

# Report

## How Usable Are Outdoor Wireless Networks?

Amelia Bryne Potter & Neal McIntyre  
*Community Wireless Infrastructure Research Project*

Catherine Middleton  
*Ryerson University*

*Abstract:* This report discusses the usability of outdoor Wi-Fi networks. Based on a study of wireless networks in Toronto, the report outlines usability challenges related to device availability, technical limitations, and constraints of the physical usage environment. Guidelines are offered to improve the design of outdoor Wi-Fi networks, but it is also noted that other options may prove to be more feasible for the provision of broadband access in municipalities.

*Keywords:* Wireless; Broadband applications; Broadband networks

*Résumé :* Ce rapport traite de la fonctionnalité des réseaux Wi-Fi extérieurs. Se fondant sur une étude de réseaux sans fil à Toronto, il passe en revue les défis liés à la disponibilité des appareils, à leurs limitations techniques et à l'environnement physique de leur utilisation. Nous proposons des normes qui amélioreraient la conception des réseaux Wi-Fi extérieurs, tout en remarquant que d'autres options pourraient s'avérer plus pratiques pour assurer un accès à large bande sûr dans les municipalités.

*Mots clés :* Sans fil; Applications à large bande; Réseaux à large bande

### **Outdoor Wi-Fi: Infrastructure of the future?**

This research was motivated by an interest in understanding the future for an outdoor wireless network in Toronto, deployed on a for-profit basis at a time when similar networks in the United States were proving to be unsustainable. The report provides insights into the usability of the network, suggesting improvements to make outdoor Wi-Fi more usable but also making the case that outdoor

---

Amelia Bryne Potter is a researcher with the Community Wireless Infrastructure Research Project ([www.cwirp.ca](http://www.cwirp.ca)) and the Ethos Group ([www.ethoswireless.com](http://www.ethoswireless.com)). Email: [ameliabpotter@gmail.com](mailto:ameliabpotter@gmail.com). Neal McIntyre is a researcher with projects including the Community Wireless Infrastructure Research Project ([www.cwirp.ca](http://www.cwirp.ca)). Email: [neal.mcintyre@gmail.com](mailto:neal.mcintyre@gmail.com). Catherine Middleton holds a Canada Research Chair in the Ted Rogers School of Information Technology Management at Ryerson University, 350 Victoria Street, Toronto, ON M5B 2K3. Email: [catherine.middleton@ryerson.ca](mailto:catherine.middleton@ryerson.ca).

**Canadian Journal of Communication, Vol 33 (2008) 511-524**

©2008 Canadian Journal of Communication Corporation

wireless Internet deployments are not likely to serve the needs of users looking for reliable, everyday Internet access. The research was conducted by members of the Community Wireless Infrastructure Research Project ([www.cwirp.ca](http://www.cwirp.ca)) and is part of a broader study of public broadband infrastructures.

Over the past few years hundreds of communities in North America have established their own broadband networks (Vos, 2007). Wireless technology has played a key role in many of these developments. Because it is relatively inexpensive to deploy, and because it operates on open (i.e., unlicensed or licence-exempt) spectrum, Wi-Fi has lowered the barriers to entry for building Internet infrastructure (Lehr & McKnight, 2003; Sandvig, 2004; Sirbu, Lehr, & Gillett, 2006). Cities and community organizations that use wireless technology have typically chosen one of two infrastructure models, either (1) aiming to seamlessly cover an entire area—such as a city or its downtown core—with a wireless signal, or (2) providing more site-specific access via hotspots in public spaces, cafés, or other locations (Shamp, 2004).

In Canada, the City of Fredericton's Fred-eZone ([www.fred-ezone.com](http://www.fred-ezone.com)) and Montréal's Île Sans Fil ([www.ilesansfil.org](http://www.ilesansfil.org)) have been providing wireless Internet access to local residents and visitors for several years, with many of their hotspots providing connectivity to indoor locations (cafés in Montréal; hotels, malls, the airport, a truck stop, and cafés in Fredericton—see Crow & Miller, 2008, and Powell, 2008, for detailed descriptions of the Île Sans Fil and Fred-eZone networks). But many wireless networks, whether hotspot- or area-based, have focused on providing outdoor access. For example, ubiquitous networks such as Toronto's One Zone or Google's Mountain View, California, network have been engineered to primarily provide outdoor coverage, and community groups such as Wireless Toronto and NYCwireless offer outdoor Wi-Fi access in spaces like public parks and squares. Although users may purchase Wi-Fi modems to draw these signals indoors, coverage for these particular networks or hotspots is guaranteed only for outdoor spaces.

