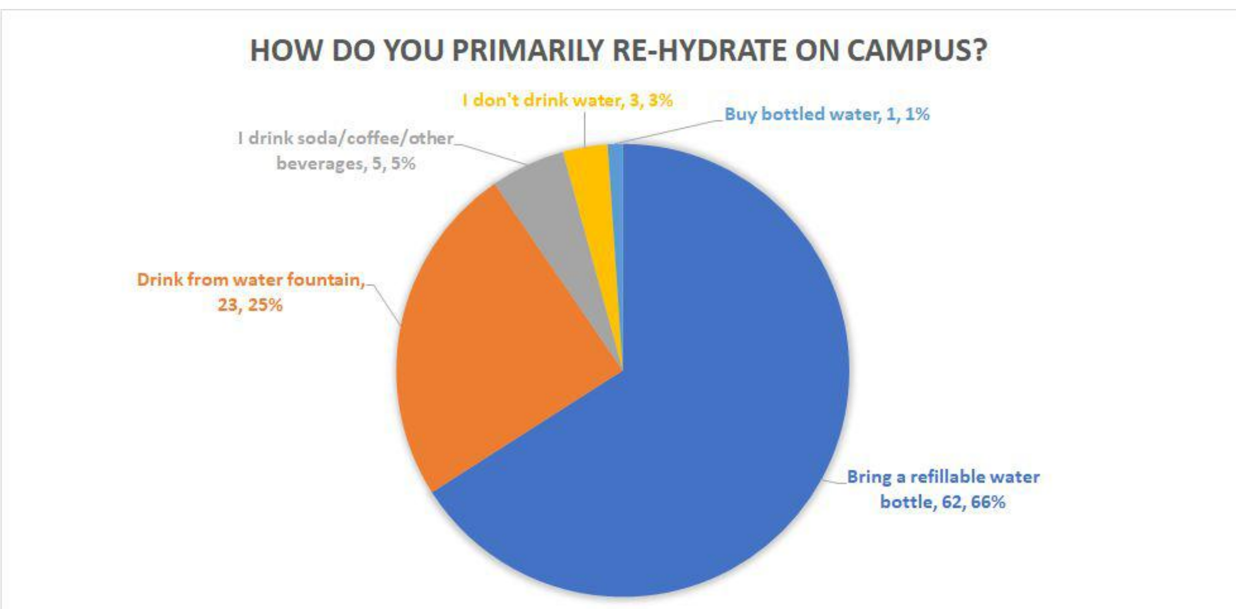


Figure 2. How do you primarily re-hydrate on campus?

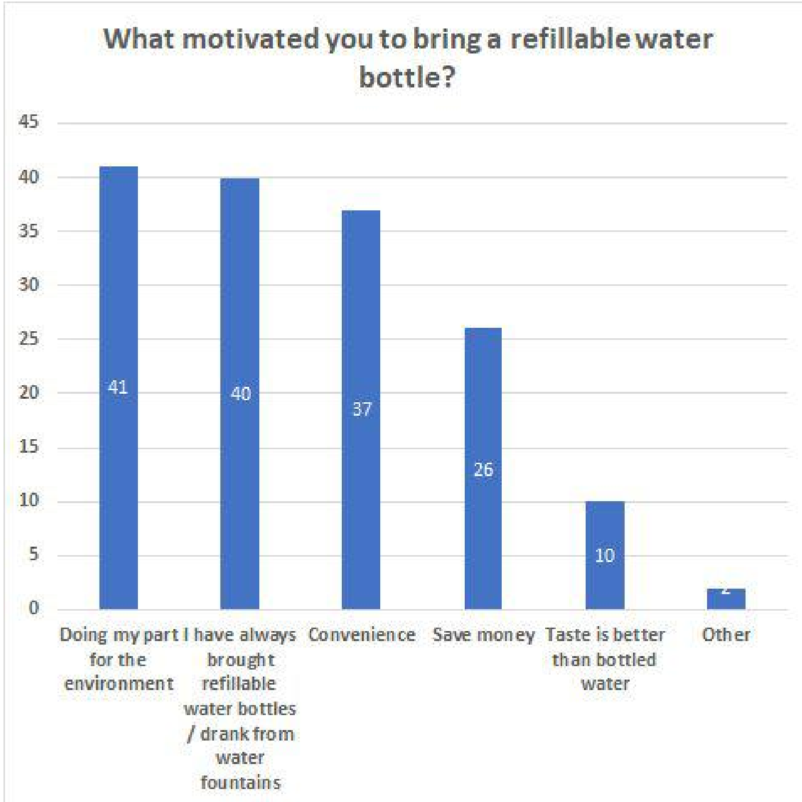


Figure 3. What motivated you to bring a refillable water bottle?

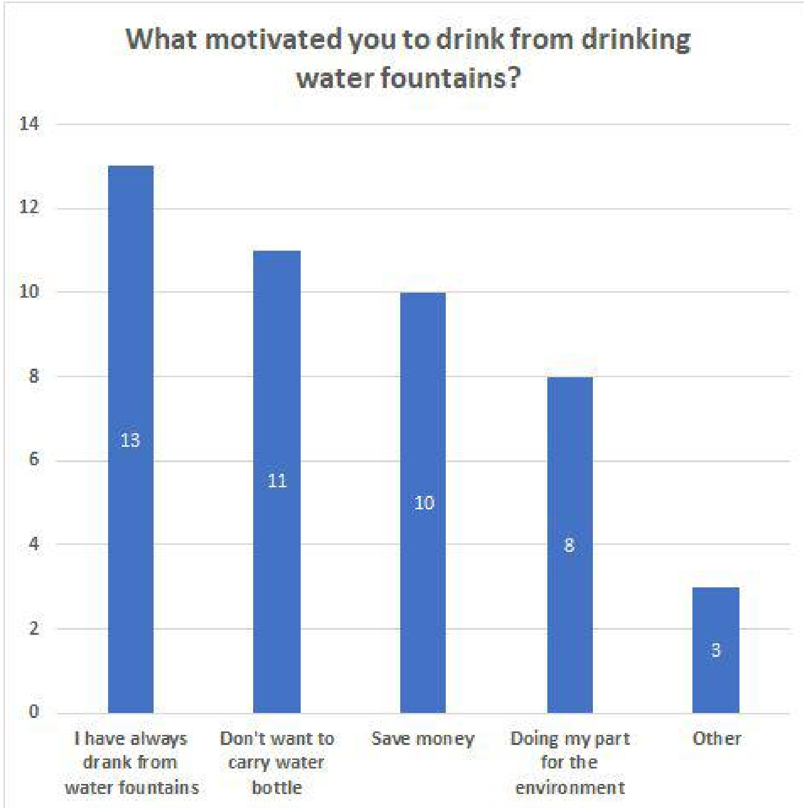


Figure 4. What motivated you to drink from drinking water fountains?

