The Insider Leak:

Designing and Developing an Application to Locate Publicly-Accessible Restrooms in Washington, DC

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Introduction

Washington, DC – like most American cities – has a dearth of public restrooms. While many American cities boasted public restrooms throughout the nineteenth and early twentieth centuries, a combination of development and politics led to their removal and, consequently, the removal of a vital support to enable equitable access to public life (Kristof, 2021). Many people may not have the resources – time or financial – to purchase something from an establishment in order to use their restroom. However, some places often provide free access to their restrooms: Public libraries, gas stations, grocery stores, and city government-run recreational centers or parks are frequently on that list. In Washington, DC, the Smithsonian Institution museums, which charge no entry fee, are also potential restroom candidates. An individual in need may not know which facilities offer free restroom access, nor where to find them, so they need a location-based service to identify usable toilets. The modern ubiquity of smartphones means that most people in Washington, DC, are walking around with a reasonably accurate GPS in their pocket, supporting the utility of a location-based service. Smartphones typically use assisted GPS for navigation, which is accurate enough for commercial applications; assisted GPS has a median error range of only eight meters (Gao and Mai, 2018). This paper will examine public restroom access in Washington, DC to accompany a proposed location-based cellphone application identifying those restrooms and walking routes throughout Washington, DC that incorporate them.

Related Works

Public restroom access is not only a convenience issue for tourists or citizens, though it is certainly that; it is also a social justice and equality issue. Kitchin and Law (2001) describe the inability of individuals in Ireland with physical disabilities to access public restrooms and the severe limitations that places on the spatial extent of their everyday activities. They note how "landscapes are constructed through particular power geometries and shaped by notions of citizenship and social justice" and that modern emphasis on architectural aesthetics and efficiency have continued to sideline consideration of accessibility, even with growing disability rights movements (Kitchin and Law, 2001). In a separate consideration – though similar in its attention to access, health, and dignity – Banks (2020) describes the removal of public restrooms from American cities throughout the latter half of the twentieth century and the impact that has had on public health and ability to participate in public life for unhoused people and people working in industries without ready access to facilities such as taxi or truck drivers. Other studies have investigated the connection between gender and public restroom access. Access to safe, clean public toilets allows women to be more present in society, which can favorably impact women's ability to engage in business or politics, or even simply be a tourist – which brings its own economic advantages for an urban area (Flanagan, 2014 and Ellisa and Luana, 2021). While this paper and application will focus on users with access to smart devices, which precludes some of the neediest populations, the serious social justice concepts underpinning the need for access to public restrooms – including easy knowledge of where they are located – will inform this paper and the application's development.

Developing the application itself is a complex undertaking requiring a careful balance of functionality and user experience. There are some basic considerations necessary when designing an app: First, the simple consideration of if the application in question is filling a need at all; addressing a particular gap for a specific industry can all but guarantee an app's popularity (Kacandes, 2015). The next decisions concern selecting software development kits (SDKs) and whether to develop on an

operating system-specific, or native, platform or choose a cross-platform option. While native development using a platform-specific application programming interface (API) allows easier access to mobile phone functions such as storage and GPS, cross-platform development options have matured to the point where the benefits of easier development – specifically, not having to utilize multiple APIs in multiple languages to interact with each platform – and broader potential usage outweigh any challenges (Belov, 2012 and Hyunh and Ghimire, 2015). However, not all cross-platform development tools are created equal, and not all work on all platforms, although the vast majority work with Android and iOS (Dhillon and Mahmoud, 2015). Difference in access (e.g., Android's API is open source, whereas iOS is not), frequency of updates, and consistency among phones using the operating system can hamper the success of cross-platform or hybrid development (Joorabchi, Mesbah, and Krutchen, 2013).

An additional consideration is developing a web-based application rather than a mobile platform-based application. While web-based applications can be accessed by a browser on any type of mobile phone, they require internet or data connection to function and are not optimized to display in a mobile phone's smaller screen (Willocx, Vossaert, and Naessens, 2015). Web applications also often require the synthesis of multiple programming and scripting languages to effectively display the user interface and interact with the background processes supporting it, meaning more opportunities for a failure on the page (Swain, et al., 2016). Finally, web applications are not discoverable in any app store; potential users need to know they exist and proactively download or visit the application, placing a greater advertising burden that could hamper an application's success (Hyunh and Ghimire, 2015).

The application examined in this paper is a location-based services (LBS) application; LBS applications create some additional challenges when considering the user experience (UX) design. For the purposes of this paper, an LBS application is one in which the app provides information or services to a user on a mobile device based on their geographic location; it can pinpoint the correct location using either the mobile network and cell ID or the GPS function in the device (Omnisci, n.d.) The limited screen size and bandwidth hamper potential design processes for mobile applications, but an iterative process of focus groups, detailed fictional user scenarios, prototypes, and expert evaluation can reveal the key functionalities needed for the app and how best to display them so the user can maximize the geographic information retained (Loeffler, et al., 2021, Yew, et al., 2020, and Mayordomo-Martínez, et al., 2019). Opening the application on a large scale and in a "tracking" mode, i.e., where the map projection follows the user rather than remaining oriented on cardinal directions, may buck traditional cartographic trends but improves UX (Loeffler, et al., 2021). Creating a relational database from which a feature's attributes can be queried ensures the data is not only thorough for each feature (as it will list all the intended attributes), but also consistent across the features – leading ultimately to a better app (Mayordomo-Martínez, et al., 2019 and Dickson, 2020). One additional design hurdle faced by LBS app designers is the balance of allowing a user to navigate or orient themselves within the app while still being able to translate that location to the real world around them (Yew, et al., 2020). I ultimately intend to develop the application on a holistic platform such as ArcGIS App Studio, which supports the cross-platform development of LBS applications using the Esri technological backbone (Esri, 2021).

Beyond the development of the actual app, I will eventually enlist strategies to attract and retain users – and ensure a viable return on investment for the effort put into building the app. Advertising on websites for similar industries can attract new users, as can reviews by notable mobile app development publications (Kacandes, 2015). Maintaining user engagement is perhaps the most vital part of a successful app, and successful strategies to achieve that include high levels of user feedback

and frequent updates or additions (Kacandes, 2015 and Lee and Raghu, 2014). I intend to solicit constant user feedback via an interactive Edit function so that users can adjust data to guarantee accuracy.

Turning specifically to developing restroom-locating applications, there are several attributes that the American Restroom Association (ARA) suggests are vital to a useful application:

- "Highlight or add emphasis to those facilities available year-round, 7 days a week and at least between 8:00 am and 9:00 pm, including holidays.
- Where portable sanitation units (porta-johns) are listed, note if they are known to be routinely cleaned and serviced
- Highlight true municipal public restrooms units and restrooms in buildings clearly open to the public such as train stations
- Avoid listing small privately owned mercantile establishments (ex. coffee shop), unless they advertise availability
- List restrooms in urban parks that meet the availability requirement listed in the first bullet
- Note possible security restrictions (ex photo ID required) that might impact access to government municipal building restrooms.
- Note if the facility is a single toilet restroom that may be current occupant locked" (2021).

These criteria can guide developers in designing the relational database used as the basis for a LBS application. Multiple applications, mobile phone- and web-based, currently exist that achieve these criteria to varying degrees of success, in addition to other LBS application UX standards.

I discovered five total restroom-locating applications on the Google Play Store, of which only one was also available on the iOS app store. Two additional applications no longer exist, although as of 2019 both were available (Bidasaria, 2019). Flush (fig. 1) is available on both app stores and claims a constantly updated database of 150,000 restrooms worldwide (Ruston, 2021). It contains information for each toilet about accessibility and conditions for entry (specifically, whether a key or code is necessary and if it costs money); users can also update the data for each of those categories. Additional features including linkage to Google Maps for navigation to a selected toilet using the phone's location, the ability to be used offline without navigation, the ability to filter for free or accessible toilets, and a toggle between metric and imperial units (Ruston, 2021). However, the use of black icons against a primarily gray basemap make the toilet locations sometimes difficult to discern. Flush does not meet all of the ARA's criteria for a restroom locator because it does not list a facility's hours, it does include private establishments, and it does not immediately differentiate between different locations such as parks, municipal buildings, or sites with portable restrooms.

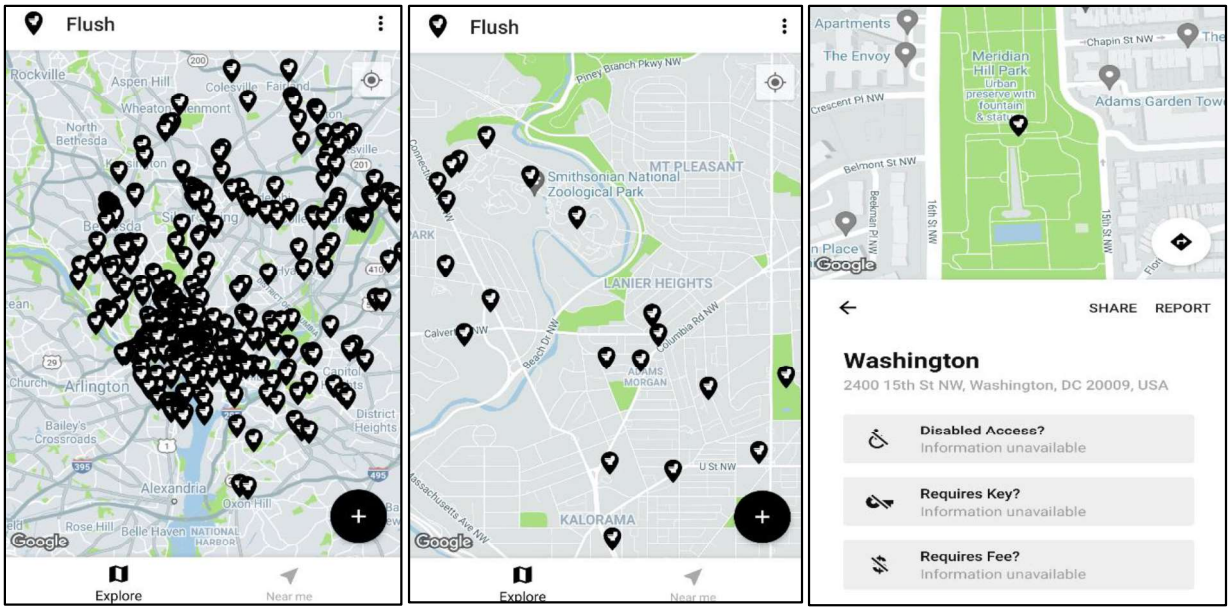


Fig. 1: Flush app screenshots, showing from left-right the greater Washington, D.C. region; one section of Washington, D.C.; and one selected restroom (Ruston, 2021).