Cities and community groups have aimed to meet a number of social and economic goals by establishing wireless networks, including making affordable broadband connections available to those who are not currently connected; stimulating economic development; and making city services, such as meter reading, or building inspection, more efficient (Center for Digital Government, 2005; Wireless Philadelphia Executive Committee, 2005; Wireless Task Force, 2006). While outdoor wireless networks may help to achieve some of these goals, it is questionable whether they are the network architecture best suited to improving Internet access. That is, while many outdoor wireless networks may aim to provide ubiquitous (every place) coverage, ubiquitous service does not necessarily lead to universal (every person) access, nor does ubiquity guarantee usability.

Research shows that while people do make use of outdoor wireless networks, and the behaviour of users varies from place to place, user numbers for these networks may be lower than expected (Hampton, Livio, Trachtenberg, & Sessions, 2008). Indeed, as of mid-2008, the leading Internet service providers in the municipal wireless arena, MetroFi and Earthlink, had shut down their networks in the Silicon Valley, Portland, Philadelphia, and elsewhere (Cox, 2008).

Although the Philadelphia network appears to have been resuscitated, the provision of outdoor wireless is now less central to its efforts to bring connectivity to the citizens of Philadelphia (Waxman, 2008). Outdoor networks can be useful to certain types of users, such as mobile workers in need of secondary access, away from their primary Internet connection (see Middleton, 2007, for a more detailed discussion of the prospects for outdoor wireless networks in the United States and Canada). But given some of the usability challenges they pose, these networks may do little to improve connectivity for those without affordable broadband service at home or the office, and as such they may have limited effectiveness in promoting economic development.

### **Wi-Fi in Toronto: Toronto Hydro Telecom's One Zone and Wireless Toronto**

In March 2006, Toronto's Mayor David Miller and Toronto Hydro Telecom's President David Dobbin announced the development of wireless Internet access to blanket Toronto's downtown core, signalling "the beginning of a new era in telecommunications in the city of Toronto" (Miller, 2006). Toronto Hydro Telecom, an affiliate of Toronto Hydro, outlined an ambitious plan that would eventually provide residents across the entire City of Toronto with access to broadband Internet service, and would also provide wireless monitoring of residents' electrical meters (Els, 2006). In promoting its "One Zone" ([www.one-zone.ca](http://www.one-zone.ca)), Toronto Hydro Telecom was always very clear that as a private corporation, albeit with the City of Toronto as its "sole shareholder's shareholder," it would need to recoup its investment in network infrastructure by charging fees to users (Dobbin, 2007; Gravelle, 2007). This meant that unlike free Wi-Fi zones and hotspots provided in other municipalities (and by Wireless Toronto), the One Zone network in the City of Toronto would operate on a pay-for-use basis.

Profits from Toronto Hydro Telecom's operations, including the One Zone, were to be returned to Toronto Hydro, which pays an annual dividend to the city. If the initial One Zone deployment in the downtown core proved profitable, then the network could be expanded to cover the rest of the city, resulting in larger dividends to the City of Toronto "that might be used for a new park, new services or lower property taxes" (Gravelle, 2007, p. 17). Clement and Potter (2008) argue that in taking this for-profit approach, Toronto Hydro Telecom missed an opportunity to make use of public assets to build a broadband network that would serve the public interest.

Toronto Hydro Telecom believed that the best location for a trial of their Wi-Fi network was the downtown core, because it included the financial core, educational institutions, provincial government offices, and private residences (Gravelle, 2007). Given the need to recoup its investment and to deliver on its promise of future dividends to the city, establishing a network that would be appealing to fee-paying users was essential. The One Zone was centrally located, and many people lived and worked in its coverage zone, but these potential users were generally already well served by wired Internet connections (some provided by Toronto Hydro Telecom's fibre optic network). Although Toronto Hydro Telecom issued more than 43,000 passwords for One Zone network use during a

six-month free trial period, when the network started charging for use, demand dropped drastically, and it appeared that further expansion of the network would be unlikely (Harvey, 2007). With the recent sale of Toronto Hydro Telecom to Cogeco Cable, the long-term future of the One Zone is uncertain. The prospect of the One Zone profits contributing dividends to the City of Toronto no longer exists, but Cogeco Data Services continues to operate the One Zone as a pay-for-use wireless Internet service.