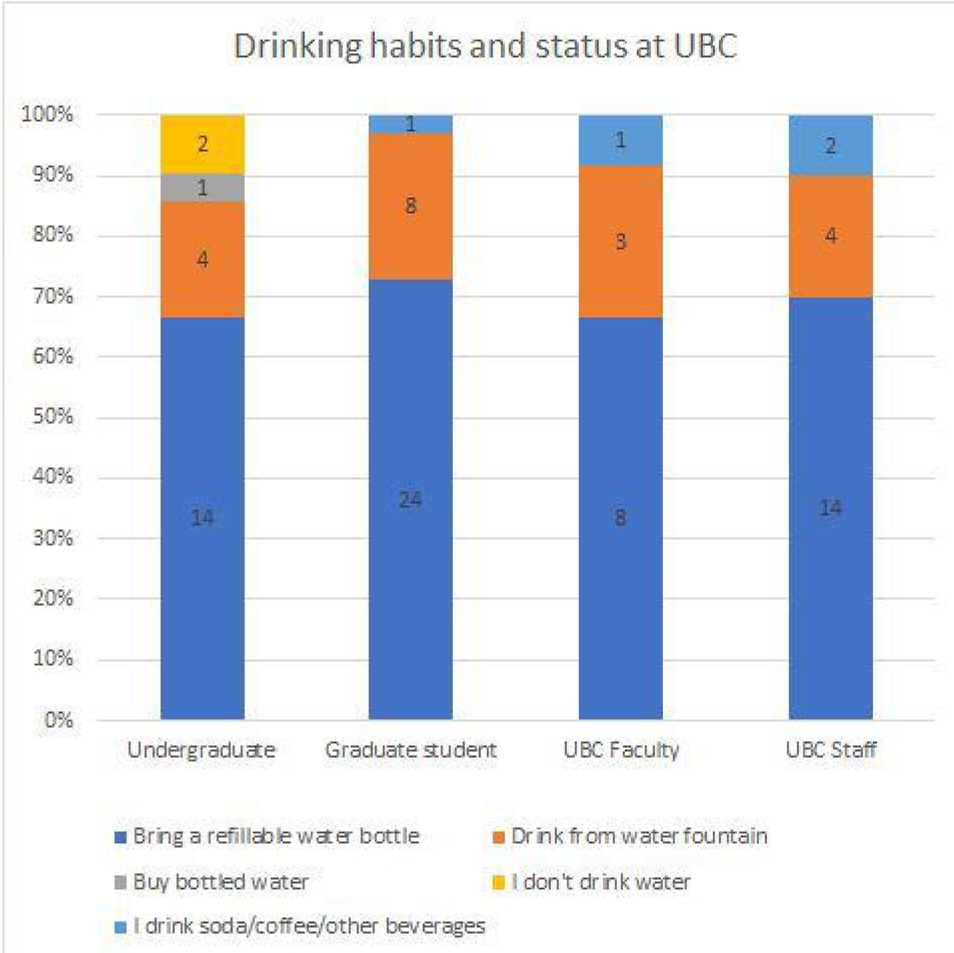


Figure 5. Drinking habits and status at UBC

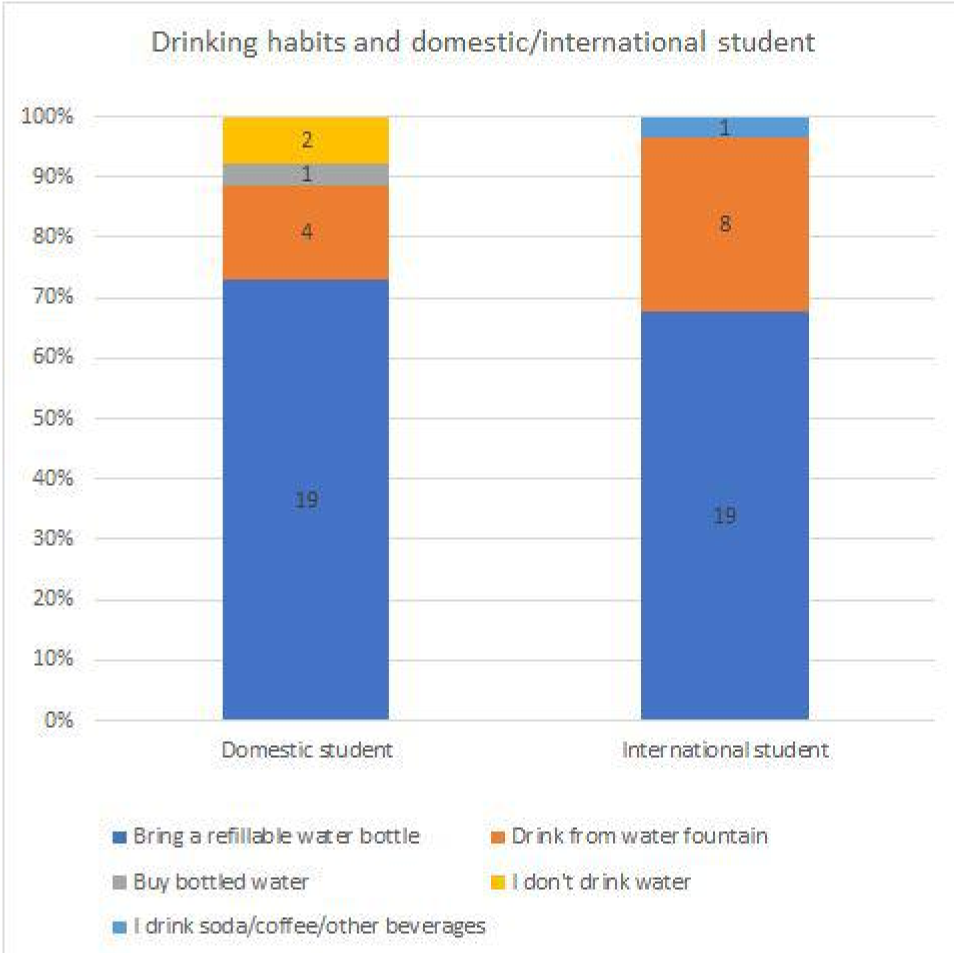


Figure 6. Drinking habits and domestic/international student

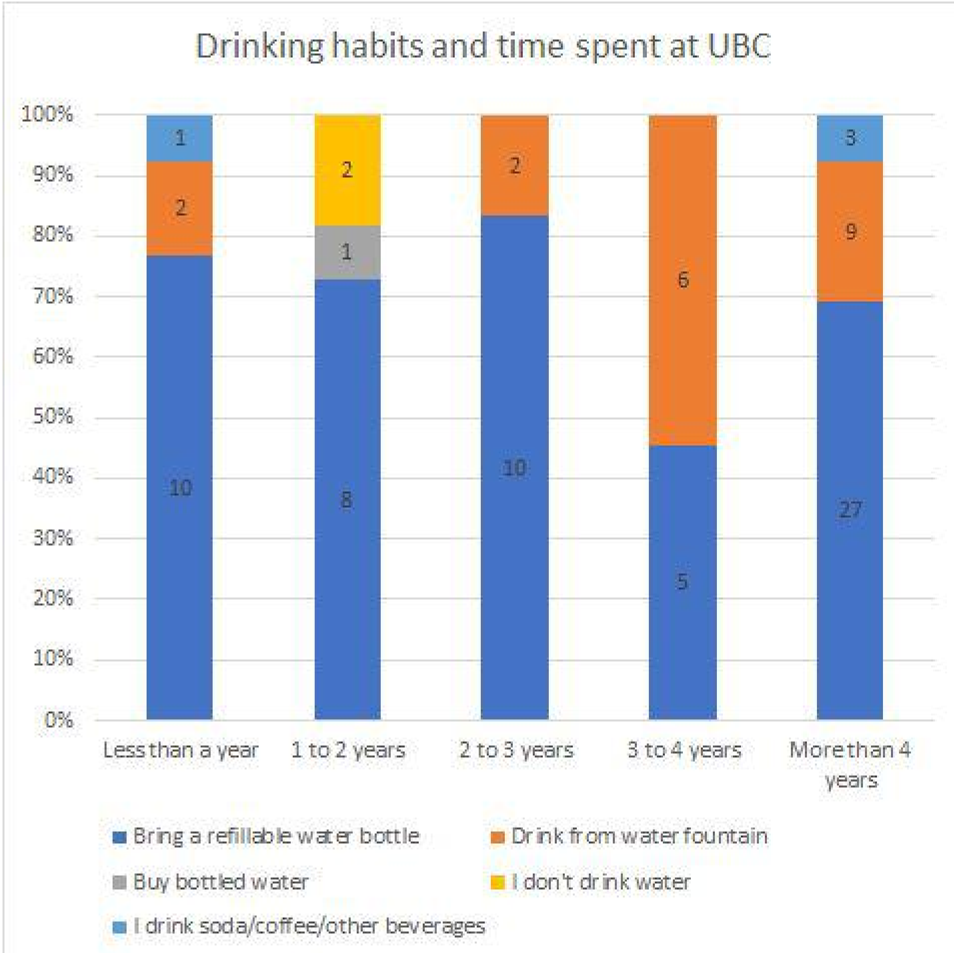


Figure 7. Drinking habits and time spent at UBC

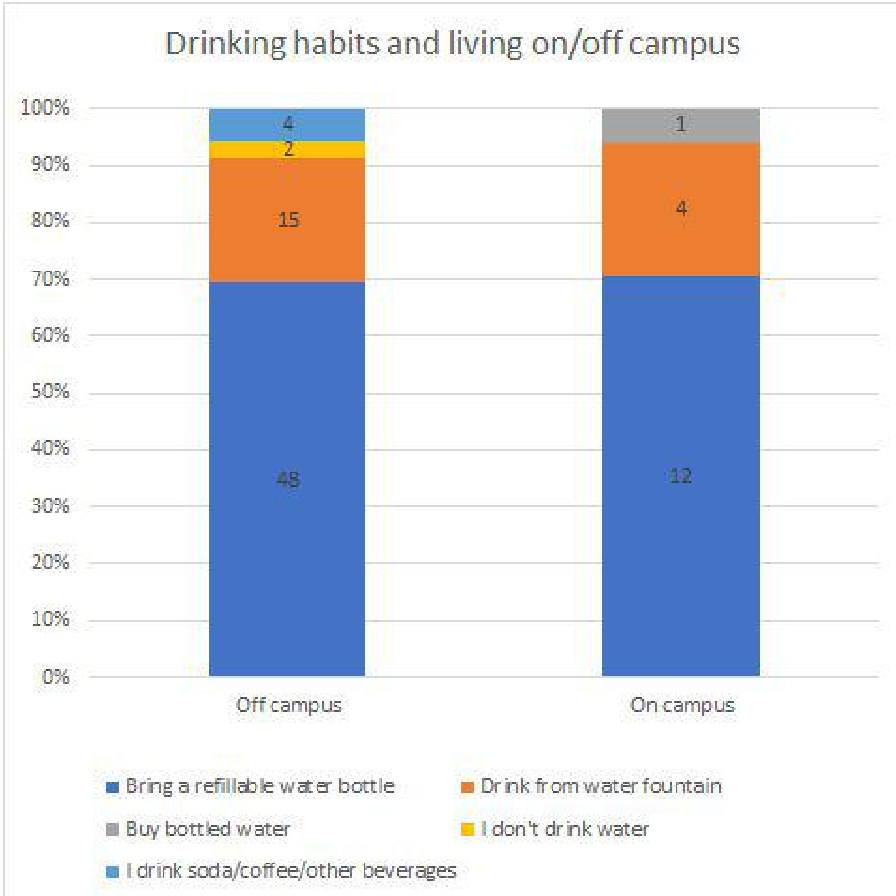


Figure 8. Drinking habits and living on/off campus

Locations	Count	Proportion
At the bus loop	60	29.1%
Near Sauder	50	24.3%
Near Buchanan	45	21.8%
Near Engineering	18	8.7%
Thunderbird Park	10	4.9%
Don't know/don't care	4	1.9%
Near the Nest	4	1.9%
Along main mall	3	1.5%
Near Koerner Library	3	1.5%
Near the bookstore	2	1.0%
Orchard Commons	2	1.0%
As many locations as possible	1	0.5%
Near geography	1	0.5%
Near steps to wreck beach	1	0.5%
No need	1	0.5%
Rose garden	1	0.5%