Where is Public Toilet (fig. 2) is only available on the Google Play Store, but it contains significantly more detailed information about each toilet and provides more filtering options (sfcapital, 2021). It also connects to Google Maps for navigation and continent-level datasets are available for download to enable offline usage. The display has better color contrast than Flush, but the additional information – while useful – makes the display at times (sfcapital, 2021). Where is Public Toilet also does not achieve all of the ARA's criteria, because it almost exclusively features restrooms in private business, missing several known restrooms in public parks or facilities, but it does feature more detailed information about accessibility and conditions for entry.

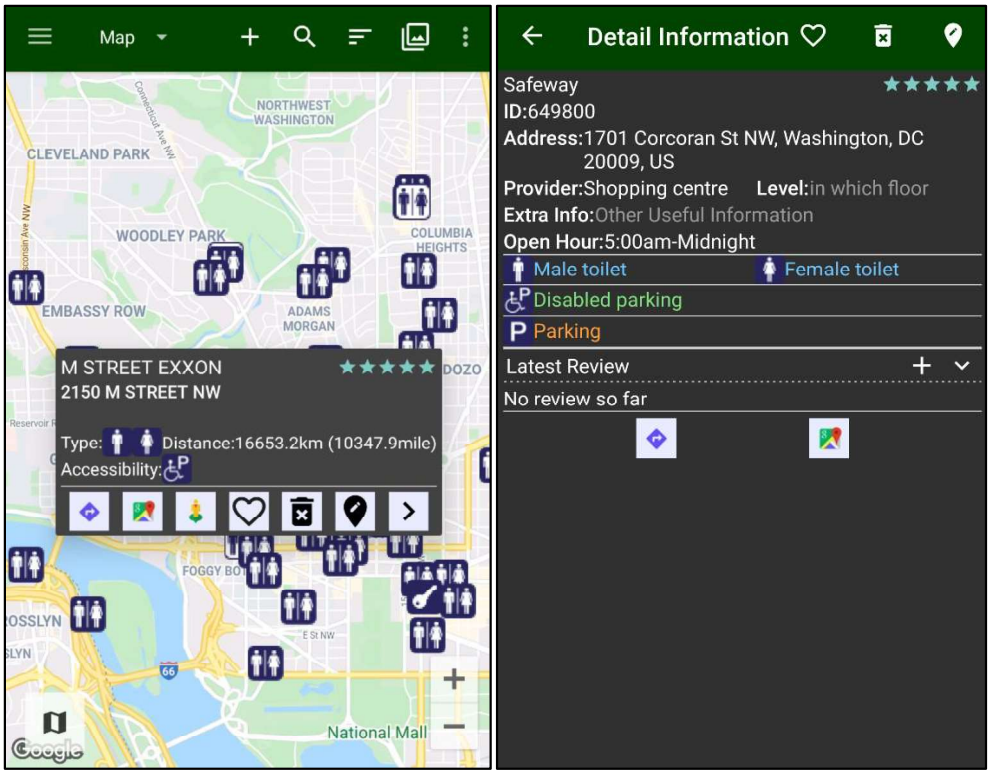


Fig. 2: Where is Public Toilet app screenshots showing from left-right the popup for choosing a toilet and the detailed information (sfcapital, 2021).

Several national or local web-based applications also exist for locating restrooms. The Australian National Public Toilet Map (fig. 3), sponsored by the Australian Department of Health, provides an exemplary restroom locator (Aus Dept. of Health, 2021). It includes restrooms in both public and private facilities and highlights many different accessibility and entry attributes for each one. Users can also save restrooms to a favorites list and view a location in Google Street View to better orient themselves (Aus Dept. of Health, 2021). However, it does not include navigation. The UK's Great British Toilet Map (fig. 4), created by British academics and software developers, features an excellent user interface and extremely comprehensive filters for accessibility and entry conditions (Public Convenience, 2021). It also provides navigation by redirecting to Google Maps if a user selects the Directions button and has easy filters to find public restrooms that have certain necessary characteristics. Both web applications fulfill the ARA's restroom locator criteria; however, because both are web-based, users may have difficulty accessing them without reliable internet.

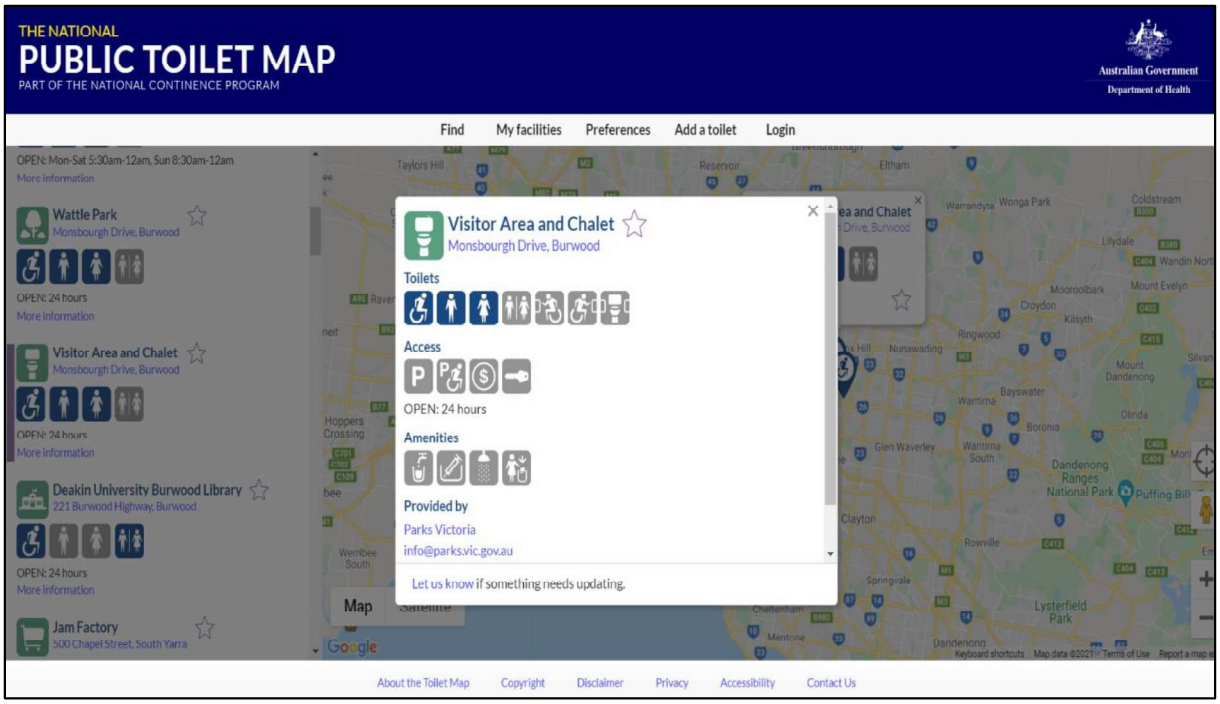


Fig. 3: The Australian National Public Toilet Map, sponsored by the Australian Department of Health; the screenshot displays details for a specific public restroom (Aus Dept. of Health, 2021).

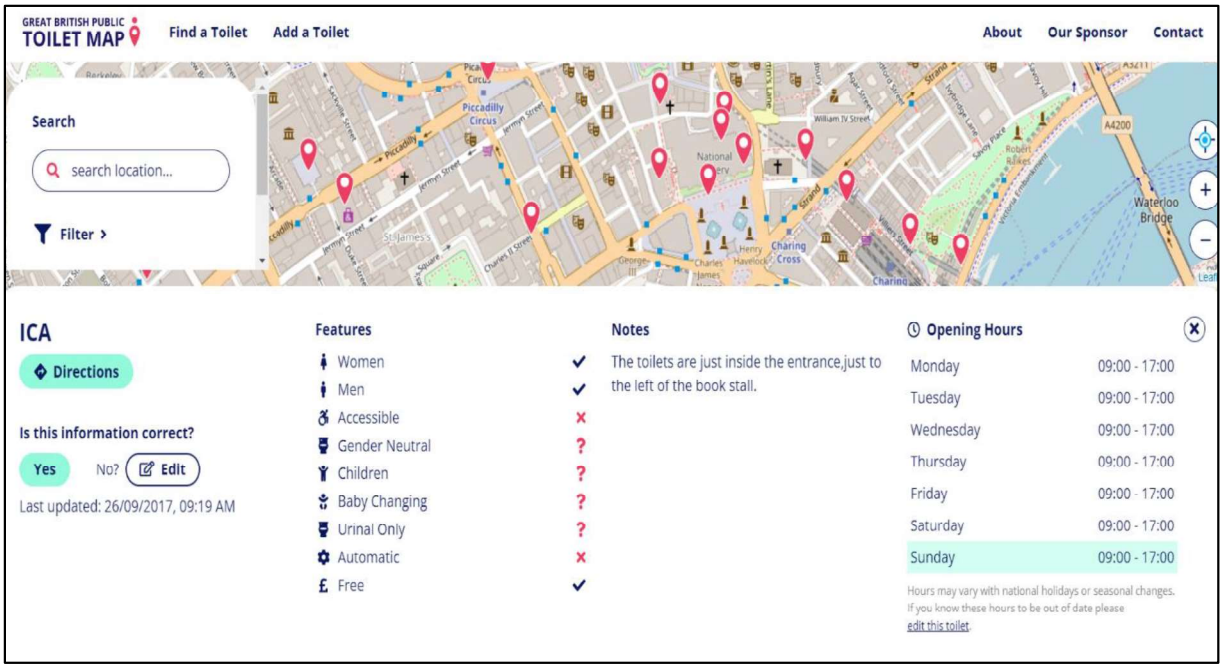


Fig 4.: The Great British Public Toilet Map contains the most detailed information on accessibility and conditions for entry, including directions with a building to the restroom (Public Convenience, 2021).