Ranked by consulting firm Novarum (2007) as the top-performing wireless broadband network in North America, the One Zone network is technically robust. But given that the network is designed to primarily serve outdoor locations, it is not necessarily particularly user-friendly. Nor is it the only option for Wi-Fi Internet access in Toronto, as Wireless Toronto also provides outdoor wireless service ([www.wirelesstoronto.ca](http://www.wirelesstoronto.ca)). Wireless Toronto was founded in 2005, and its volunteers now operate 40 hotspots in Toronto. (See Cho, 2008, for a detailed case study of Wireless Toronto.) Although Wireless Toronto's service is not ubiquitous, its hotspots offer free service to users, sponsored by local organizations or businesses. At the time of our study, Wireless Toronto provided free outdoor coverage at some of the same locations as the One Zone, and also provided connectivity in various indoor locations, lessening the appeal of paying for One Zone access.

### **Case study: Outdoor wireless service in Toronto**

During the late summer and early fall of 2007, we tested 18 different locations in central Toronto covered by at least one outdoor wireless Internet service provider. When we did our fieldwork, the major provider of outdoor wireless Internet service in Toronto's downtown core was Toronto Hydro Telecom's One Zone network. One Zone provides ubiquitous wireless service within a six-square kilometre zone at the cost of \$5 per hour, \$10 per day, or \$30 per month ([www.onezone.ca/pricing.html](http://www.onezone.ca/pricing.html)). We connected to this network at various spots within each of the five sectors of the One Zone (paying the access fee), including locations in and around universities, hotels, offices, and public spaces. We tested Wireless Toronto's outdoor hotspots as well as some indoor spots whose signals reached outside. For example, it was possible to access Wireless Toronto hotspots located in bars and cafés that were closed when we visited, by sitting outside the premises.

We tested the network in each of the locations with one of two types of wireless devices, a Wi-Fi enabled laptop computer or a Nokia N800 Internet tablet. The locations were tested at times and days when they might reasonably be expected to be frequented by users—such as a public square in the business district at noon on a Thursday or a park at 4:00 p.m. on a Friday. We spent about 30 minutes at each location, connected to the Internet (when possible), and filled out an online form describing the space and connection quality, noting factors such as signal strength, availability of seating, other network signals, the presence of other users (if any), and the general atmosphere and convenience of using the Internet in that particular location. Our objective was to determine whether it would be possible to use the Internet at each location for any period of time (i.e., for more than just quickly looking up basic information or checking email). We also wanted to assess whether the location was a place our researcher would actu-

ally want to use the Internet, in order to determine whether the access point provided a viable alternative to other types of Internet connections. A summary of the findings is provided in Table 1 below, and detailed data is provided in Appendix 1. Of the 20 hotspots visited, only 6 were ones that could be considered comfortable places to use the Internet.

**Table 1: Network test results**

	Wireless Toronto (10 hotspots)	One Zone (10 locations)	Total (/20)
Comfortable place to use Wi-Fi	4	2	6
Able to use the network inside	6	1	7
Access to power outlet	0	1	1
Seating at tables	5	5	10
Easy to connect to the network	8	8	16
Strong signal	7	8	15
Network speed (> 2 Mbps)	7	7	14
Other users at this hotspot	1	0	1

Table 1 shows that although the networks were generally easy to connect to and provided good-quality Internet access, usability was compromised. We believe that this is why we were unable to find many users in outdoor locations. There is no doubt that there are more users than we observed, but consistent with Hampton, Livio, Trachtenberg, and Sessions (2008), we found that outdoor wireless users are not highly visible in Toronto. Perhaps more importantly, our testing indicated to us that outdoor access to Wi-Fi was unappealing for anything other than quick Internet access, suggesting that the long-term sustainability of fee-for-use outdoor Wi-Fi access is limited.

### Usability challenges

Based on these tests we have identified a number of usability issues for outdoor wireless networks, which can be categorized as device, environment, and technical challenges.

