

Report #9 in the series Transitway Impacts Research Program

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Perception of Waiting Time at Transit Stops and Stations



CTS Report 16-01

**CENTER FOR
TRANSPORTATION STUDIES**

UNIVERSITY OF MINNESOTA

Technical Report Documentation Page

1. Report No. CTS 16-01/TIRP #9	2.	3. Recipients Accession No.	
4. Title and Subtitle Perception of Waiting Time at Transit Stops and Stations		5. Report Date February 2016	
		6.	
7. Author(s) Yingling Fan, Andrew Guthrie, David Levinson		8. Performing Organization Report No.	
9. Performing Organization Name and Address Humphrey School of Public Affairs University of Minnesota 301 19th Ave S Minneapolis, MN 55455		10. Project/Task/Work Unit No. CTS # 2013049	
		11. Contract (C) or Grant (G) No.	
12. Sponsoring Organization Name and Address Center for Transportation Studies University of Minnesota 200 Transportation and Safety Building 511 Washington Ave. SE Minneapolis, MN 55455		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes http://www.cts.umn.edu/Publications/ResearchReports/			
16. Abstract (Limit: 250 words) <p>Waiting time in transit travel is often perceived negatively and high-amenity stops and stations are becoming increasingly popular as strategies for mitigating transit riders' aversion to waiting. However, beyond recent evidence that realtime transit arrival information reduces perceived waiting time, there is limited empirical evidence as to which other specific station and stop amenities can effectively influence user perceptions of waiting time. To address this knowledge gap, the authors conducted a passenger survey and video-recorded waiting passengers at different types of transit stops and stations to investigate differences between survey-reported waiting time and video-recorded actual waiting time. The authors employ regression analysis to explain the variation in riders' reported waiting time as a function of their objectively observed waiting time, as well as station and stop amenities, while controlling for weather, time of day, personal demographics, and trip characteristics. Based on the regression results, most waits at stops with no amenities are perceived at least 1.3 times as long as they actually are. Basic amenities including benches and shelters significantly reduce perceived waiting times. Women waiting for more than 10 minutes in surroundings perceived to be insecure report waits as dramatically longer than they really are, and longer than do men in the same situation. The authors recommend a focus on providing basic amenities at stations and stops as broadly as possible in transit systems, and a particular focus on stops on low-frequency routes and in less safe areas for security measures.</p>			
17. Document Analysis/Descriptors public transit, bus transit, light rail transit, bus stops, bus stop shelters, rail transit stations, waiting time, planning, perception		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 76	22. Price

Perception of Waiting Time at Transit Stops and Stations

Final Report

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February 2016

Published by:

Center for Transportation Studies

University of Minnesota

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511 Washington Ave. SE

Minneapolis, MN 55455

This report represents the results of research conducted by the authors and does not necessarily represent the views or policies of the Center for Transportation Studies, the University of Minnesota, or the sponsoring organizations of the Transitway Impacts Research Program.

The authors, the Center for Transportation Studies, the University of Minnesota, and the sponsoring organizations of the Transitway Impacts Research Program do not endorse products or manufacturers. Any trade or manufacturers' names that may appear herein do so solely because they are considered essential to this report.

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Executive Summary

All modes of transportation have costs associated with them. Critical among these costs is time. In terms of time cost, transit faces an inherent disadvantage that is not shared by other modes: waiting time. Waiting time in transit travel tends to be perceived negatively. Walking time to and from transit, and time spent aboard transit vehicles are generally perceived as taking roughly as long as they really do. Transit users, however, perceive waits for transit vehicles to arrive as significantly *longer* than they really are—anywhere from 1.5 to 4 times as long in existing research. Such perceptions present a significant obstacle to encouraging mode shifts from automobile to transit.

High-amenity stations such as those provided on light rail lines, transit centers served by multiple routes, improved bus shelters and information improvements, such as real-time NexTrip signs, are becoming increasingly popular as strategies for mitigating transit users' aversion to waiting and transferring. Existing research shows that real-time departure information can dramatically reduce the perceived length of waits. Little research exists, however, on what specific aspects of stations and stops are effective in making transit trip times seem “shorter” to users.

To address this lack of knowledge, with the support of the Transitway Impacts Research Program, the authors conducted a study comparing Twin Cities transit users' self-estimates of their waiting time with their actual waiting times. The study addresses the overall research question: How do the design of amenities provided and the environments surrounding transit stations and stops impact users' perceptions of waiting time? The study takes a uniquely systematic perspective, including a wide range of stop and station types, transit modes, times of day and seasons. We seek to explain waiting time perceptions as a function of stop/station design and environment. We offer recommendations to reduce perceived waiting times—and ultimately improve the experience of using transit—that can be applied at an appropriate scale to any place people wait for transit vehicles: from a light rail station to a humble curbside bus stop.