Washington, D.C has extremely limited public restrooms access, and even more limited public knowledge about their locations. As of 2018, only two public restrooms – at the Lincoln and Jefferson Memorials – were open 24/7, and both of those are isolated on the National Mall (Bernbaum, 2018). In 2017, only 11 out of 85 private businesses visited by the People for Fairness Coalition allowed non-

paying customers to use their restroom; that number probably fell further as the COVID-19 pandemic shuttered businesses and even public libraries, a frequent option for restroom usage (Bernbaum, 2018 and Anderson, 2020).

Options to locate the limited public restrooms in Washington, D.C. are similarly scant. The DC Department of Human Services lists public restrooms in Downtown Washington, D.C., including their addresses and opening hours, but does not include any information about accessibility or navigation (Department of Human Services, n.d.). An interactive web-based map in 2017 highlighted the closest public restroom to every Metro Station, but it is no longer supported (Prince of Petworth, 2017). The most comprehensive option for locating public restrooms in Washington, D.C. is Google Maps (fig. 5). While Google Maps does include navigation and a well-known user interface, it does not show all of the available restrooms in the city, nor does it provide accessibility information (Google Maps, 2021).

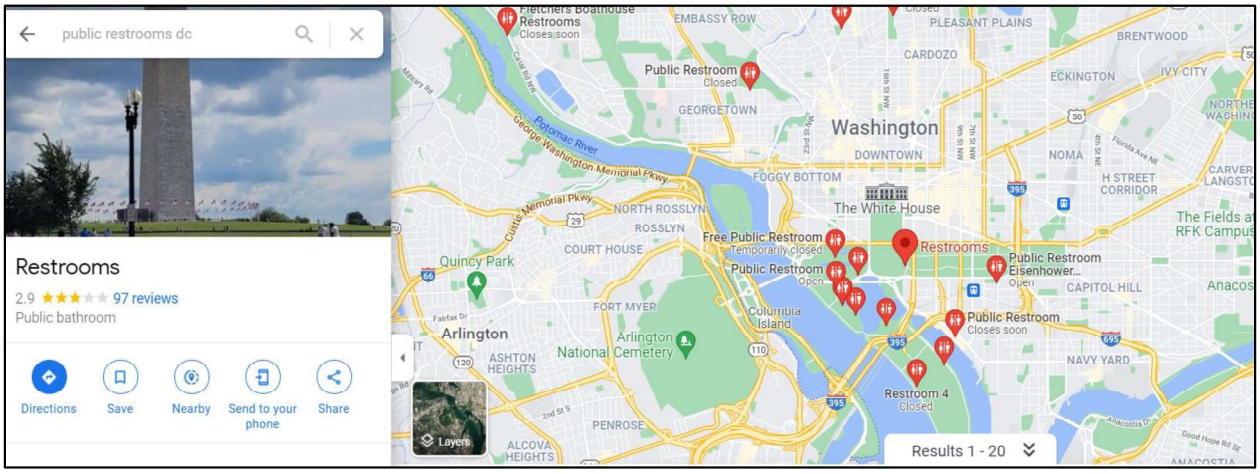


Fig. 5: Google Maps screenshot for Washington, D.C. showing the limited number of restrooms captures; Google Maps also includes limited additional attributes for each restroom (Google Maps, 2021).

In April 2019, the DC City Council approved new legislation to update public restroom facilities for the city (Shokraei and Vitka, 2021). Two locations were chosen in public parks, though construction had not been completed as of March 2021 (Department of General Services, 2021). At the beginning of the COVID-19 pandemic, the Department of Human Services also placed nine temporary restrooms in areas of the city known for high rates of people experiences homelessness; it is unknown whether those will be made permanent (Department of General Services, 2021). Adding public restrooms in Washington, DC, especially in business districts away from the National Mall, is an admirable goal to promote health, equity, and even tourism. Creating a cross-platform application allowing users to locate those public restrooms is an additional step that would allow Washington, D.C. to better capitalize on the success.

Methodology

Data Gathering

The first step towards building this restroom-locating application is to create a geodatabase and populate it, using both existing datasets and newly collected data. A relational database – the foundational method for storing geospatial information for later use in complex applications – consists of multiple tables, each highlighting different attributes, all linked by keys (Bolstad, 2019). Figure 6

shows a notional Entity-Relationship diagram for this application, which is a method of sketching out the different parts of a relational database.

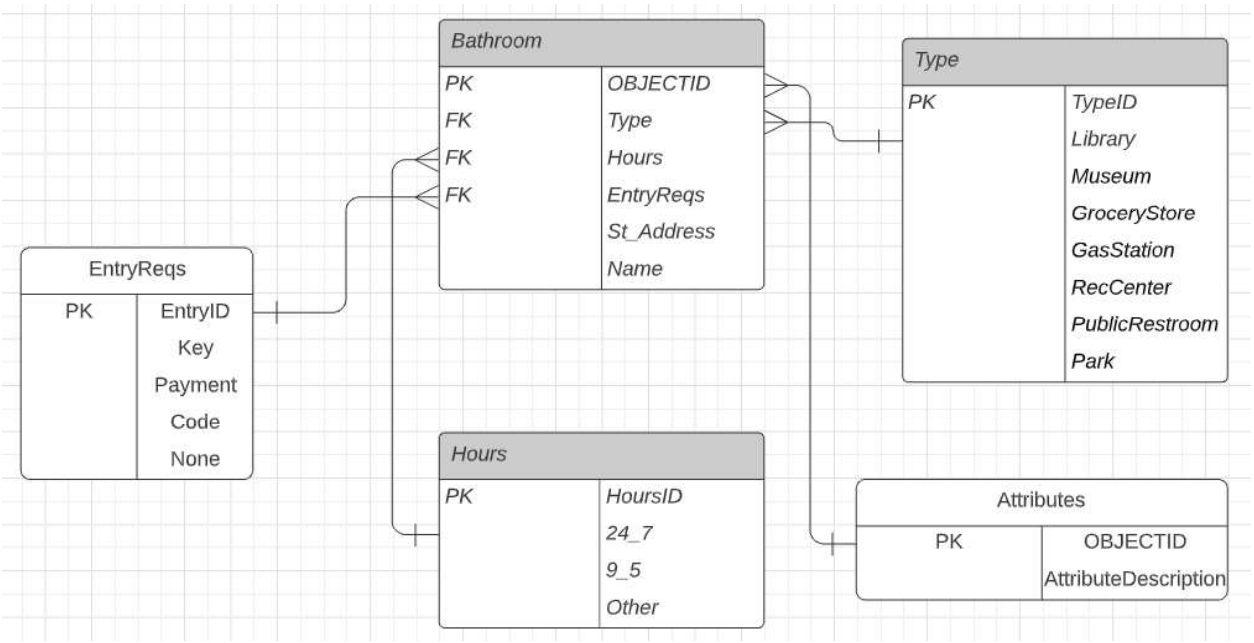


Fig. 6: Notional Entity-Relationship diagram identifying each first each restroom, then certain characteristics that might describe it.

Once I have created the basic structure of the geodatabase and decided the attributes to highlight, the next step is to identify data to populate it. The first existing dataset I will use is GoogleMaps, which includes 10 public restrooms throughout Washington, D.C., primarily located along the National Mall or in city-owned parks (GoogleMaps, n.d.). Another important dataset is one locating all of Washington, D.C.'s public libraries, of which there are 26 (DC Public Library, n.d.). While some public libraries may require a person to possess a library card to use the restroom, library cards are free to acquire and thus the restroom remains accessible. The National Parks Service also notes the locations of restrooms throughout Rock Creek Park, an important outdoor recreation location in Washington, D.C. (NPS, n.d.). The final existing dataset I will use is one compiled by the DC Department of Public Works identify several different types of publicly accessible restrooms, both temporary and permanent, as well as the suggested locations for restrooms pursuant to the DC City Council's 2019 ordinance requiring new ones (DCist, 2021).

Project Management and Requirements Creation

Project management ideology shapes the entire process of designing an application, and I will use Agile Software Development methodology. Agile methodology is one in which the designer is in constant communication with the client, iterating through multiple rounds of development and refinement (Beck, et al., 2001). Agile development embraces constantly changing requirements and eliminates all but the most necessary steps (Beck, et al., 2001). While this application fulfills several of the criteria known to derail agile development – a novice team and a self-initiated product – I believe using an agile methodology will enable faster development of a better app (Krutchen, 2011).

I will also consider the context in which I use Agile methodology. Factors to consider include the size of the organization building the product; project governance within the organization; team size and geographic distribution working on the product; stability and level of innovation of the product and its infrastructure; rate of change of the product; and sensitivity of the product (Krutchen, 2011). As a solo developer using established systems to create a valuable, but non-sensitive, product, this project is not an ideal case for Agile methodology, but it will be a more efficient project management process than a traditional waterfall process. The volume of front-loaded work in traditional waterfall project management – including creating strict timelines, work delineation, and expectations for the final product – would significantly delay when I could start prototyping my application, and time is a major concern for a short-term project such as this one.

Using Agile principles, I will develop the application in a series of sprints. At the end of each sprint, I will coordinate with the client to refine requirements and adjust the product as needed. The first sprint will detail the basic requirements for the application; in the second, I will prototype the application. Any remaining sprints in the Agile development will be spent on building, editing, and adding to the application.

Creating detailed requirements and prototypes are two vital parts of designing an LBS application. I will use a process known as scenarios-based design to navigate how potential users would interact with the application. User scenarios, based on detailed research of expected potential users, allow designers to understand why someone is using the application through investigation of how they use it, which can provide invaluable insight into necessary functions and UX requirements (Ghazaryan, 2015). The scenarios are relatively brief descriptions of the application's potential use, but they aid in avoiding a solutions-based approach that may be simple, quick, and gratifying to the designer, but does not actually facilitate users' full enjoyment of the product (Rosson and Carroll, 2002). While I will likely be unable to conduct a multi-hundred participant survey to research user scenarios, I will create a survey for use by several dozen individuals located in the Washington, D.C. metropolitan region as the basis for my scenarios. I will create at least three separate scenarios to detail different levels of technological acumen, use cases, and necessary functionalities. Figure 7 demonstrates some of the questions I could include on my user scenario survey, though it is not exhaustive.