#### Device challenges

Challenges that access devices pose to using outdoor wireless service differ by type of device but broadly include issues of portability, safety, and ease of browsing the Internet. With the high price of data services for mobile phones, it is thought that small Wi-Fi-enabled mobile devices such as tablets like the Nokia N800, the iPod Touch, or iPhone, or Wi-Fi-enabled mobile phones will become increasingly common. But at the time of our fieldwork, very few Wi-Fi-enabled smart phones were available on the Canadian market, making it likely that Wi-Fi-enabled laptops were the access device of choice for many mobile Internet users.

Although laptops are designed for portability, they are not as easy to transport as smaller devices. In addition, users may be reluctant to use their laptops in public places like parks for fear of theft. Further, laptops are commonly used while the user is in a seated position while resting the device on a table or other surface. During testing we found tables in only half of the access points, limiting

our testers' desire to spend any length of time at locations where they could not use their laptops comfortably. Finally, outdoor mobility becomes a particular issue for owners of laptops with a short battery life. While many indoor spaces where laptop use is common, such as cafés, have power outlets that customers can use to recharge their computers, we only found one outdoor location with a power outlet. The man using this outlet to recharge his cellphone warned us not to let anyone know about it because he was afraid that the city might remove or cover the outlet if it knew citizens were making use of it to do things like recharge mobile devices.

Despite these drawbacks to using laptops outdoors, they do have some advantages for mobile users compared to smaller devices, especially in terms of navigating websites quickly and easily. Device manufacturers have found innovative ways to allow users to navigate Web pages on smaller screens, and websites are making an effort to ensure that their pages are compatible with mobile devices, sometimes creating a secondary site for these kinds of users. However, there is far less standardization for mobile browsers than for their laptop and desktop browser cousins, and there are often problems in logging onto the network. For today's users, whether or not a certain website will be functional on a particular mobile device is often a matter of luck. In addition, using tablet or touch screen devices that have no keyboards can be time-consuming for some activities that could be quickly completed on a laptop, for example writing an email. So, although it may be more comfortable, safe, and easy to use a smaller mobile device outdoors, users may not be willing to trade these conveniences for the time and effort it now takes to access and use the Internet through them. This choice likely depends on the particular user, including how often, and for what purpose, they access the Internet while away from their home or office.

### **Environment challenges**

We discovered that environment-related factors such as sunlight, temperature, and physical space pose additional challenges to the usability of outdoor wireless networks. Lighting was often a considerable hindrance to using the Internet outdoors. For obvious reasons we did not attempt to use the outdoor wireless networks on rainy days, but we found that sunny days were not ideal either. Even at the brightest setting, which drained the battery faster than lower settings, laptop screens were difficult to see clearly in the sunlight. The best lighting situations were in the shade, such as under trees, in the shadow of a building, or under an outdoor table umbrella. However, tree leaves that provide shade also degrade Wi-Fi signals, decreasing the quality of the connection.

Working outside in the late summer and early fall was often quite pleasant. It was possible to access the Internet in locations throughout the downtown core that would likely be convenient to office workers in need of a breath of fresh air or travellers exploring the city. But Toronto is quite cold for six months of the year: Would as many users want to use the network in January as in July? In below-freezing temperatures it seems unlikely that people would use a laptop or tablet for extended periods of time outdoors, if at all. Although people certainly use mobile devices such as Wi-Fi tablets and laptops year-round, being able to duck into a building lobby, indoor public space, or café would likely be prefer-

able to using one outside when the weather is cold, as winter gloves and keyboards do not mix. And while the One Zone signal can be pulled indoors with the help of a wireless modem, it is up to each business or location to enable indoor use and users would still have to pay to access the network. Only one of the One Zone locations we tested provided connectivity indoors, compared to six Wireless Toronto hotspots.

As mentioned, we found that outdoor seating—crucial to laptop users—was hard to come by and was often limited to benches and picnic tables in parks or public squares. While park benches were an improvement to squatting or sitting on the grass or sidewalk, benches were generally usable for only 20 to 30 minutes before they became uncomfortable. Picnic tables in the shade or outdoor tables with umbrellas were ideal environments to use the outdoor wireless networks with a laptop, but tables were only found in half of the locations.

### **Technical challenges**

We found the One Zone network and Wireless Toronto hotspots were generally reliable and operated at broadband speeds (average speed for One Zone spots tested: 2.1 Mbps, for Wireless Toronto: 2.9 Mbps). Signal strength was generally strong, but there were some locations where it was not possible to get a signal although there should have been one. In addition, in the case of Wireless Toronto's hotspots, it was sometimes a matter of trial and error to discover where the signal was available (e.g., within a park or other large space). Finally, unlike in a café, restaurant, or other indoor location, there was no person on-site for either network to ask for help with getting a connection or to whom to report any trouble in connecting.