Figure 9. Survey Response to Locations

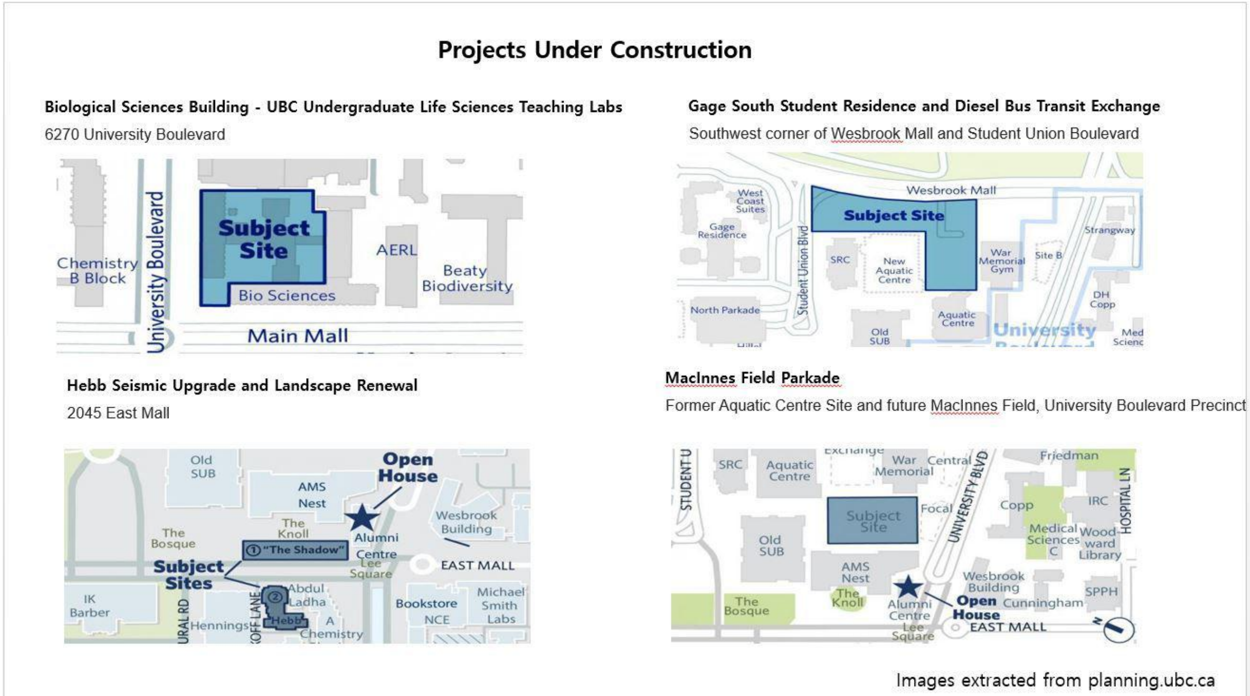


Figure 10. Projects that are currently under construction

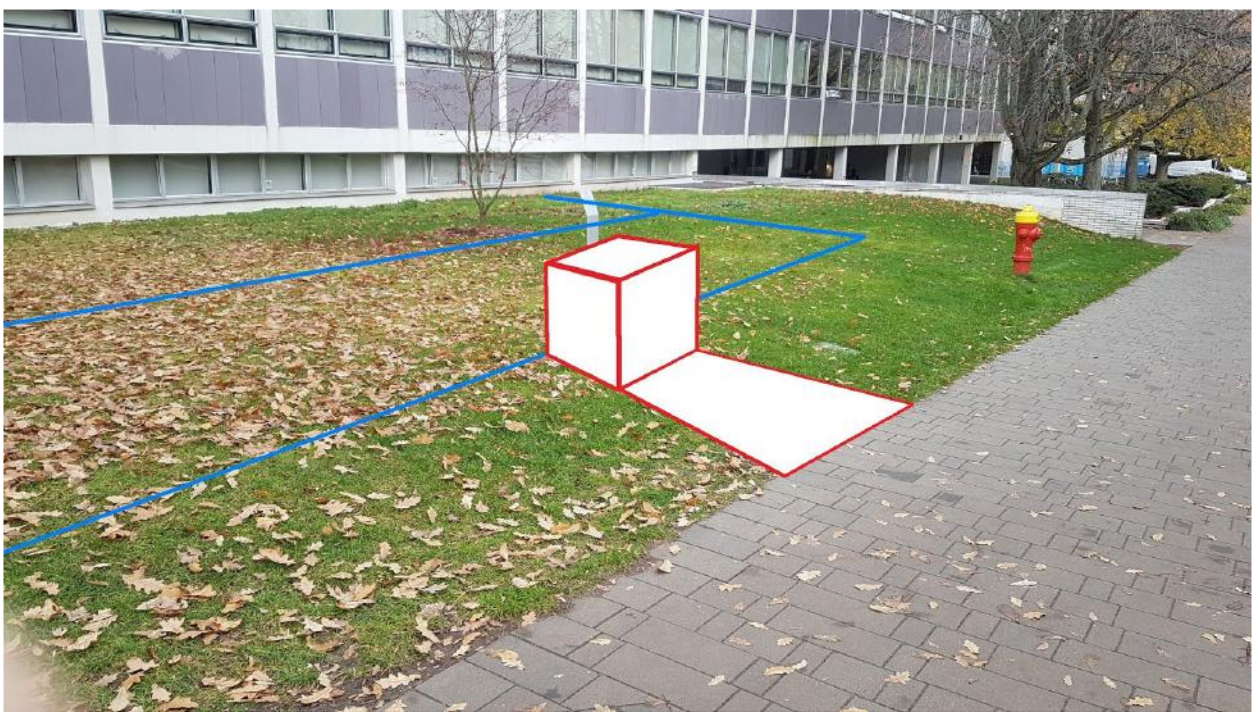


Figure 11. Buchanan location 1.

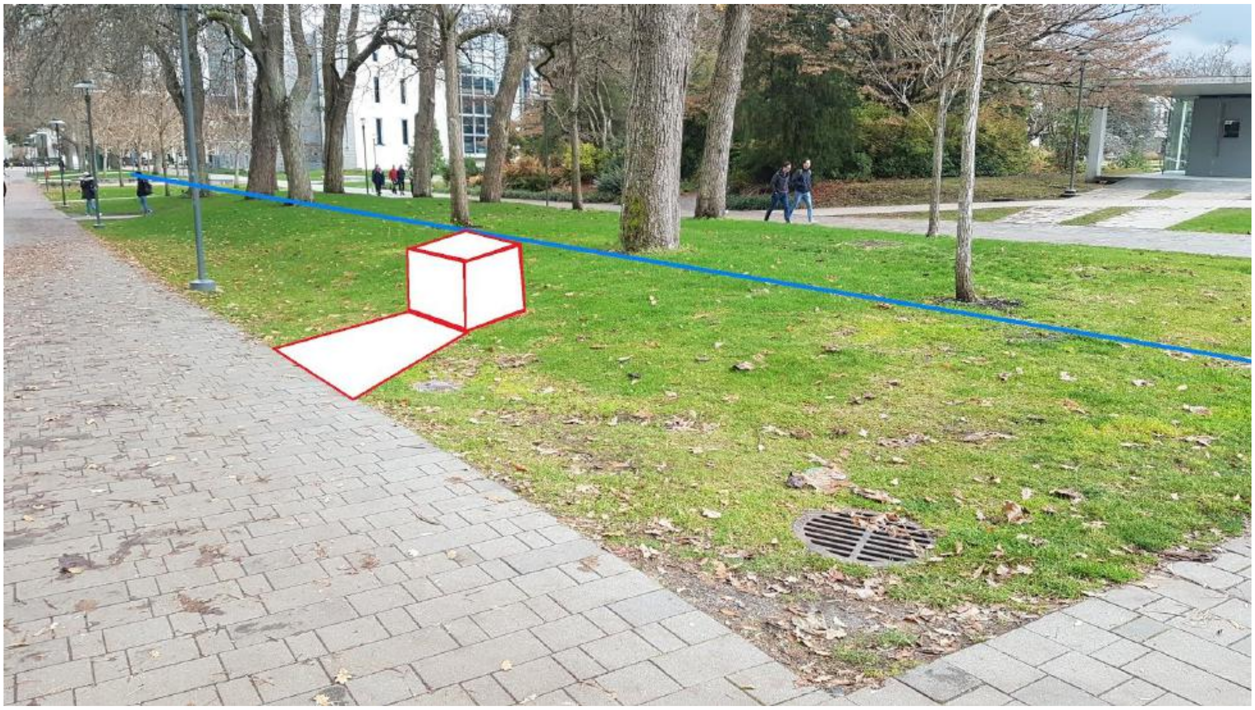


Figure 12. Buchanan location 2.