1. *Do you often need to use a restroom when out casually?*
2. *Are you usually able to find one quickly?*
3. *Are you usually able to find a free restroom, or do you usually have to visit a store or restaurant?*
4. *Do you believe that major cities should provide free public restrooms?*
5. *Do you usually carry a smartphone when out casually?*
6. *How comfortable are you using navigation apps such as Google Maps?*
7. *How likely would you be to regularly use an app that could locate free public restrooms?*
8. *What features would you consider necessary for such an app?*

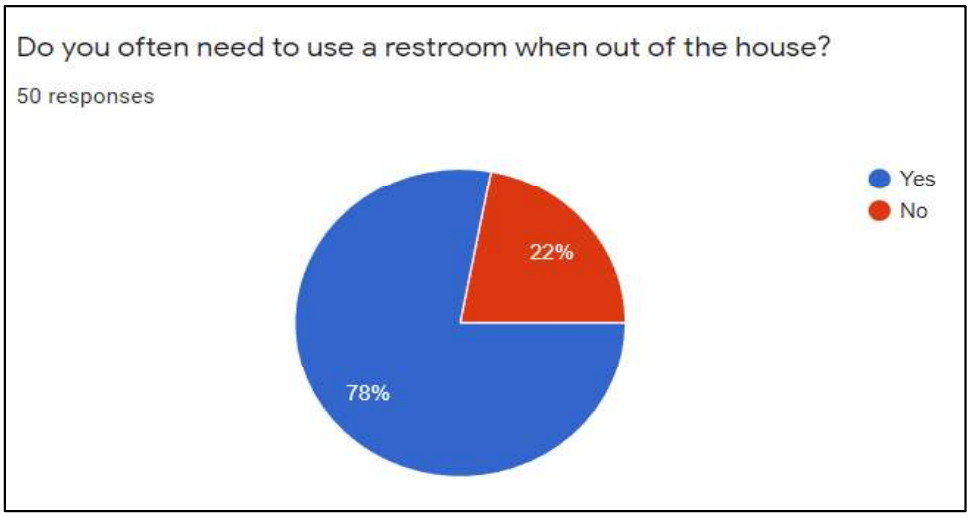
Fig. 7: I will create a survey, including the above notional questions, to gather requirements for the application.

Prototyping the application is also important for refining requirements. Many types of prototyping exist, from paper all the way to functional digital versions, and progressing through the different types allows iterative user interaction, assumption testing, and UX improvement (Murphy, 2018). Following my requirement definition via a survey and user scenarios, I will create a wireframe

prototype. Wireframing strikes the balance in the prototyping stage between utility to the designer in identifying potential features and deficiencies and amount of time spent creating it. I will create two types: one will be high-fidelity, which will illustrate the data's representation using real data; the second will be low fidelity, created with an online wireframing tool, that will allow users to understand how they would interact with the application (Roth, et al., 2017). The final step in prototyping is to work with potential users to conduct a cognitive walkthrough of the wireframe, where the prototypes will be compared to the user scenarios (Roth, et al., 2017). The walkthrough will be a qualitative exercise with open-ended questions, encouraging discussion and problem identification.

User Experience Survey

Fifty potential users of the Insider Leak responded to my UX survey. The respondents' ages ranged from 19 to 72, but the majority were of the same or similar socioeconomic status and ethnic background. Such homogeneity in a sample likely indicates some bias in the results due to increased access to smartphones, transportation, and restroom facilities for white, middle- to upper-middle-class Americans, which distorts any analysis of or reflection on the results. Despite this, the data provide useful insight into user preferences that I will incorporate into my scenarios. As seen in Figure 8, 78 percent of my survey respondents affirmed a need to use a restroom often when out of the house, but only 56 percent are usually able to find one quickly, which validates the necessity of this application. The percentage of respondents able to find a restroom quickly also likely reflects the age and ethnicity of many respondents: They may be more likely to travel by car or purchase something in order to use a café or restaurant bathroom. 66 percent of respondents feel very comfortable using smartphone location-based services such as Google Maps, while 24 percent feel somewhat comfortable, indicating that users will understand the basic premise of the application.



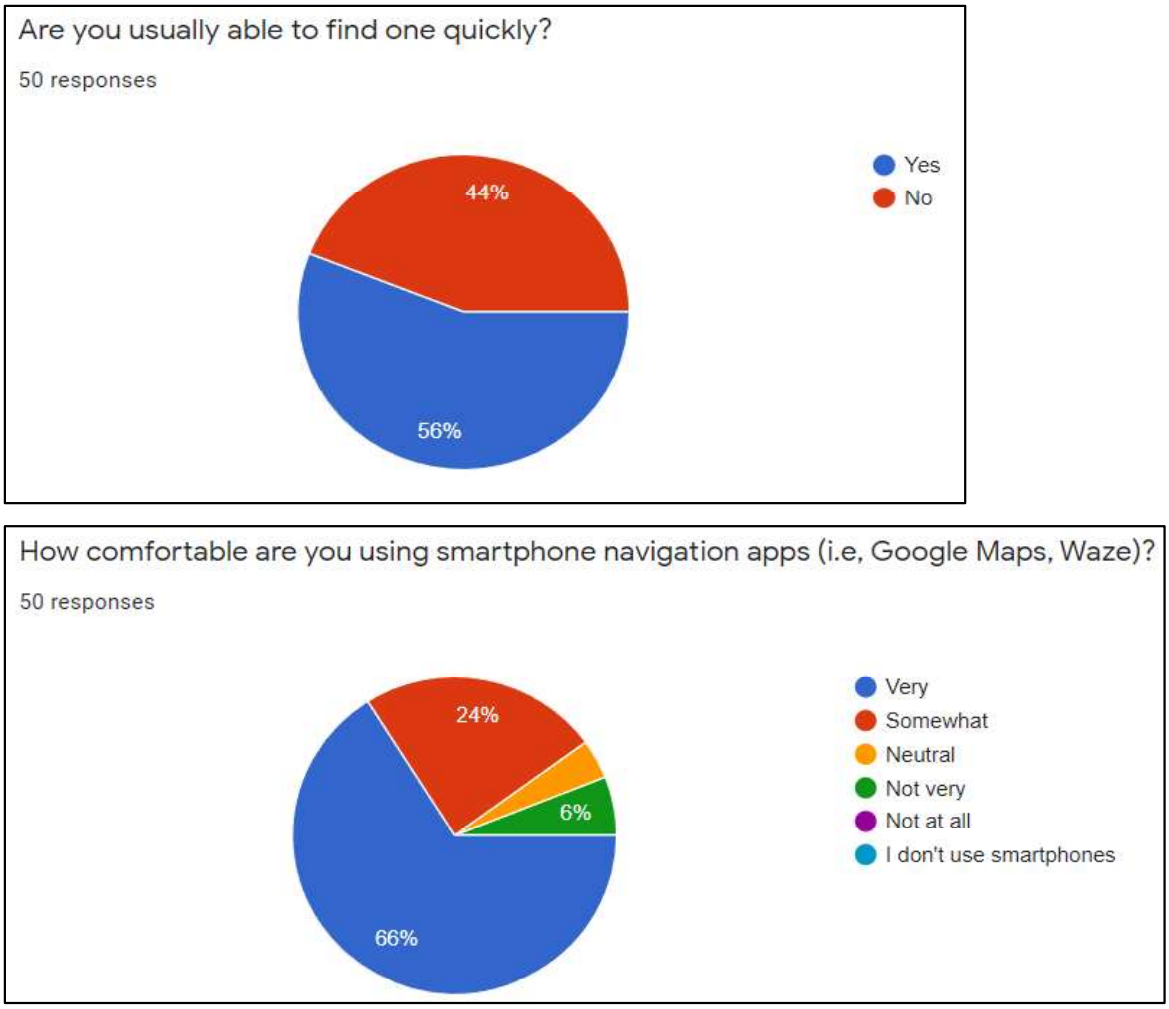


Fig. 8: Screen captures of UX survey responses indicating (from top to bottom) respondents' need to use the restroom out of the house, ability to find one quickly, and comfort with smartphone navigation apps.

Respondents were also questioned about restroom attributes and app features. The most-desired attributes for The Insider Leak to feature for each restroom were location and cleanliness – with 80 percent of respondents valuing those – and conditions for entry (i.e., whether a key or code is required to use it), with 72 percent of respondents valuing that. None of the other suggested attribute options were selected by more than 50 percent of respondents; they included accessibility, gender divide, single or multiple stalls, and previous user reviews. Some respondents provided their own suggested attributes, which included social distancing or mask rules, open hours, and current wait time.

Regarding smartphone navigation application features, respondents preferred different features. The most-desired feature was offline navigation, with 60 percent of respondents choosing it. 40 percent of respondents selected a favorites/saved list as a preferred feature, 28 percent an add/edit/delete function, and only 16 percent wanted the ability to take and upload photographs. The final question provided free text space to allow respondents to propose either additional app features or additional restroom attributes they would like to see in the Insider Leak. Many coalesced around navigation, conditions for entry, adequate supplies (such as soap or toilet paper), and cleanliness. However, outlier responses provided interesting ideas that would be useful to many users, including:

- "Awkwardness of using it factor"
- "Most important thing right now is COVID safety. After this passes, we will no doubt have another emergency. Apps are good when they direct us to safe spaces"
- "Changing table / water fountain / vending / other amenities icon but primarily cleanliness rating"
- "Identify whether freestanding or made available through an institution such as a museum."

User Experience Design

User scenarios are an important step in user experience (UX) design because when designers create these scenarios, they can reflect on actual human interaction with their application (Rosson and Carrol, 2002). Rosson and Carroll (2002) particularly advocate user scenarios created with user input, rather than drawn purely from the developers' brains; greater interaction with potential users throughout the design process leads to more beneficial products. The use of scenarios has grown in popularity recently in many design-based fields looking to increase designers' understanding of and empathy for potential users, proving beneficial in fields such as creating adaptive technology for children with learning disabilities and modernization of the workplace (Camburn, et al, 2017, and AlSabban, et al, 2020).