The Wi-Fi networks were technically robust, but it is noted that there are means of accessing the Internet using mobile devices that are more reliable, convenient, and secure than Wi-Fi. For people who are looking for Internet access while away from their home or office, smart phones like the BlackBerry provide excellent ubiquitous and secure access to email. In addition, although not available in Canada at the time of this fieldwork, devices such as the Apple iPhone (that can use a cellular network to provide Internet access where no Wi-Fi is present) hold promise. We anticipate that for quick Internet access, smart phones will be many users' device of choice in future. For those who are looking for regular Internet access for extended periods of time, there is the option of using a cellular company's wireless high-speed service, which provides ubiquitous connectivity to laptops using a card or USB modem.

### **Design guidelines**

Wireless networks have the potential to offer users mobile Internet access and to enhance public space. Working outside on a summer day can be a pleasant way to take a break from the office environment, and the ability to access data on the go can have major productivity and convenience benefits. But outdoor Wi-Fi networks pose serious device and environment usability challenges. Although we do not believe that outdoor networks are a good substitute for reliable primary access at an indoor location, new technology developments and design guidelines that address these challenges could significantly improve their usability. We suggest



that communities and users considering outdoor wireless take into account the following points.

### **Device**

Technical advances in wireless devices may help improve the usability of outdoor networks. For example, new mobile browsers are emerging that more closely mimic desktop browsers, such as Skyfire ([www.skyfire.com](http://www.skyfire.com)) and Safari ([www.apple.com/iphone/internet](http://www.apple.com/iphone/internet)), improving Internet usability on smaller devices. Wi-Fi phones or smaller, lighter laptops could provide an alternative to existing mobile telephone services, using ubiquitous networks to make free calls over the Internet and thereby increasing the usefulness of outdoor Wi-Fi. In addition, advances in backlit LCDs and anti-reflective film are making devices more usable in sunny conditions where shade is not available.

### **Environment**

When making decisions about building a wireless network, communities should take the local climate and city architecture into consideration. Will the network be usable year-round? What indoor locations should be served? What seating options are already available for mobile device users? Are power outlets available? Are shade and shelter from the rain available throughout the planned network area? If not, would the community consider investing in these amenities as part of the wireless network deployment?

### **Technical**

New developments in wireless technology and spectrum access may lead to devices and bandwidth more capable of sending signals indoors from exterior access points. Meanwhile, communities planning outdoor wireless networks with an objective of improving access to the Internet should have a plan for helping users to get the signal indoors. This might involve actions such as selling or renting routers, or providing limited indoor access in locations where users are likely to want to make use of the network year-round.

### **Conclusion**

In summary, outdoor wireless networks pose a number of device, environment, and technical challenges to usability. Communities that are considering an investment in such networks should take these factors into consideration when making their decision as well as in the design of the network itself. These challenges may influence a community's decision about whether to go ahead with an outdoor wireless network deployment and whether to choose a ubiquitous, hotspot, or other coverage model. For cities like Toronto, where wireless networks already exist, network managers can improve the usefulness of networks by addressing the issues identified in this report. The suggestions outlined here address the issue of usability of outdoor wireless networks but do not address broader questions of whether a wireless network will serve the needs of the community.

Given the sale of the Toronto Hydro Telecom network, the issue of the One Zone's ability to contribute dividends to the City of Toronto is now moot. But it appears that the network, as currently deployed, is at best making a limited contribution to improving Internet access for residents of and visitors to Toronto. We



question the decision to focus on outdoor network coverage, especially with a for-profit model, and encourage other municipalities considering the deployment of wireless broadband networks to examine the outcomes of the One Zone project carefully. This report shows that network deployments that focus on providing connectivity outdoors provide limited value, given their usability constraints. As noted above, it is possible to make technical adjustments that would improve the usability of such networks, but we argue that it is far more important to consider usability before building outdoor networks. The starting point for determining whether or not to build broadband infrastructure should be a full-scale assessment of community needs, with a view to understanding the role of broadband in meeting such needs. Only after a clear understanding of the purpose of the network is established should questions of network design and coverage be addressed.