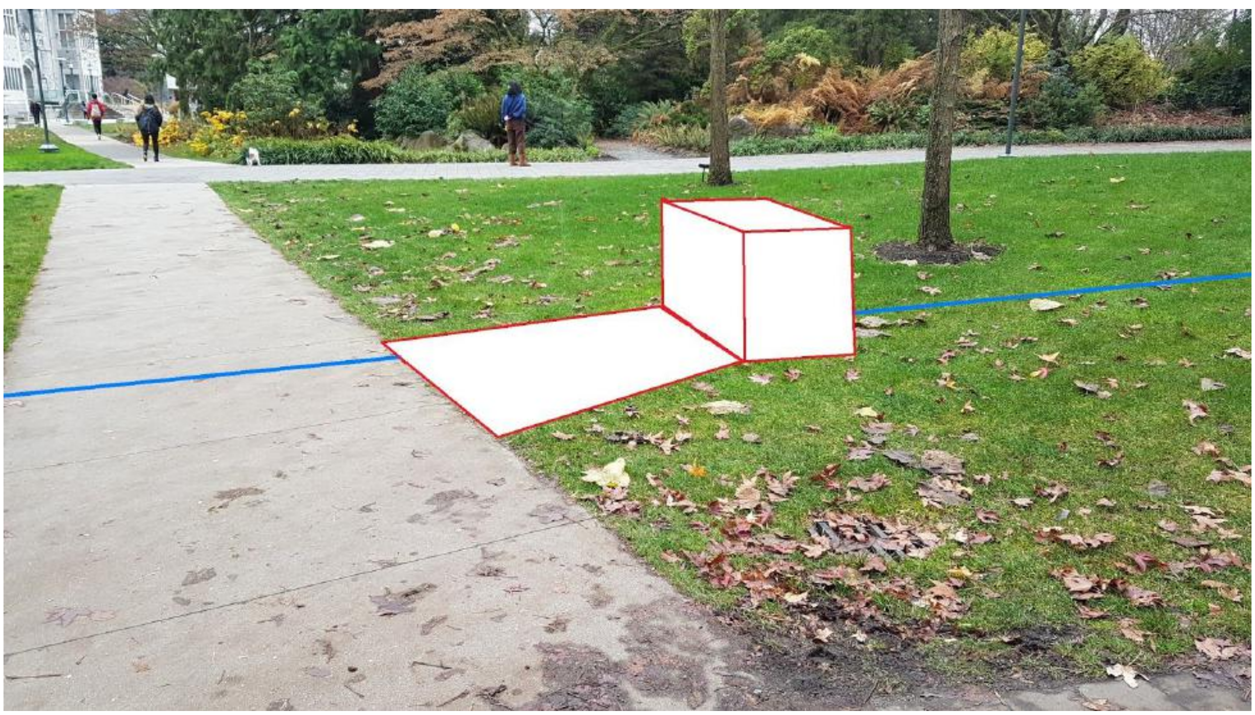


Figure 13. Buchanan location 3.

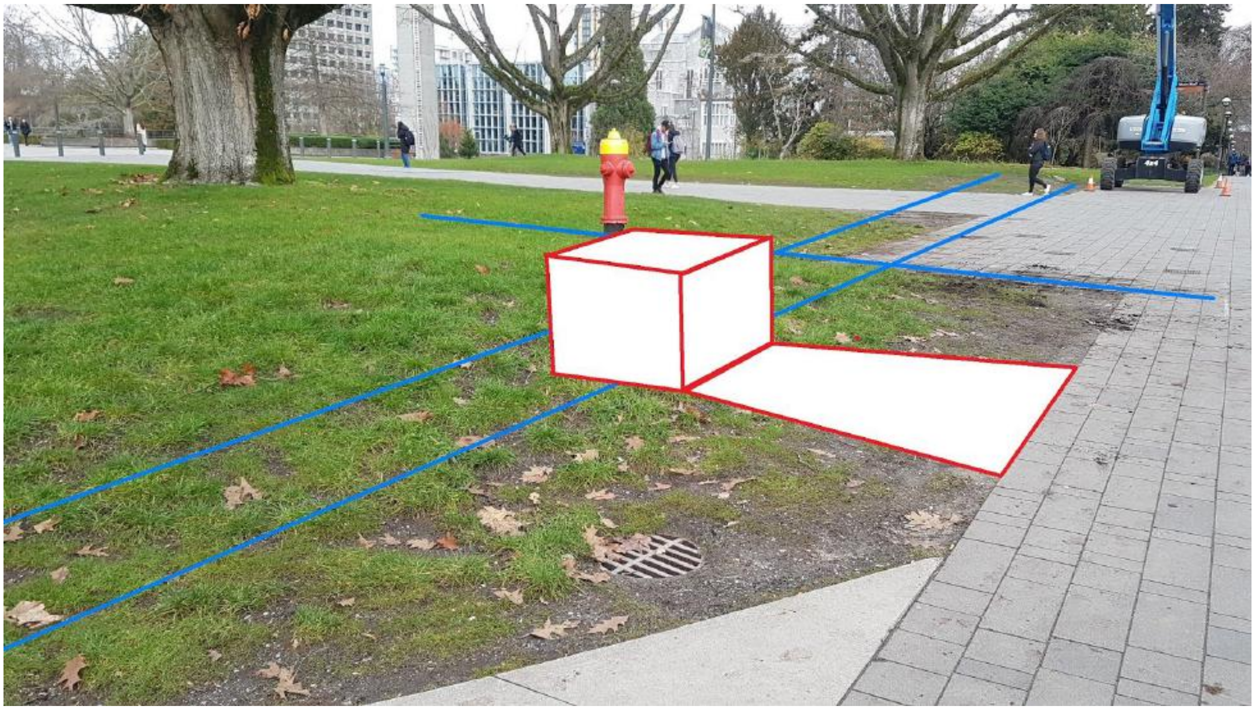


Figure 14. Sauder location 1.

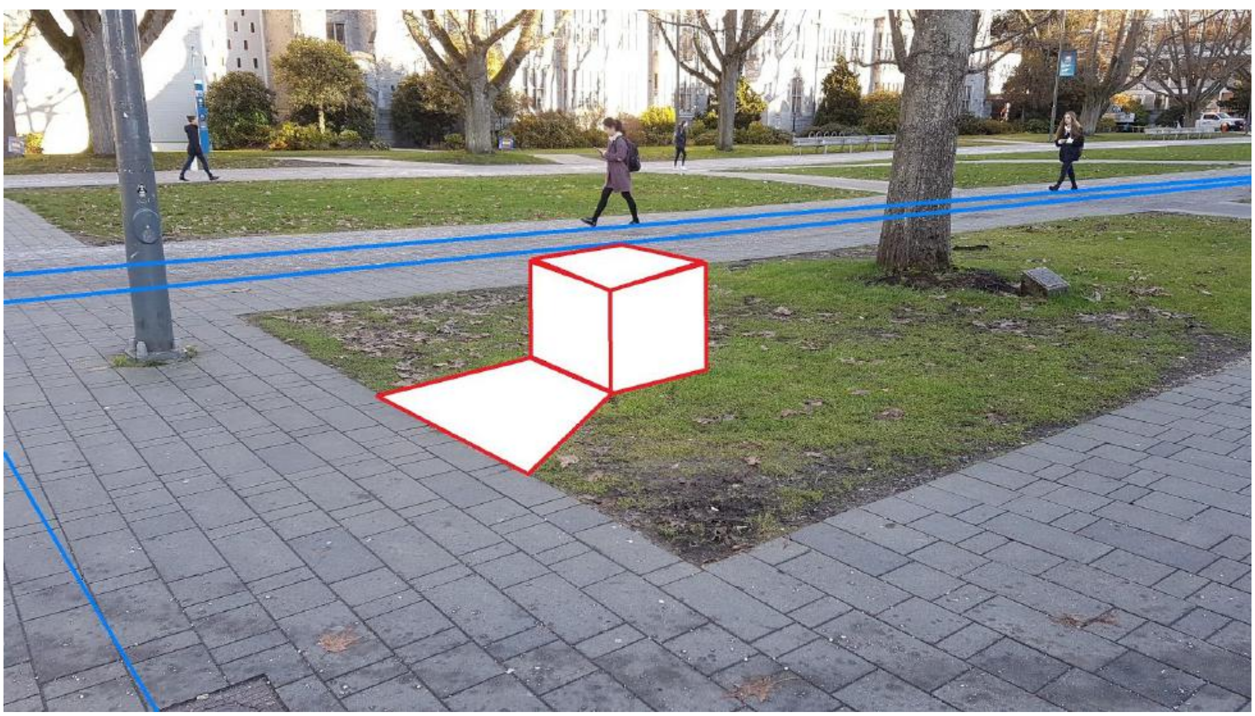


Figure 15. Sauder location 2.

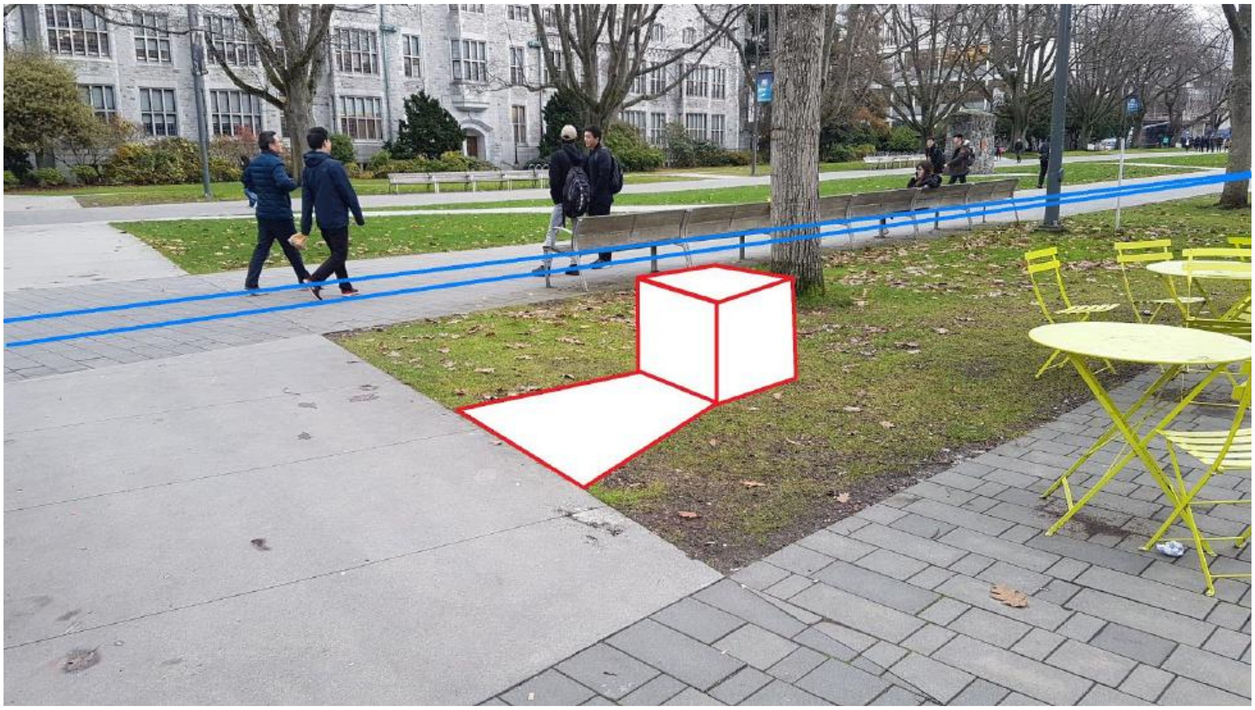


Figure 16. Sauder location 3.