The below tables illustrate several potential use scenarios for the Insider Leak. The first table of scenarios were informed by the results of my user survey and informal conversations with potential users. The second table, examining the social justice implications of the Insider Leak, was informed by analysis, reflection, and prior research into the issue of restroom equity.

Scenario	**Description**
Run This City	Lisa is training for a marathon and is completing a long training run around Washington, DC. She prefers to run in more populated areas for safety. Halfway through her 16-mile run, she realizes she has to go to the bathroom but forgot her wallet, leaving her with no cash to pop into a coffeeshop. Lisa pulls out her iPhone and opens The Insider Leak; her phone's location was already on to sync her run with Strava. She filters by condition for entry – seeking a free restroom – and located no more than half a mile from her. The app highlights a restroom in a grocery store close by that does not require a purchase to use. She saves the location to her favorites lists, knowing she'll have future runs along this route, and then follows the simple walking directions to the location.
Tourist in Town	Lisa is visiting her adult son in Washington, DC. She loves walking around the bustling streets and beautiful monuments, both with her son and alone while he's at work. However, due to several medical conditions, Lisa frequently must find a restroom on short notice. Her son downloads The Insider Leak onto her smartphone and teaches her how to use it, walking her through the instructions splash screens, so that she can still find restrooms even when she is walking without him. One day she is walking in Georgetown and the need strikes. Using The Insider Leak, she locates a DC municipal building with a public restroom. The restroom turns out to be very messy and not recently cleaned, so Lisa leaves a review to warn future users.
Making Additions	Lisa works for the DC Department of Public Works. Pursuant to new 2019

	regulation – implementation was delayed by the pandemic – she is part of the team piloting new public restrooms in DC. She creates an account on The Insider Leak and, using the add/edit function, adds profiles for the two new restrooms. She adds attributes such as cleanliness, conditions for entry, accessibility, and directions for access if they are not immediately visible. Every so often she checks on the user reviews left at those locations and uses that as another tool to stay on top of maintenance and cleaning.

Scenario	**Description**
Construction Conundrum	Lisa is working on a construction site not far off the National Mall. The site-provided port-a-potty is often either in use, extremely dirty, or out of toilet paper and hand sanitizer, so she used The Insider Leak to identify all of the nearby restrooms. She constantly updates her favorites list for all of the restrooms near her site and on the walk back to the closest Metro stop – of which there are not many. One day on a break, a coworker asks if she knows where they could find a restroom. She finds one, but she knows it is out of cell service range. She downloads the directions for offline navigation and accompanies her coworker to the location.
Driven by Need	Lisa is a taxi driver in Washington, DC, and therefore thinks she knows the city pretty well. While passengers rarely (if ever) ask for a drop-off at a public restroom, she spends so much time cruising around the city that she has built up a sizable mental list of where safe, free restrooms – with parking – are located. Lisa downloads the Insider Leak when she hears of it, more out of curiosity than an expectation of actual need. However, in perusing the restrooms highlighted in the app, she notes a few that she frequents that are missing. She adds them, and continues to do so every time she drives past one she forgot; she also takes care to update attributes for all of them to include parking proximity.
Seeking Safety	Lisa lives in Southeast DC, halfway between the Benning Road and Anacostia Metro Stations. The distance to each from her home is at least two miles. Lisa does not own a car; while she often takes the bus from close to her apartment to one of those metro stops (and vice versa), she is not always able to do so. Sometimes Lisa needs to use the restroom en route home after a long day and commute, but neither of the metro stops have restrooms for customers, although the Benning Road stop is near some convenience stores that do. She downloads the Insider Leak while on the train home. She looks at all of the public restrooms along her route, reading reviews for mentions of safety and examining the surroundings on the map. The ability to access a safe restroom on her walk home provides Lisa comfort and solace on particularly long days.

Prototype Creation and Refinement

The next step after analyzing the user experience (UX) survey results and creating potential user scenarios is to begin prototyping an application. Using an online wireframing tool – such as Balsamiq, which is what I used to create Fig. 9 – allows the designer to clearly visualize the different functions and

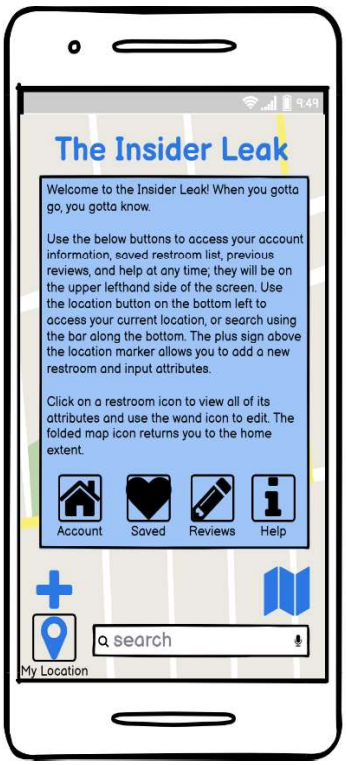
parts of the app. The designer uses this prototyping exercise to continue envisioning how users will interact with the app, allowing continued refinement and engagement with potential users before committing the resources to build an application (Roth, et al., 2017). In addition to improving UX, prototyping allows designers to better understand the resources needed to develop the product, whether it is an app or other software (Arnowitz, Arent, and Berger, Chapter One). Designers, upon seeing the interfaces and functions necessary, can predict the scale of work needed for full development, which can then be translated into a budget and schedule.

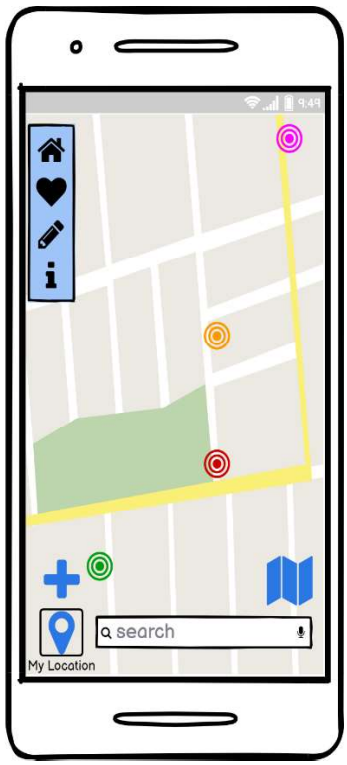
At this stage in my creation of the Insider Leak, I chose wireframe prototyping as the best option to continue its development. Arnowitz, Arent, and Berger (2007) recommend wireframing to fit the following characteristics: The prototype is aimed at an internal audience for narrative purposes; it can be quickly created in the early or middling stages of development; and it uses a low- or medium-fidelity output to display the product's concepts, rather than experiences (Chapter Seven). While development of a commercial app or product would likely require multiple stages of prototyping, for this project I will focus on a wireframe prototype for conceptualization and later create pilot or beta versions of the app itself for use as an interactive prototype.

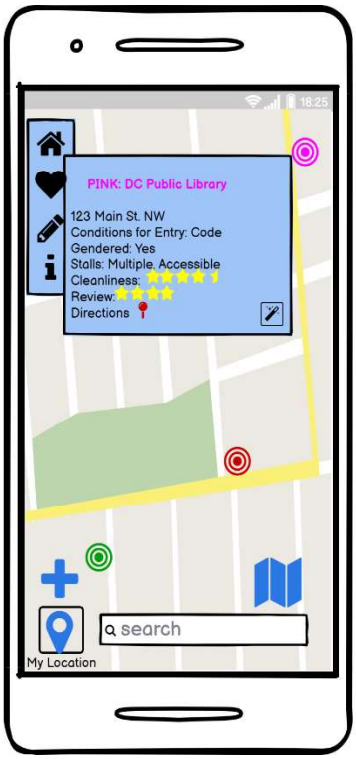
Figure 9 shows my wireframe prototype. Using the results of my UX survey and scenario reflection, I created a low-fidelity concept of The Insider Leak, although the limitations of the prototyping software (discussed below Fig.9) make it an imperfect prototype. I chose the color scheme and simplicity of design based on the answers to my UX survey; the favored color pattern was blue, and there were several calls for simple design and minimal extraneous features. These preferences discovered in my survey results are consistent with previous studies that found a strong correlation between limited clutter in a map and usability (Lavie, Oran-Gilad, and Meyer, 2011). Lavie, Oran-Gilad, and Meyer (2011) also found that a greyscale map with a contrasting cursor provided the best objective results for user response time. However, based on the results of my survey, I will instead adhere to Lavie, Oran-Gilad, and Meyer's lessons of simplicity and color contrast, choosing a simple basemap and bright blue cursor to identify the user.

The top left screenshot displays the opening splash screen when users open the app. I chose to include basic instructions and simple icons to encourage users who may not be as comfortable with location-based services. Additionally, the functions to search, zoom in on a user's location (drawn from the phone's GPS), return to the map's home extent, and add a new feature are always visible. The top right screenshot shows the basic screen after closing the opening splash. The default extent will be zoomed to out to the entire city, and the user can zoom in on their location using a widget. All bathrooms visible within the range will appear, with different types of restrooms in different colors for ease of visibility and discernment. Shortcuts to the main account page, saved list, previous reviews, and help screen will remain in the top left corner.

When a user clicks on a particular restroom, as shown in the bottom left screenshot, a window with basic attributes and reviews will appear. The red map marker button displayed in the attributes list will also link users to directions from the phone's location to directions. The black wand in the lower right corner of the attribute box allows users to edit that restroom's attributes. Finally, the bottom right screenshot shows what will be displayed on the help screen; the first help window will provide a key to the different colored restroom icons and what they indicate, for users' ease of reference.