### Acknowledgments

This research was made possible through a financial contribution from Infrastructure Canada. The views expressed herein do not necessarily represent the views of the Government of Canada. We thank Nabeel Asim for his assistance with field-testing and acknowledge the helpful comments of the anonymous reviewers.

### Wi-Fi networks cited

City of Fredericton. Fred-eZone. [www.fred-ezone.com](http://www.fred-ezone.com).  
Cogeco Data Services (Toronto). One Zone network. [www.onezone.ca](http://www.onezone.ca).  
Île Sans Fil (Montréal). [www.ilesansfil.org](http://www.ilesansfil.org).  
NYCwireless (New York City). [www.nycwireless.net](http://www.nycwireless.net).  
Wireless Philadelphia. [www.wirelessphiladelphia.org](http://www.wirelessphiladelphia.org).  
Wireless Toronto. [www.wirelesstoronto.ca](http://www.wirelesstoronto.ca).

### References

- Center for Digital Government. (2005). *Building the untethered nation: A strategic guide for communities on wireless technology and broadband infrastructure*. Folsom, CA: Center for Digital Government. URL: [http://www-1.ibm.com/industries/government/ieg/pdf/wireless\\_guide.pdf](http://www-1.ibm.com/industries/government/ieg/pdf/wireless_guide.pdf) [July 7, 2008].
- Cho, Hanna Hye-Na. (2008). Towards place-peer community and civic bandwidth: A case study in community wireless networking. *Journal of Community Informatics*, 4(1), URL: <http://ci-journal.net/index.php/ciej/article/view/428> [August 20, 2008].
- Clement, Andrew & Potter, Amelia Bryne. (2008). Saving Toronto Hydro Telecom's One Zone Project from Itself: Alternative Models for Urban Public Wireless Infrastructure. *Journal of Community Informatics*, 4(1).
- Cox, John. (2008, April 21). Municipal Wi-Fi 2.0: As large-scale, for-profit projects falter, innovative new models emerge. *Network World*, 22.
- Crow, Barbara, & Miller, Tammy. (2008). *Île Sans Fil case study map*. Toronto: Community Wireless Infrastructure Research Project. URL: [http://www.cwirp.ca/files/CWIRP\\_ISF\\_case.pdf](http://www.cwirp.ca/files/CWIRP_ISF_case.pdf) [August 20, 2008].
- Dobbin, David. (2007, May 29). Speech presented at the *Canadian Municipal Wireless Applications Conference*, Toronto, ON. the URL: [http://www.onezone.ca/pdf/05-29-07\\_Dave%20Dobbin\\_Canadian%20Municipal%20Wireless%20Applications%20Conference.pdf](http://www.onezone.ca/pdf/05-29-07_Dave%20Dobbin_Canadian%20Municipal%20Wireless%20Applications%20Conference.pdf) [May 30, 2008].