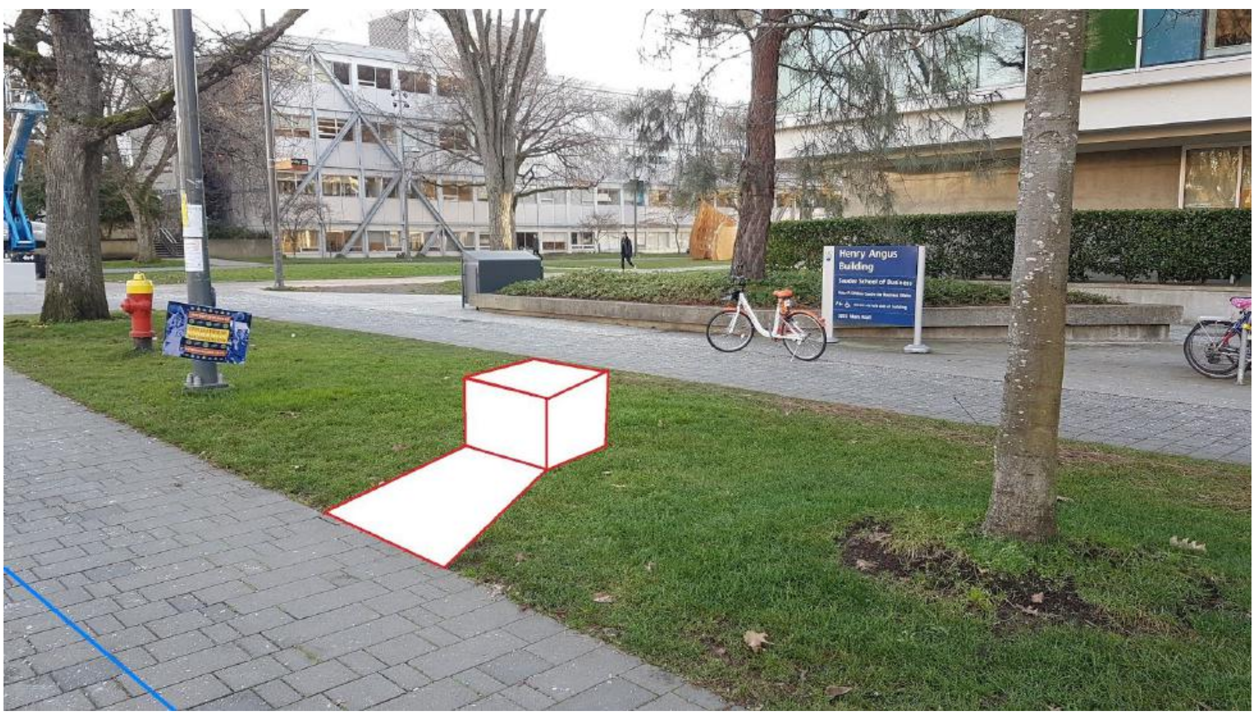


Figure 17. Sauder location 4.

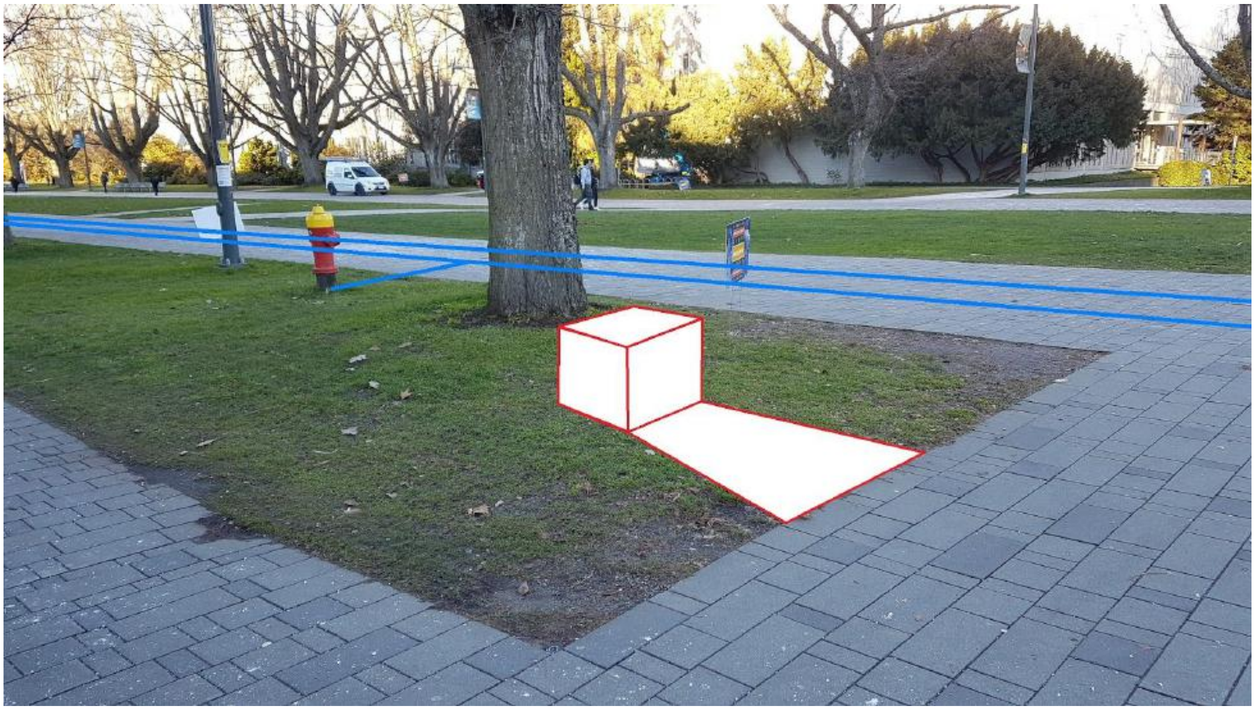


Figure 18. Sauder location 5.

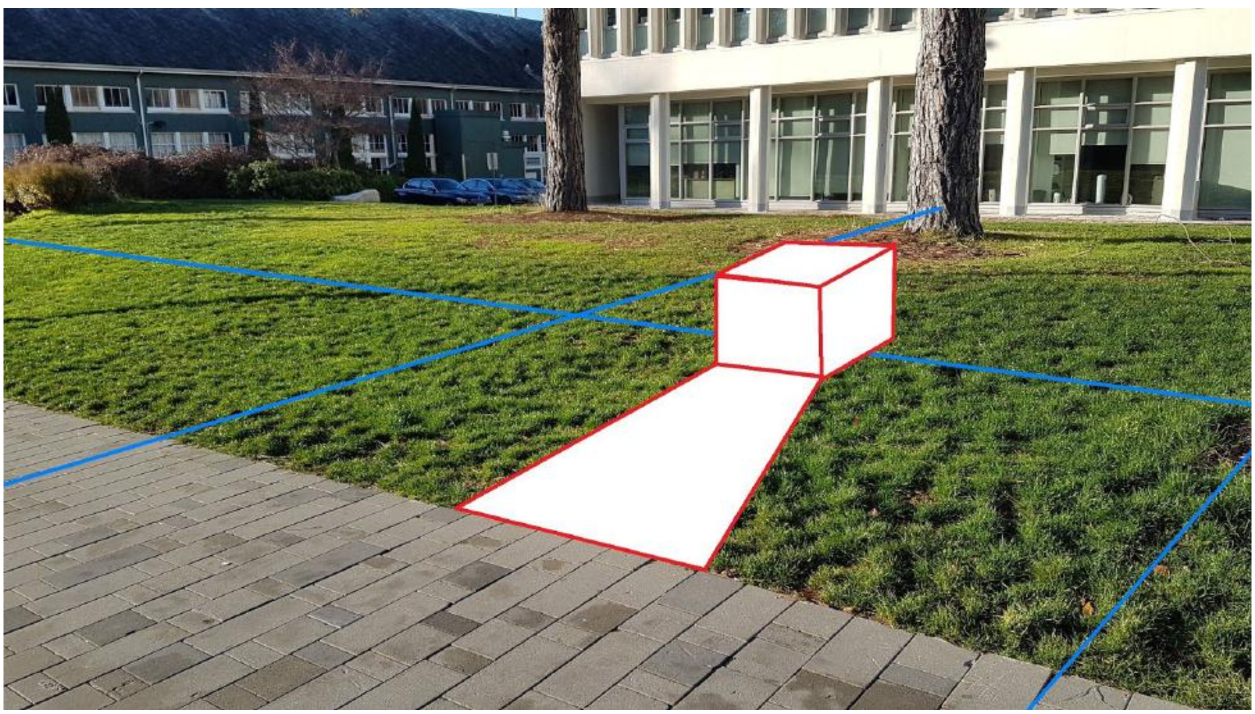


Figure 19. Sauder location 6

Table 1

Why do you prefer to buy bottled water instead of using a refillable bottle/drinking from the water fountain?

Answer	Result
Bottled water tastes better than tap water	1
I forget to bring my water bottle	1
Save weight and space in my bag	1

Table 2

Why do you not drink water on campus?