The Insider Leak
Welcome to the Insider Leak! When you gotta go, you gotta know.
Use the below buttons to access your account information, saved restroom list, previous reviews, and help at any time; they will be on the upper lefthand side of the screen. Use the location button on the bottom left to access your current location, or search using the bar along the bottom. The plus sign above the location marker allows you to add a new restroom and input attributes.
Click on a restroom icon to view all of its attributes and use the wand icon to edit. The folded map icon returns you to the home extent.
Account
Saved
Reviews
Help
search
My Location


search
My Location


PINK: DC Public Library
123 Main St. NW
Conditions for Entry: Code
Gendered: Yes
Stalls: Multiple Accessible
Cleanliness:
Review:
Directions
search
My Location


HELP
Page 1
Restroom key:
DC Public Library
Freestanding Public Restroom
City or Municipal Building
Park or Outdoor Place
Portable Restroom
Pharmacy or Grocery Store
Restaurant or Cafe
Museum
search
My Location

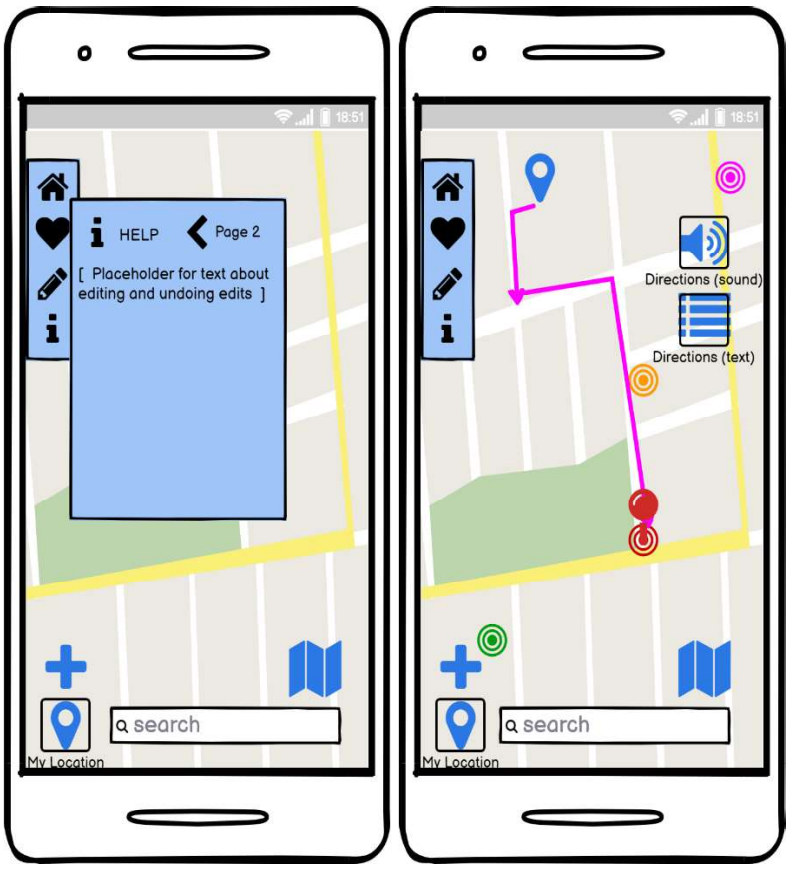


Fig. 9: Screen captures showing a low-fidelity wireframe prototype of The Insider Leak; the wireframe demonstrates how users would interact with the application in several ways.

While the above wireframe provides a conceptual vision for The Insider Leak, the prototyping software left some gaps. I used Balsamiq, an online prototyping software with free and paid levels (Balsamiq, 2022). Balsamiq has dozens of options for symbols and basemaps, but not all of the ones available via Esri software. For example, I used a simple bullseye in the prototype to represent each restroom. I am building the app on Esri's App Studio for ArcGIS software, which will afford me access to the full range of Esri symbols; I intend to use the variety of restroom-related symbols published in the ArcMap Symbol Library, which include single genders, multiple genders, accessible, and other types of restrooms, as seen in Figure 10 (Esri, 2021). Different symbols, along with different colors clearly explained, will communicate more information to users in a brief view.

Fig. 10: A sample of the restroom-related symbols available in the ArcMap Symbol Library.

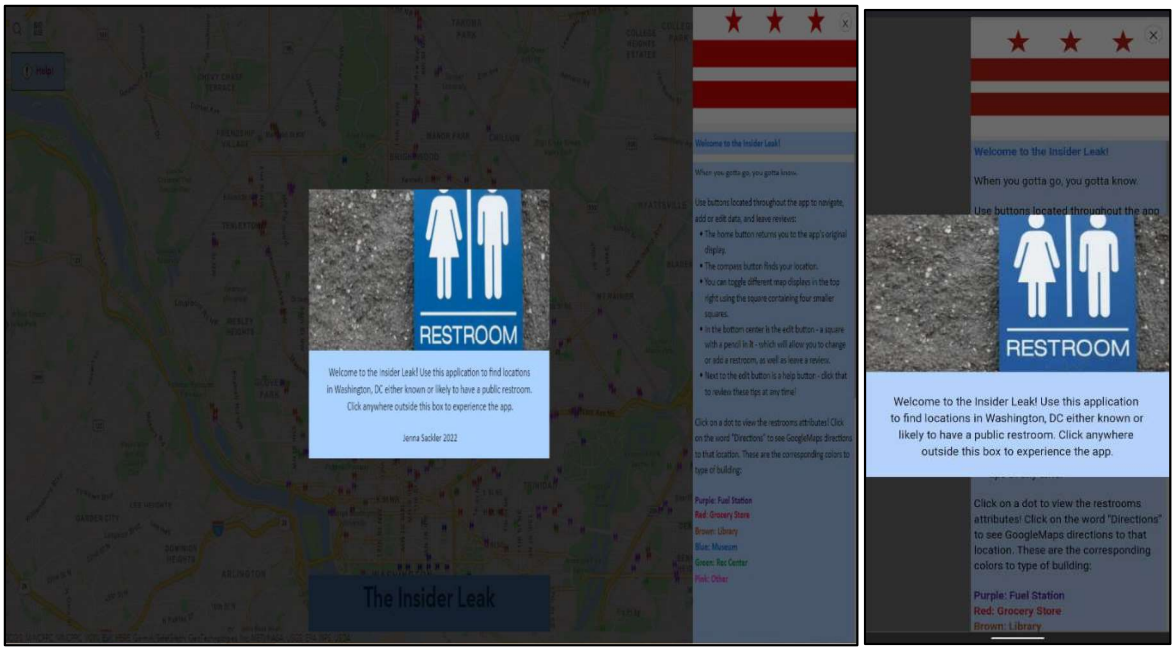
App Development Process

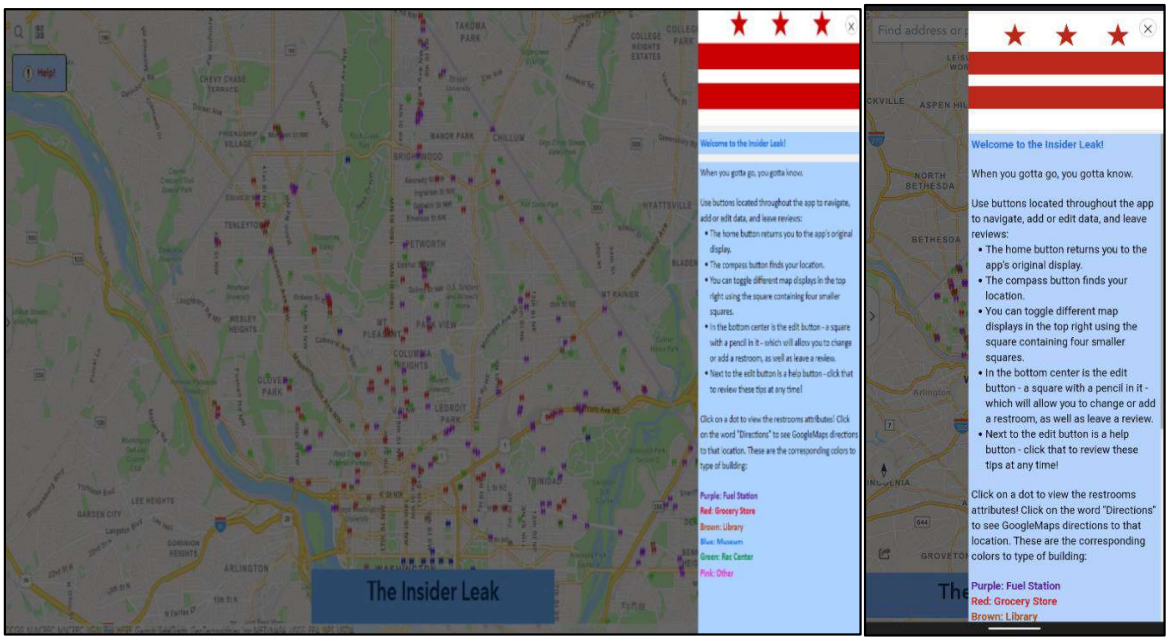
I used Esri tools to create The Insider Leak. Using Washington, DC's GIS data repository Open Data DC, I identified several types of facilities likely to provide public restrooms: grocery stores, museums, recreation centers, libraries, and gas stations (Open Data DC, Various datasets, 2021). I downloaded each dataset as a CSV file then combined them, keeping only the latitude longitude, name, and street address columns; each dataset had several other columns relevant to either the data or however it was used by the original creators. I added a "type" column – indicating the type of facility – to enable easy sorting and symbol assignment. I then used ArcGIS Pro to create a new point feature class, DCPublicRestrooms.shp, which I published into my ArcGIS Online content. This became the basis of The Insider Leak.