- Els, Mark. (2006, March 9). Visionary fibre guy turns Toronto wireless. *Network World Canada*. URL: <http://www.intergovworld.com/article/df62f5510a01040800f0541dc04dfef6/pg1.htm> [August 24, 2008].
- Gravelle, Sharyn. (2007). Speech presented at the *Wireless Cities Summit*, Toronto, ON. URL: [http://www.thtelecom.ca/downloads/01-24-07\\_Sharyn%20Gravelle%20Speech\\_Wireless%20Cities%20Summit.pdf](http://www.thtelecom.ca/downloads/01-24-07_Sharyn%20Gravelle%20Speech_Wireless%20Cities%20Summit.pdf) [April 27, 2007].
- Hampton, Keith N., Livio, Oren, Trachtenberg, Craig, & Sessions, Lauren. (2008). *Is WiFi use compatible with public space?: Wireless Internet use, sociability, and social networks*. Presentation to the International Communication Association, Montreal, QC.
- Harvey, Ian. (2007). Getting in on the WiFi game. *Technology Quarterly*, 22-25.
- Lehr, William, & McKnight, Lee W. (2003). Wireless Internet access: 3G vs. WiFi? *Telecommunications Policy*, 27, 351-370.
- Middleton, Catherine A. (2007, September). *A framework for investigating the value of public wireless networks*. Paper presented at the 35th Research Conference on Communication, Information and Internet Policy, Arlington, VA. URL: [http://cwirp.ca/files/middleton\\_tprc\\_2007.pdf](http://cwirp.ca/files/middleton_tprc_2007.pdf) [November 1, 2007].
- Miller, David. (2006). *Office of the Mayor of Toronto Wi-Fi announcement*. URL: [http://www.toronto.ca/mayor\\_miller/speeches/wifi.htm](http://www.toronto.ca/mayor_miller/speeches/wifi.htm) [August 25, 2008].
- Novarum. (2007). *Wireless broadband rankings*. URL: <http://www.novarum.com/Rankings.htm> [August 21, 2008].
- Powell, Alison. (2008, April). *Fredericton's Fred-eZone: Defining and designing public broadband*. Case study report for the Community Wireless Infrastructure Research Project (CWIRP). URL: [http://www.cwirp.ca/files/CWIRP\\_eZone\\_case.pdf](http://www.cwirp.ca/files/CWIRP_eZone_case.pdf) [August 20, 2008].
- Sandvig, Christian. (2004). An initial assessment of cooperative action in Wi-Fi networking. *Telecommunications Policy*, 28(7/8), 579-602.
- Shamp, Scott A. (2004). *Wi-Fi clouds and zones: A survey of municipal wireless initiatives*. Athens, GA: Mobile Media Consortium, University of Georgia.
- Sirbu, Marvin, Lehr, William, & Gillett, Sharon. (2006). Evolving wireless access technologies for municipal broadband. *Government Information Quarterly*, 23, 480-502.
- Vos, Esme. (2007). *Muniwireless.com: 1 August 2007 list of US cities and regions*. URL: <http://muniwireless.com/reports/docs/Aug-1-2007summary.pdf> [August 25, 2007].
- Waxman, Ben. (2008). *Wireless Philadelphia: Back from the dead?* The Next Mayor blog. URL: [http://blogs.phillynews.com/dailynews/nextmayor/2008/06/wireless\\_philadelphia\\_back\\_fro.html](http://blogs.phillynews.com/dailynews/nextmayor/2008/06/wireless_philadelphia_back_fro.html) [August 28, 2008].
- Wireless Philadelphia Executive Committee. (2005). *Wireless Philadelphia business plan: Wireless broadband as the foundation for a digital city*. URL: <http://web.archive.org/web/20051029025846/http://www.phila.gov/wireless/pdfs/Wireless-Phila-Business-Plan-040305-1245pm.pdf> [July 7, 2008].
- Wireless Task Force. (2006). *Wireless in Boston*. URL: <http://www.cityofboston.gov/wireless/Boston%20Wireless%20Task%20Force%20Report%20-%20Final.pdf> [July 7, 2008].

**Appendix 1: Detailed Observational Data**

Areas were defined by Toronto Hydro Telecom, and are shown on their detailed coverage map: [http://web.archive.org/web/20070311214948/http://onezone.ca/coverage\\_maps.html#](http://web.archive.org/web/20070311214948/http://onezone.ca/coverage_maps.html#)

Area 1 = Financial Core: Queen Street to Front Street, Spadina Avenue to Church Street

Area 2 = Hospitals/Ryerson: College Street to Queen Street, Spadina Avenue to Church Street

Area 3 = University of Toronto/Ontario Ministries: Bloor Street to College Street, Spadina Ave to Yonge Street

Area 4 = Downtown WeStreet: Queen Street to Front Street, Bathurst Street to Spadina Street

Area 5 = Downtown EaStreet: Queen Street to Front Street, Church Street to Parliament Street

Service Provider	Area	Location Type	Comfortable			Indoor access			Power access			Tables for seating	Ease of Connection	Signal	Speed	Other Users	Comments
			Indoor access	Power access	Tables for seating	Indoor access	Power access	Tables for seating									
One Zone	1	Courtyard	No	No	No	No	No	No	No	Easy	Strong	2 Mbps	No	I can see how workers in the offices would be well served by being able to come outside and work. However, without tables here it would get uncomfortable quickly.			
One Zone	1	Park	No	No	No	No	No	No	Easy	Strong	3 Mbps	No	The lack of tables means it would be difficult to work out here for too long.				
One Zone (also a WT hotspot)	2	Public Square	No	No	No	No	No	No	Easy	Strong	3 Mbps	No	The tables and chairs were all full, so I'm sitting on one of the benches. There's a show playing. The music is awful. I'm looking forward to getting out of here.				
One Zone	2	Coffee Shop	No	Yes	No	No	No	No	Easy	Strong	<1 Mbps	No	I'm surprised to get a signal inside, however I'm sure it's only because I'm right up against a large window and am very close to the access point. It's quite hot in here, so I wouldn't be tempted to stay long.				