Answer	Result
Lack of Convenience	4
Taste	2
Concerned about hygiene and safety of tap water on campus	1
I just do not	1

Table 3

What would make you switch to reusable tap water?

Answer	Result
Better access to water fountains on campus by increasing the number of fixtures	1
Better tasting tap water	1

Table 4

GIS Layers

Name	Type	Attributes	Source
Buildings	Polygon	Name, shape, location	UBC Geodata
Water mains	Line	Location	UBC Campus + C Planning
Enrolment statistics	Table	Name, number	Vancouver Academic Calen
Food outlets	Points	Name, location	UBC Food Services
Survey results	Polygon	Name, location	Online survey
Interview results	Polygon	Name, location	In-person interviews
Existing fountains	Points	Name, location	Water Outlet Map 2013

Table 5

Weighting factors

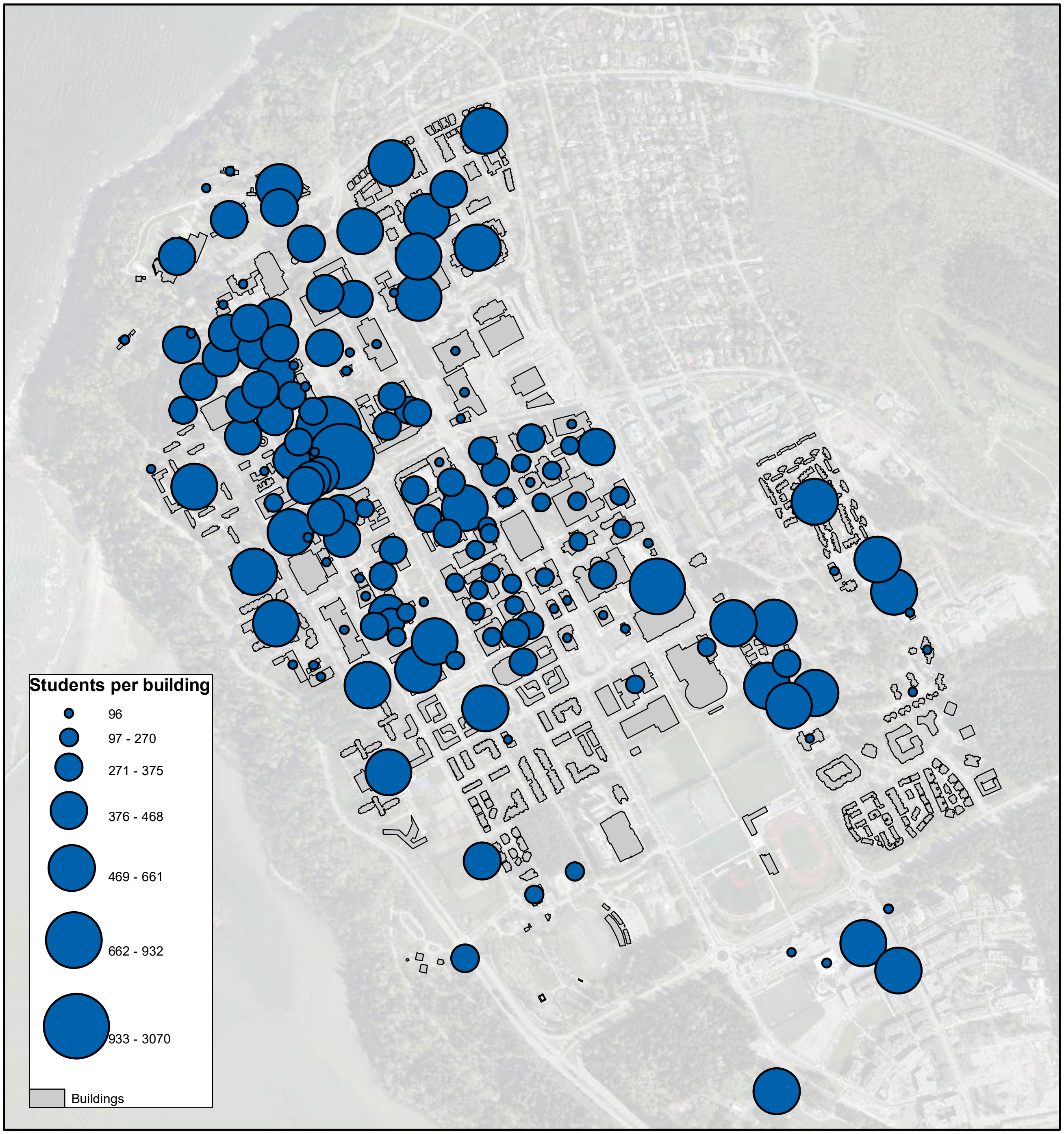
Determinant Factor	Weight Applied
Population hotspot	0.30
Survey results	0.25
Interview results	0.20
Within 50m of a food outlet	0.20
50m away from of existing fountain	0.05

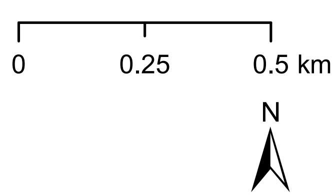
Map 1. UBC campus buildings

Buildings

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 2. UBC population density





Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
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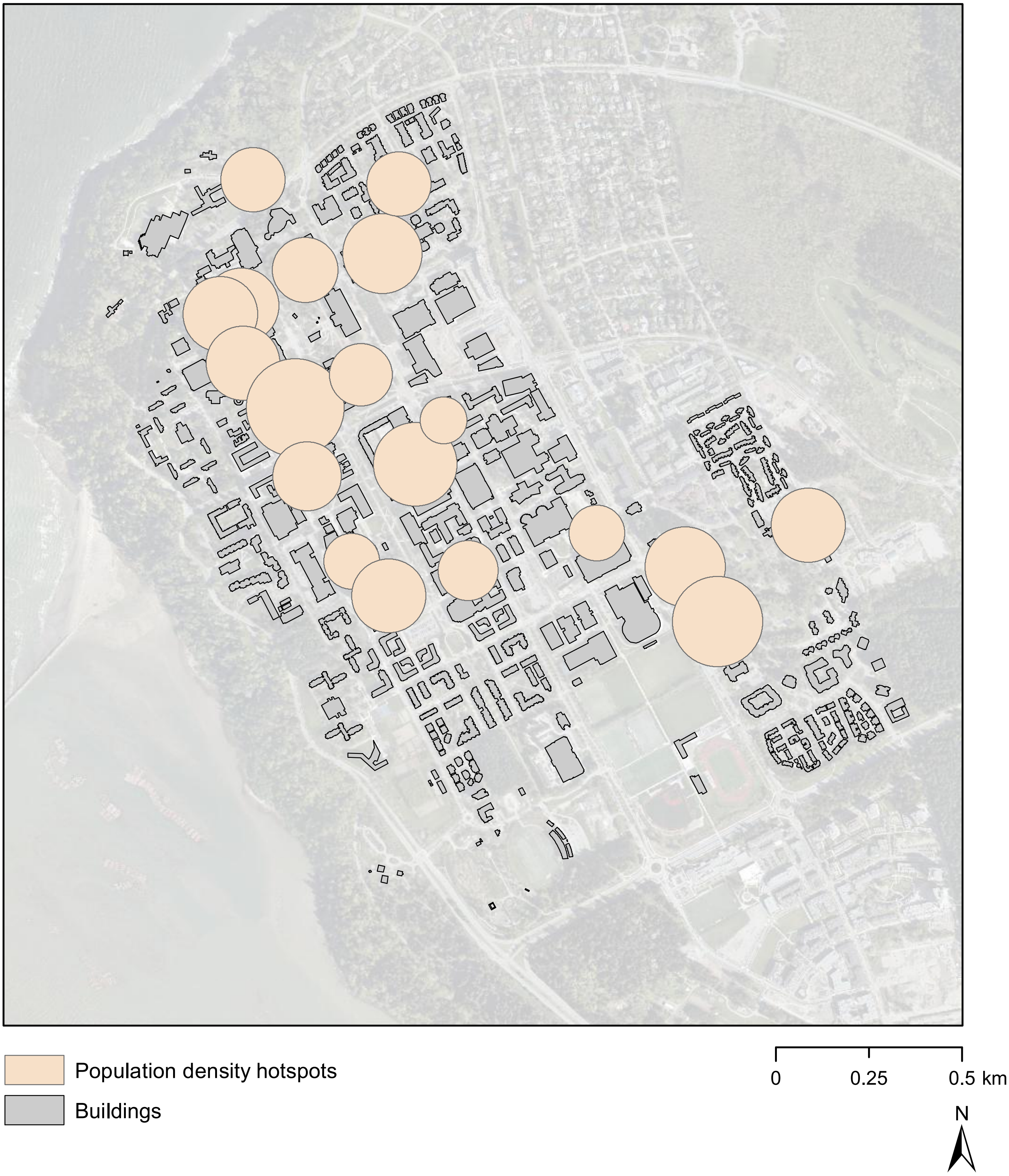
Nov 2018

Map 3. UBC population density hotspots



Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
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Nov 2018

Map 4. UBC main water pipelines

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 5. UBC food outlets

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 6. Preferred location from survey results