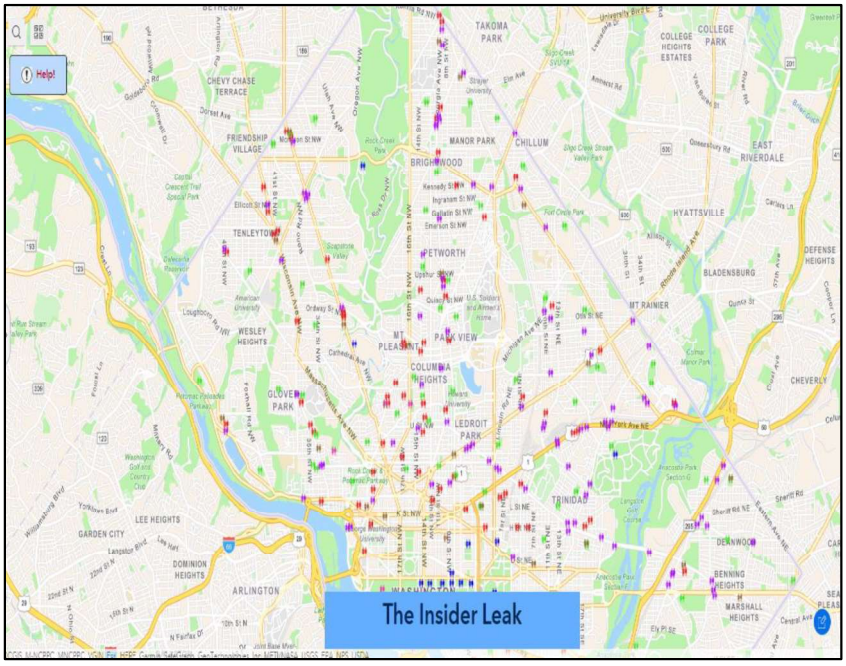
I built the application itself with ArcGIS Experience Builder (ExB). ExB is an Esri tool that allows users to choose from a variety of templates to create web applications (ArcGIS Experience Builder, n.d.). It provides more customizable options than ArcGIS Web App Builder, such as flexible layouts, the ability to integrate 2D and 3D maps in the same application, and mobile-centric design (Developer, 2020). Users can choose a mobile phone-sized shell in which to design the application to ensure it will render correctly on a phone.

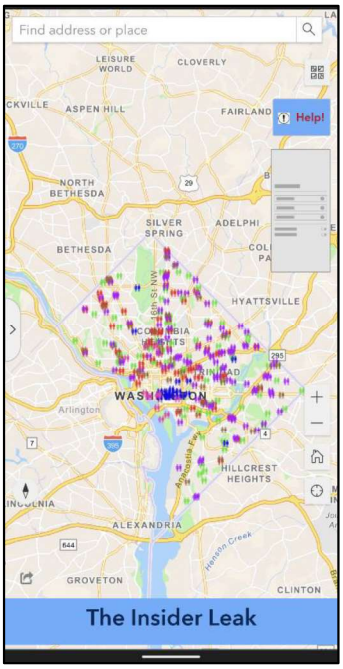
While UX considerations were at the forefront throughout the requirements definition and prototyping phase, the iterative process of building the Insider Leak in ExB provided another opportunity to review UX concerns within the confines of the app development platform. Bartling et. al (2021) reaffirmed that an interactive map's viewers would have bring varying levels of experience and ability to their use of the tool, in addition to specific cultural backgrounds; they determined that a simple, high contrast basemap provided the most users with the most success and confidence when using certain map-based services. Unrau, Ostkamp, and Kray (2017) determined through a heatmap study of click frequency how users interacted with a web-based geospatial application. Tools to locate the user and pan or zoom were most frequently clicked, along with locations on the map itself, so the study found those tools to be most important to display in simple, easily visible icons. Following these guidelines, I used a basic navigation basemap and brightly colored restroom icons to represent each point in the feature class. ArcGIS Online only had the basic "Toilets" icon (third from the top in Fig. 10), so I utilized highly discernable colors to maximize contrast. I also referred to the results of my UX survey to guarantee I addressed important concerns such as visibility and ease of in-app navigation.

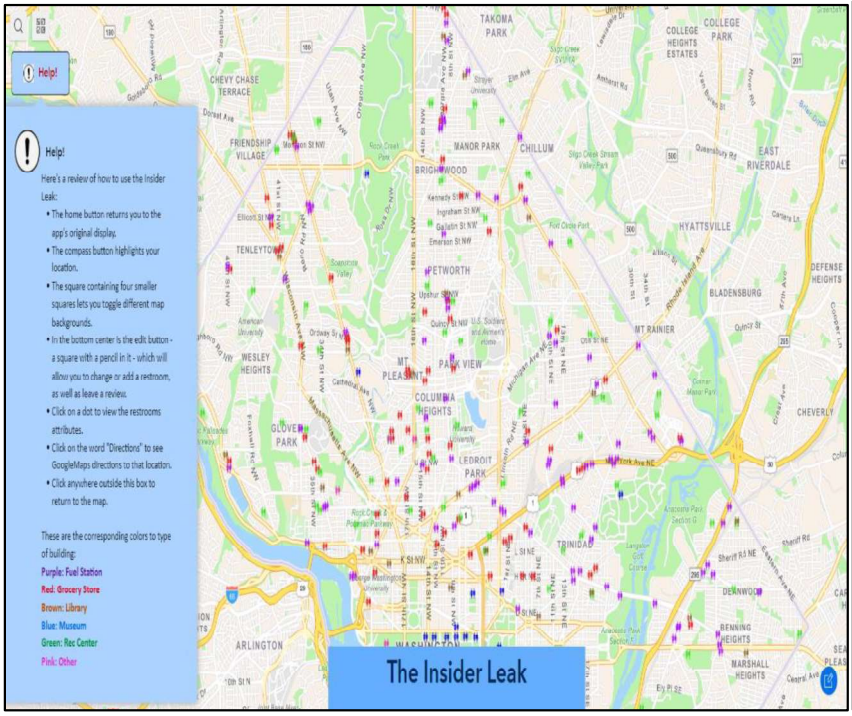
ExB supports app creation optimized for desktop, tablet, and mobile screens. The designer must arrange each element in the app for the screen size; while this means additional work for the designer, it also ensures a better experience for mobile users – this is key for the Insider Leak. Figure 11 compares several desktop (left) and mobile (right) views of The Insider Leak.

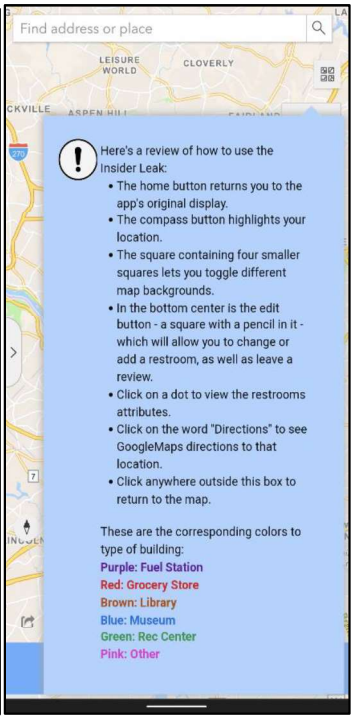

RESTROOM
Welcome to the Insider Leak! Use this application to find locations in Washington, DC either known or likely to have a public restroom. Click anywhere outside this box to experience the app.
Jenna Sackler 2022
The Insider Leak
Welcome to the Insider Leak!
When you gotta go, you gotta know.
Use buttons located throughout the app to navigate, add or edit data, and leave reviews:
• The home button returns you to the app's original display.
• The compass button finds your location.
• You can toggle different map displays in the top right using the square containing four smaller squares.
• In the bottom center is the edit button - a square with a pencil in it - which will allow you to change or add a restroom, as well as leave a review.
• Next to the edit button is a help button - click that to review these tips at any time!
Click on a dot to view the restrooms attributes! Click on the word "Directions" to see GoogleMaps directions to that location. These are the corresponding colors to type of building:
Purple: Fuel Station
Red: Grocery Store
Brown: Library
Blue: Museum
Green: Rec Center
Pink: Other


Help
The Insider Leak
Welcome to the Insider Leak!
When you gotta go, you gotta know.
Use buttons located throughout the app to navigate, add or edit data, and leave reviews:
• The home button returns you to the app's original display.
• The compass button finds your location.
• You can toggle different map displays in the top right using the square containing four smaller squares.
• In the bottom center is the edit button - a square with a pencil in it - which will allow you to change or add a restroom, as well as leave a review.
• Next to the edit button is a help button - click that to review these tips at any time!
Click on a dot to view the restrooms attributes! Click on the word "Directions" to see GoogleMaps directions to that location. These are the corresponding colors to type of building:
Purple: Fuel Station
Red: Grocery Store
Brown: Library
Blue: Museum
Green: Rec Center
Pink: Other


Help!
The Insider Leak


Find address or place
Help!
The Insider Leak


Help!
Here's a review of how to use the Insider Leak:
• The home button returns you to the app's original display.
• The compass button highlights your location.
• The square containing four smaller squares lets you toggle different map backgrounds.
• In the bottom center is the edit button - a square with a pencil in it - which will allow you to change or add a restroom, as well as leave a review.
• Click on a dot to view the restrooms attributes.
• Click on the word "Directions" to see GoogleMaps directions to that location.
• Click anywhere outside this box to return to the map.
These are the corresponding colors to type of building:
Purple: Fuel Station
Red: Grocery Store
Brown: Library
Blue: Museum
Green: Rec Center
Pink: Other
The Insider Leak


Find address or place
Here's a review of how to use the Insider Leak:
• The home button returns you to the app's original display.
• The compass button highlights your location.
• The square containing four smaller squares lets you toggle different map backgrounds.
• In the bottom center is the edit button - a square with a pencil in it - which will allow you to change or add a restroom, as well as leave a review.
• Click on a dot to view the restrooms attributes.
• Click on the word "Directions" to see GoogleMaps directions to that location.
• Click anywhere outside this box to return to the map.
These are the corresponding colors to type of building:
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Brown: Library
Blue: Museum
Green: Rec Center
Pink: Other