Service Provider	Area	Location Type	Comfortable	Indoor access	Power access	Tables for seating	Ease of Connection	Signal	Speed	Other Users	Comments
One Zone	3	University	No	No	No	No	Easy	Strong	3.5 Mbps	No	I'm just sitting on the steps. Not much use for the connection here without having somewhere to sit.
One Zone	3	Park	Yes	No	No	Yes	Easy	Strong	3 Mbps	No	I'm at the northern end of the park, sitting at a picnic table. There is plenty of shade from the trees. The picnic tables are much better for sitting down with a laptop for an extended period of time.
One Zone	4	Coffee Shop	No	No	No	Yes	Easy	Strong	3 Mbps	No	It would be good to have the connectivity here, but as this is a place of business I'd feel guilty about staying here too long without buying something.
One Zone	4	Park	Yes	No	No	Yes	Easy	Strong	3 Mbps	No	A nice quiet park, the picnic table makes it much more conducive to using a laptop for more than 10 minutes. This would be a nice place to come work during the warmer months.
One Zone	5	Park	No	No	Yes	No	Mixed	Intermittent	<1 Mbps	No	While the park is very nice, I wouldn't be able to sit here long to do any work. I just discovered a hidden power outlet here in the gazebo.
One Zone (also a WT hotspot)	5	Market	No	No	No	No	Difficult	Weak near seating	1 Mbps	No	The signal doesn't reach the seating areas of the market.
Wireless Toronto	1	Office	No	No	No	No	Easy	Strong	3 Mbps	No	I'm really just sitting in the waiting room for this office. This really isn't public space.
Wireless Toronto (also OZ hotspot)	2	Public Square	Yes	No	No	Yes	Mixed	Intermittent	Variable	No	There's a band playing on the bandstand. This is actually really cool, I'm tempted to stay here for a while. The seats and tables with shade are what make the difference here.

Service Provider	Area	Location Type	Comfortable	Indoor access	Power access	Tables for seating	Ease of Connection	Signal	Speed	Other Users	Comments
Wireless Toronto	4	Gallery	No	Yes	No	No	Easy	Strong	<1 Mbps	No	The venue has a bar and seating but is closed right now. I wouldn't be able to do any long-term work just sitting on the steps here.
Wireless Toronto	4	Bar	No	Yes	No	No	Easy	Weak	4 Mbps	No	This is a bar, but right now it's closed. I'm sitting on a bench on the front patio. This isn't really useful during the day. This wouldn't be good for long-term work. Right now I'm just using my computer on my lap. A proper table would be needed for longer term work.
Wireless Toronto	4	Park	Some- times	No	No	Yes	Easy	Strong (doesn't cover entire park)	2 Mbps	No	A very reliable hot spot but a better shaded area away from all the animals should be provided so users can fully enjoy access to Wi-Fi. The bugs in the morning will not allow any one to sit in the area for a long time.
Wireless Toronto	4	Coffee Shop	Yes	Yes	No	Yes	Easy	Strong	2 Mbps	No	It's great to be able to sit in a seat again after having to crouch on the sidewalk at the last hotspot.
Wireless Toronto	4	Patio Garden	Yes	Yes	No	Yes	Easy	Strong	4 Mbps	No	This is a patio/garden. A very nice place to sit and work. If I worked in an office here, I'd come outside to work on nice days.
Wireless Toronto	4	Coffee Shop	Yes	Yes	No	Yes	Easy	Strong	4 Mbps	Yes	The cafe is in the first floor of an office building. Most of the tenants of this building are technology/creative organizations. Tables and chairs, typical of a small cafe.

Service Provider	Area	Location Type	Comfortable	Indoor access	Power access	Tables for seating	Ease of Connection	Signal	Speed	Other Users	Comments
Wireless Toronto (also Oz hotspot)	5	Market	No	Yes	No	No	Mixed	Intermittent	Variable	No	Congested and inconvenient as there is a good chance a bird will fly into the laptop screen and damage it.
Wireless Toronto	5	Bar	No	No	No	No	Easy	Strong	2 Mbps	No	The bar is closed, so I'm crouching on the sidewalk. My foot hurts from crouching. Gotta go!