Preferred location from survey results

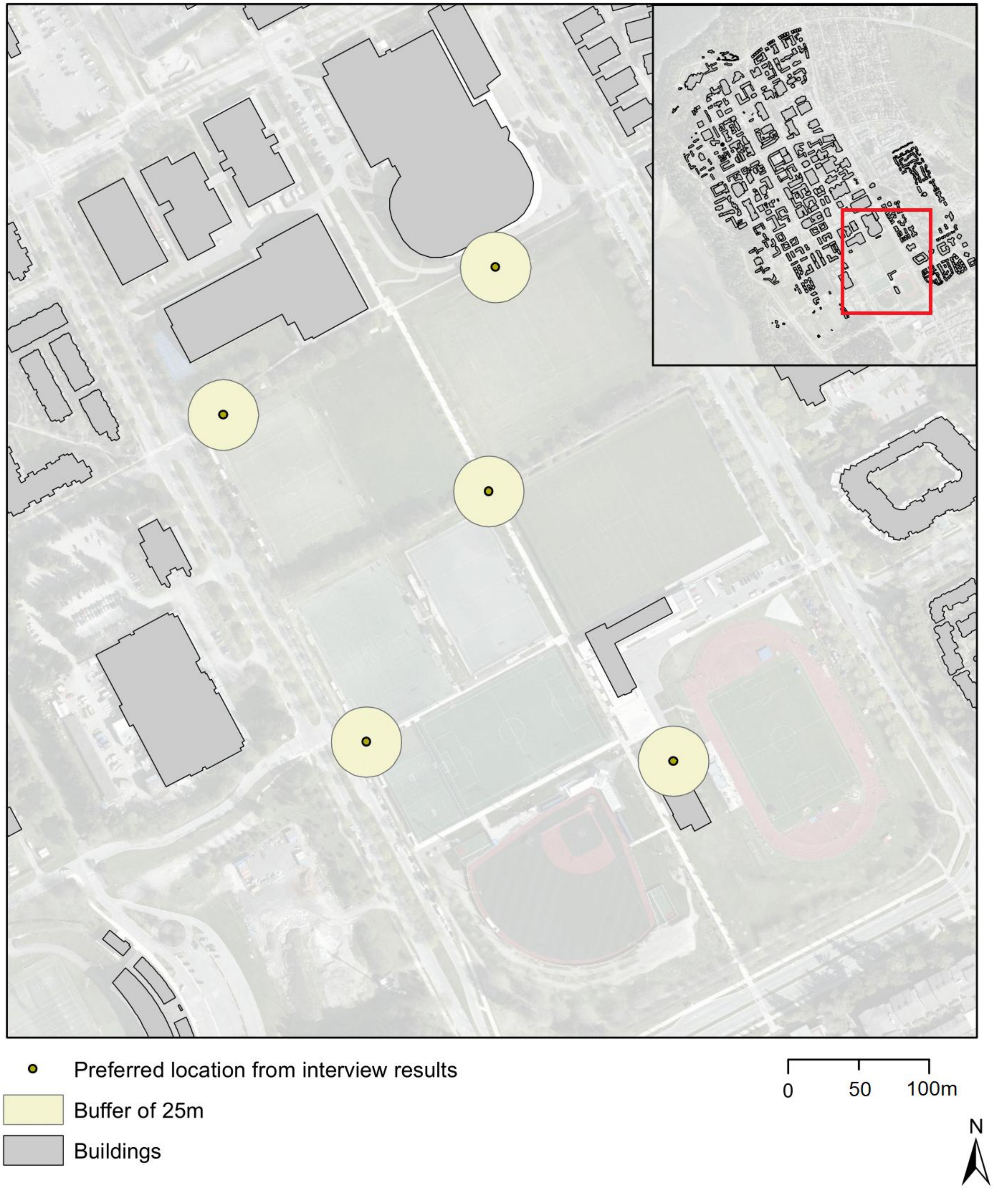
Buildings

0 0.25 0.5 km

N

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 7. Preferred location from interview results



Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 8. UBC existing drinking water fountains

Existing drinking water fountains

Existing drinking water fountains buffer of 25m

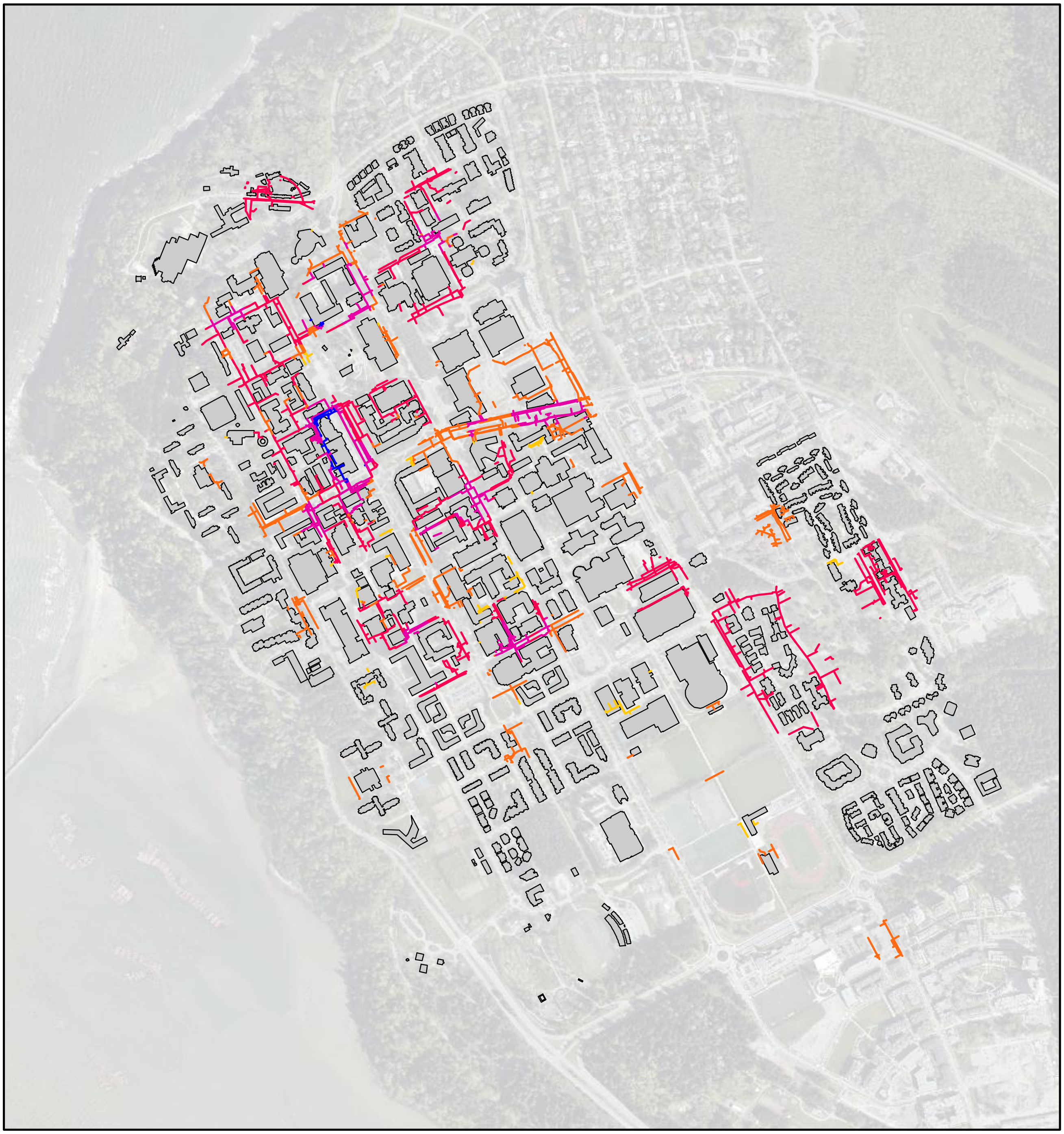
Buildings

0 0.25 0.5 km

N

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 9. Areas for placement of drinking water fountains by score



Score

- 0.000000
- 0.000001 - 0.300000
- 0.300001 - 0.350000
- 0.350001 - 0.600000
- 0.600001 - 0.800000
- Buildings

0 0.25 0.5 km

N

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 10. Top 3 scoring areas for placement of drinking water fountains

Score

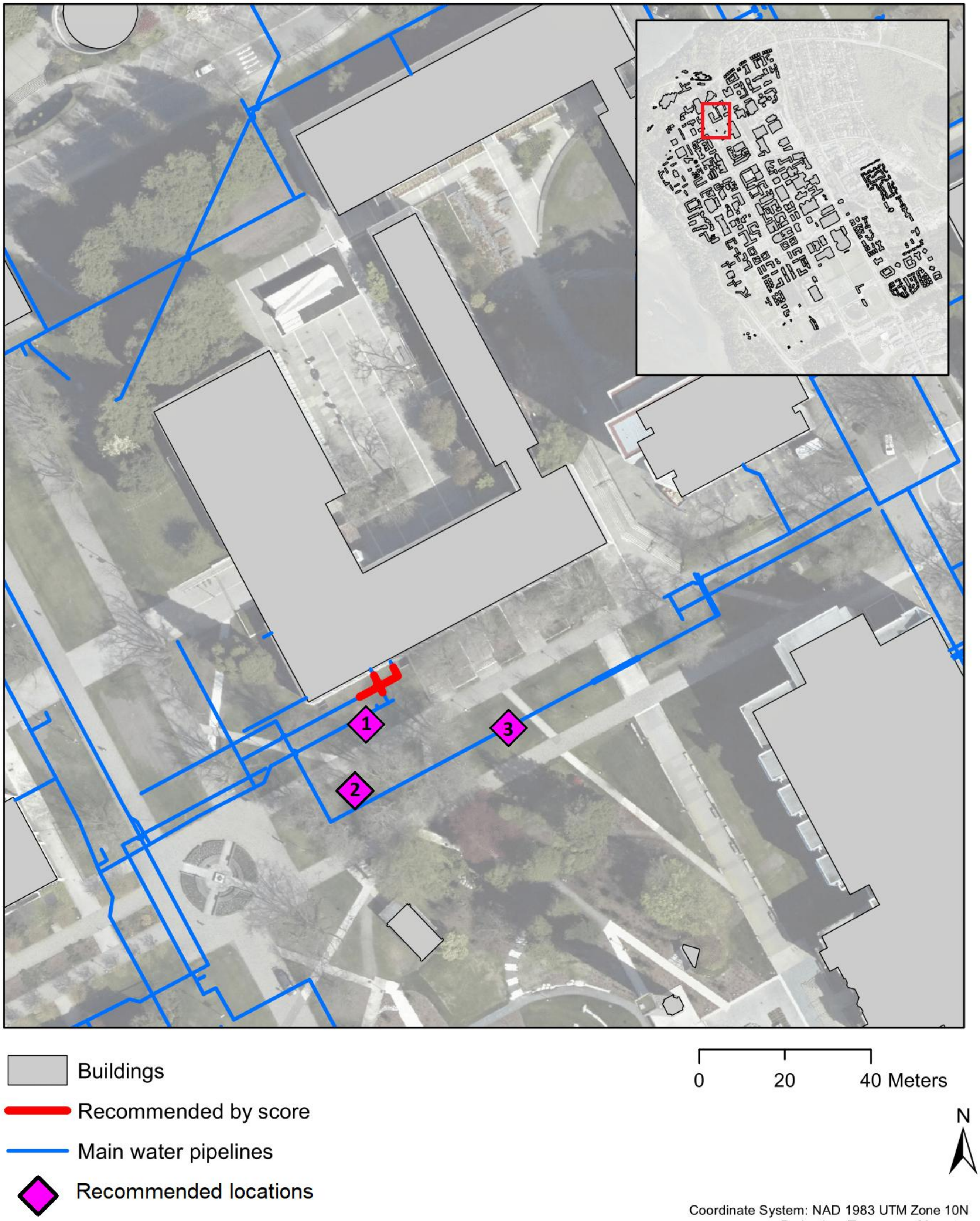
0.00 - 0.55
0.56 - 0.60
0.61 - 0.75
0.75 - 0.80
Buildings