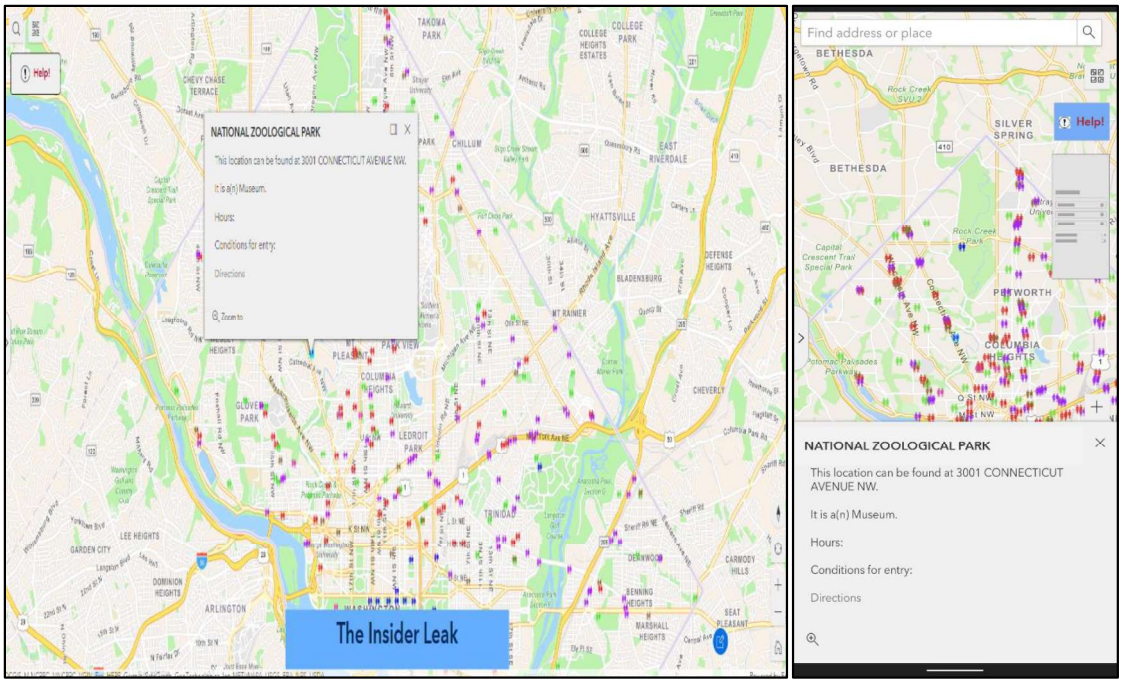

Figure 11: A series of screen captures comparing desktop (left) and mobile (right) views of the Insider Leak. From top to bottom: Splash screen; Instructions/welcome panel; home extent; help sidebar; and restroom popup.

One key feature of the current proof-of-concept of The Insider Leak, judging from my UX survey results, is the ability to navigate from the user's location to the restroom. Unlike Esri app development platforms that utilize the software development kit (SDK) and application programming interface (API) to design completely custom applications, ExB provides limited widget options – and navigation is not currently among them. I turned to Google Maps' developer platform (2022) to determine how to embed a Google Maps link into the popup for each point in the DC Public Restrooms ArcGIS Online map. Google Maps provides suggestions for creating custom URLs to perform various actions on the Maps website or app (if present on the device) without needing an SDK, API, or developer's license (Google Maps, 2022). Using the device's embedded assisted GPS, the custom Google Maps URL allows the user to easily navigate to the closest restroom. Figure 12 shows the basic structure of the Maps URL. The necessary parameters were origin, which was set to the user's location; destination, which was set using the LATITUDE and LONGITUDE fields in the shapefile; and transportation method, which was set to walking (Google Maps, 2022). I hyperlinked the Google Maps URL into each point's popup under the word Directions because a long URL could be confusing and less aesthetically pleasing for users.

Forming the Directions URL

```
https://www.google.com/maps/dir/?api=1&parameters
```

Figure 12: Google Maps Platform suggested URL for custom link to navigation functions (Google Maps, 2022).

Limitations and Opportunities

This initial version of The Insider Leak is limited by the functionality provided by ExB and the fact that the restroom database is incomplete. I would build subsequent versions of this app using App Studio for ArcGIS, where I could integrate the APIs for both Android and Apple operating systems to include additional desired features. Another limitation is the fact that the Edit widget in ExB remains in a developmental testing stage, so Insider Leak users would be unable to add, edit, or delete data in the application. This is a major setback because that edit functionality was one of the key methods to ensure data accuracy and recency, as well as overcome any deficiencies or oversights in my data entry. A third limitation is that I was unable, due to the time-constrained nature of the project, to conduct field data collection to identify portable restrooms or other bathrooms not captured in my datasets. With a functioning Edit widget, users would be able to add those points. Despite these limitations, the process of creating The Insider Leak demonstrates the relative ease, using available Esri platforms, of building a useful tool. Future versions of The Insider Leak will be built using ArcGIS App Studio, which provides more customization options and the ability to upload an app to the Android and Apple app stores (App Studio, 2022). App Studio also integrates capabilities such as Survey 123, Quick Capture, and the ArcGIS Runtime SDKs, which would lend more interactive functionality – such as adding new restrooms or reviews of visited locations – as well as improve user experience.

If I intend to pursue the full development of this application, I will need to secure at least $25,000 (Cole, 2017). There are several common ways of funding new application design: Bootstrapping, or cobbling together personal funds and donations from close contacts; crowdsourcing funds using websites such as Kickstartr or GoFundMe; loans from banks or other organizations; investment funds from angel investors or venture capitalists; and grants or funding competitions (Cole, 2017, Vides, n.d., and Cahill, et al., 2020). I will initially attempt to bootstrap the application; as I am building it myself, rather than hiring a developer, I can save on those costs, especially for the initial versions of the application. I will also research potential grant opportunities through the Washington, D.C. government or technology grants. According to the Office of the Deputy Mayor for Planning and Economic Development, the Department of Small and Local Business Development is planning to launch a funding call related to Washington, D.C.'s new public restroom installations, though the launch date has not been finalized (DSLBD, 2022). That funding call would be a key opportunity to solicit financing for publishing and maintaining my application using ArcGIS App Studio or another mobile-native, multi-platform app development software.

Lessons Learned

App development is a vital skill for modern GIS practitioners. The ubiquity of internet connectivity and smartphones has given rise to volunteered geographic information (VGI) and public participation GIS (PGIS), where ordinary citizens can contribute to the mapping of important locations around them (Elwood, 2008). These phenomena have the potential to hugely improve the visibility of historically underserved areas and support public investment in individual communities in a variety of arenas – including, in this case, public restrooms (Elwood, 2008). Despite the utility of the Insider Leak to tourists or visitors, it is DC locals who will most benefit from it. To benefit from VGI or PGIS, I need to deliver a functional application to users.

I initially intended to create a mobile-optimized version of The Insider Leak using ArcGIS App Studio; this full version would contain thorough attribute data for each restroom and would allow users

to add, edit, or delete those attributes. However, exploration of ArcGIS App Studio led me to realize that I could not deliver a complete application in the given time using that platform, because it required more advanced coding skills than I could develop in time. I turned instead to create a web application via ExB. This web application provides many of the same functionalities, but it also suffers from that common failing of web apps, which is that it does not render as well on a mobile screen as on a desktop. With additional time and coding resources, I would return to ArcGIS App Studio and create a fully functioning mobile version of The Insider Leak that would utilize navigation and editing widgets. While I have gained expertise in the application development process, I do not yet have the skills to deliver the complete Insider Leak product and need to continue to hone those skills as a GIS practitioner.

The Insider Leak fulfills many, though not all, of the American Restroom Association's guidelines for a restroom locator. For reference, those guidelines include:

- "Highlight or add emphasis to those facilities available year-round, 7 days a week and at least between 8:00 am and 9:00 pm, including holidays.
- Where portable sanitation units (porta-johns) are listed, note if they are known to be routinely cleaned and serviced
- Highlight true municipal public restrooms units and restrooms in buildings clearly open to the public such as train stations
- Avoid listing small privately owned mercantile establishments (ex. coffee shop), unless they advertise availability
- List restrooms in urban parks that meet the availability requirement listed in the first bullet
- Note possible security restrictions (e.g. photo ID required) that might impact access to government municipal building restrooms.
- Note if the facility is a single toilet restroom that may be current occupant locked" (2021).

The Insider Leak differentiates between different types of facilities hosting restrooms, allowing users to understand where they are in municipal building, parks, or other places. I also added the opening hours for almost all the points. When the Edit widget is functional, users will be able to update conditions for entry for each restroom. My original intention was to meet all the ARA criteria, however the limitations I faced building this app led me to miss several. I will emphasize meeting those criteria for any future versions of The Insider Leak.

This process also reinforced the value of Agile project management methodology. Constant contact with stakeholders – in this case an advisor and a sample of potential Insider Leak users – during short "sprints" to achieve small milestones allowed me to respond to changing requirements or the realities of novice app development. Upon discovery that I could not use ArcGIS App Studio to achieve my goals in the given timeframe, I was able to pivot to ExB and start designing a web app. Through at least six iterations of design and comment, I was able to adjust the look-and-feel of the web app to ensure I protected the most important functions highlighted via the requirements definition process. Features added or updated following interaction with potential users include more detailed use instructions, more intuitive button placement, a title banner at the bottom of the screen, and choosing restroom symbols instead of simple circles for the point symbolism.

Creating this preliminary version of The Insider Leak demonstrated the continued need for a public restroom locating application in Washington, DC. The DC Government's Office of the Chief Technology Officer (OCTO) provides an open-source geospatial data repository, Open Data DC; however, this repository did not have a comprehensive restroom-locating feature class or application (Open Data DC, 2022). Instead, I had to piece together several imperfect feature classes based on existing knowledge – or assumption – about buildings or entities that usually allow public access to their restrooms. OCTO's lack of restroom data illustrates the overall disdain for or, at best, indifference to the necessary role public bathrooms play in providing equitable access to society. Failing to compile that information in an easily accessible format has reinforced Kitchen and Law's (2001) "power geometries" that design society to disadvantage people with disabilities or medical conditions, people experiencing homelessness, people working jobs without facility access, and women.

The DC Government shows signs of understanding the need for progress on the restroom issue, with its 2019 legislation to build two new public restrooms and a grant announcement from the Department of Small and Local Business Development to compensate businesses that make their restrooms accessible to the public – although the latter has not opened as of time of writing (DSLDB, 2022). However, even with additional resources focused on improving the number of public bathrooms, the city still needs to enable individuals to actually locate these restrooms. Australia and the UK are among the countries that have built dedicated restroom-locating web applications. The Insider Leak aims to bring that function to Washington, DC, in pursuit of social justice, equality, and accessible convenience for all users.

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