0 0.25 0.5 km

N

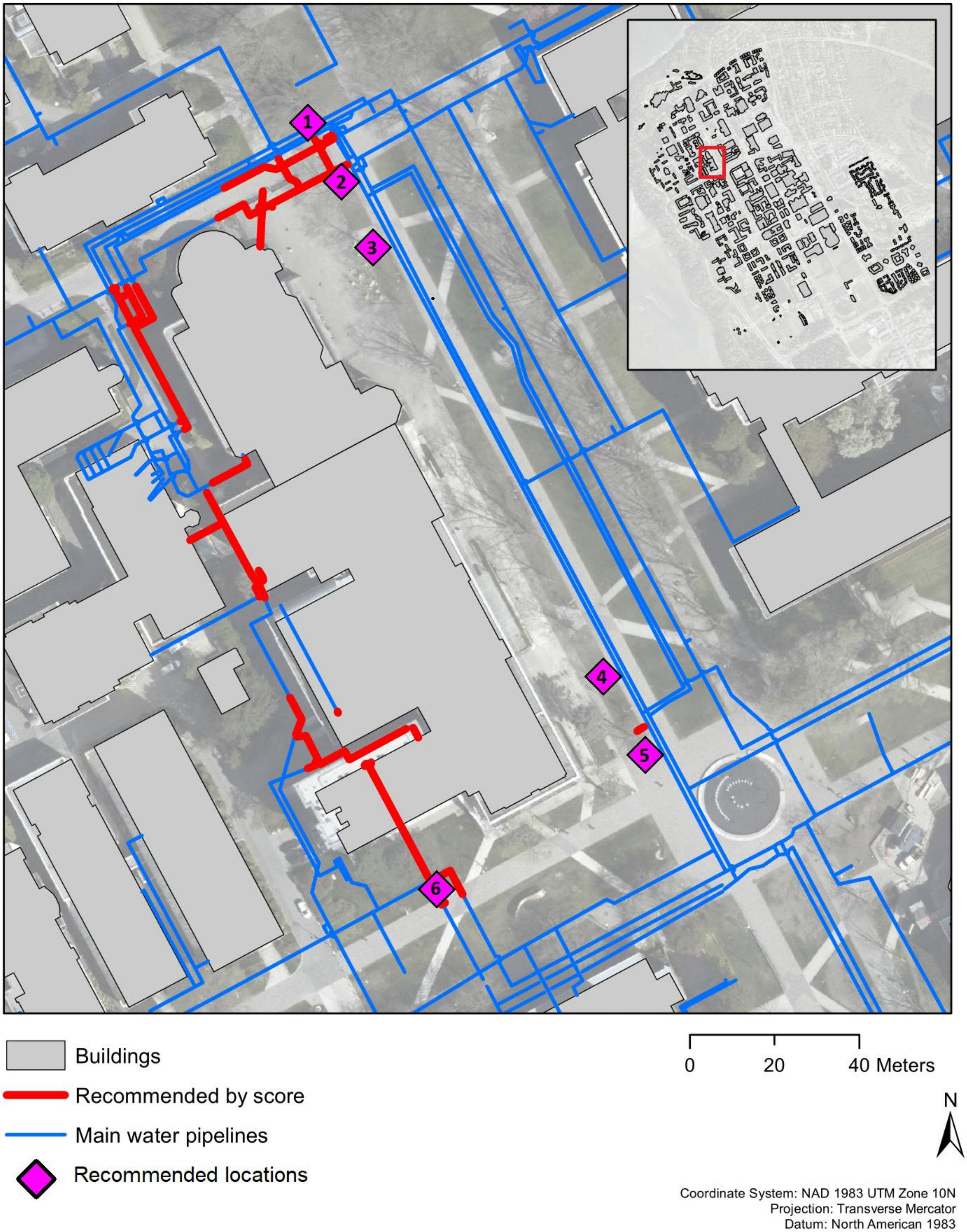
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 11. Recommended locations for drinking water fountain placement around Buchanan



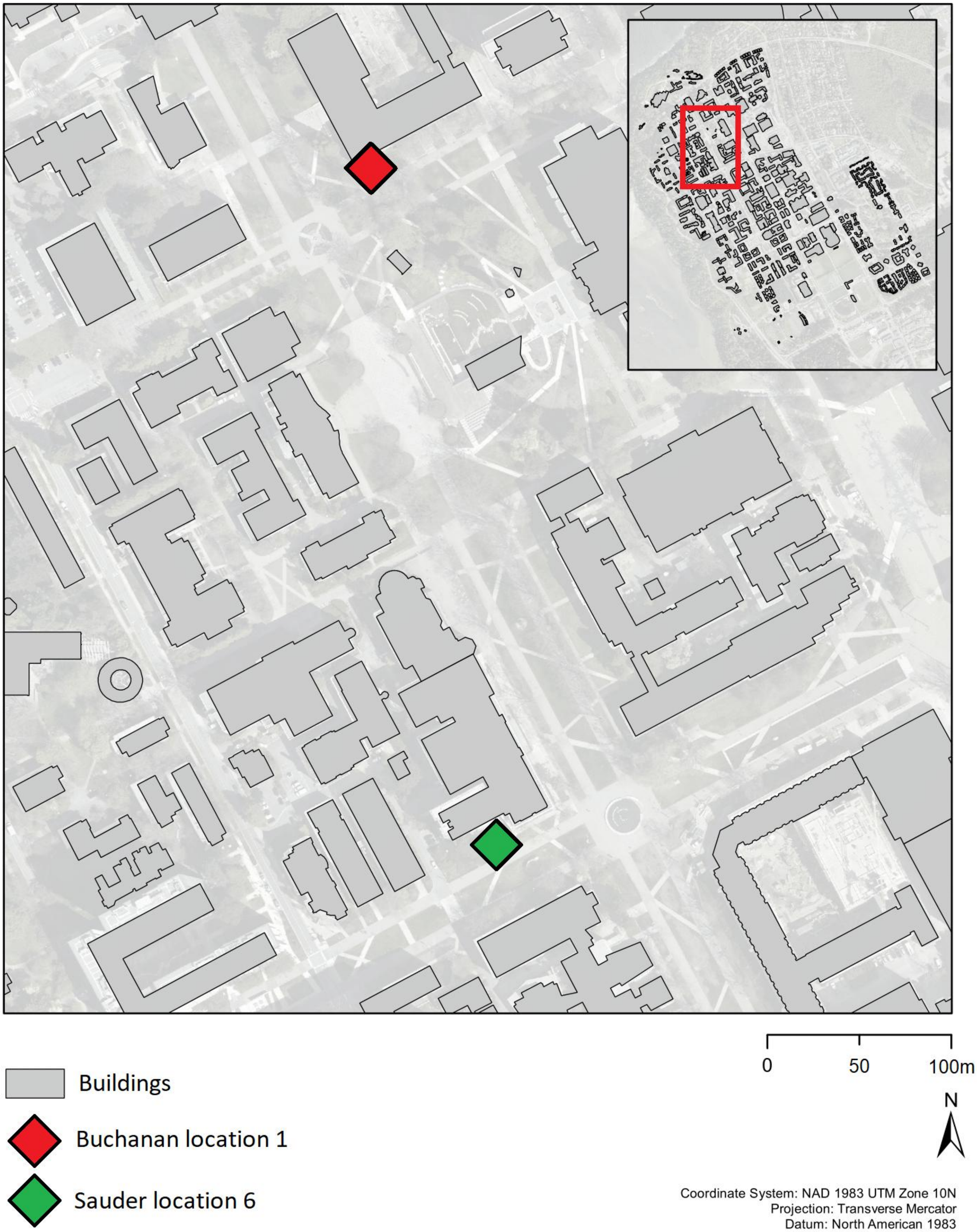
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 12. Recommended locations for drinking water fountain placement around Sauder



Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 13. Recommended locations for drinking water fountain placement at UBC



Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Brian Tan | UBC Geography Department
Nov 2018

Map 14. Obtained from Dan Cooper