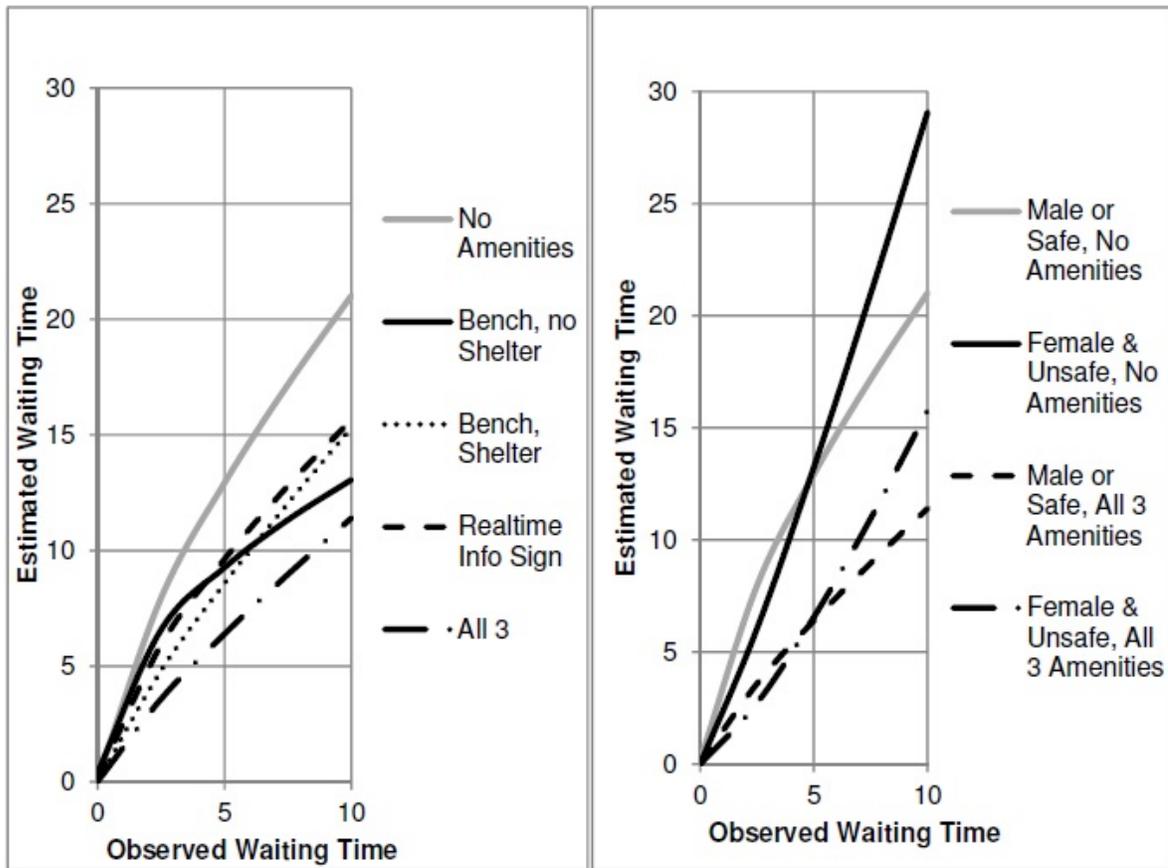


Figure E-1: Perceptions of waiting time by amenities, gender and security

We employ regression analysis to explain the variation in riders' waiting time estimates as a function of their objectively observed waiting times, as well as station and stop amenities, while controlling for weather, time of day, self-reported and observed socio-demographic characteristics and trip characteristics.

Based on the results, waits at stops with no amenities are perceived as twice as long or longer than they actually are. (See Figure E-1.) In addition to overall time perceptions, we conclude that:

- Benches, shelters and real-time departure information signs significantly reduce perceived waiting times.
- The complete package of all three nearly erases the time perception penalty of waiting.
- Women waiting in perceived insecure surroundings perceive waits as dramatically longer than they really are and longer than do men and/or respondents in perceived secure surroundings.
- The provision of stop amenities significantly reduces this disparity.

The research findings indicate recent station design decisions for Twin Cities transitways, including the Metro Green Line, and proposed stop designs for the arterial bus rapid transit (BRT) system should significantly reduce perceived waiting times.

The results of this analysis indicate the potential for transit stations and stops, and the waiting environments they create, to significantly influence passengers' perceptions of waiting time under certain circumstances. In particular, they point to the importance of seating, shelter, and information in all settings, as well as to the importance of providing a basic complete package of amenities, when seeking to increase perceptions of personal security around the least safe stops, particularly from the perspective of female passengers. Each of these findings suggests promising avenues for further analysis using these data and/or topics for more tightly focused research on each topic identified.

1 - Introduction

Unlike trips made by competing modes, transit trips have a unique travel time component: waiting time. No matter how easy the access and egress components, or how fast and reliable the in-vehicle component of a transit trip, the waiting component is travel time other modes avoid entirely. In addition, existing research shows that transit users perceive waiting time as significantly longer than it actually is. Most transit users also perceive a minute of waiting time as much longer than a minute of any in-vehicle part of their transit trips. Despite well-established general literature on the perceived length of waiting time, little research has offered a systematic examination of the specific factors associated with waiting time perceptions. Little is known regarding what aspects of stations and stops are effective in making waiting time during transit trips seem “shorter” to users. While transit providers increasingly seek to improve the experience of waiting for a transit vehicle, this lack of specific knowledge makes it difficult to identify stop and station design features that actually make waits seem shorter.

To address this lack of knowledge, with the support of the Transitway Impacts Research Program, the authors conducted a study comparing Twin Cities transit users’ self-estimates of their waiting time with their actual waiting time at the individual level. The study addresses the overall research question: How do the design of amenities provided at and environment surrounding transit stations and stops impact users’ perceptions of waiting time? The study takes a uniquely systematic perspective, including a wide range of stop and station types, transit modes, times of day and seasons. We seek to explain waiting time perceptions as a function of stop/station design and environment. We offer recommendations for reducing perceived waiting times—and ultimately improving the experience of using transit—that can be applied at an appropriate scale to any place people wait for transit vehicles: from a light rail station to a humble curbside bus stop.

The following chapter explores the literature on perceptions of time in general, perceptions of transit waiting time in particular, common strategies to reduce perceived waiting time, and research methods employed in previous studies of waiting time perceptions. Chapter 3 details our research approach and data collection procedure. Chapter 4 presents the results of our study, including sample distribution, regression analysis and model predictions. Chapter 5 draws key conclusions from the research results, identifies implications for proposed Twin Cities transit projects, and makes recommendations for future transit stop and station improvements, as well as directions for further research.

2 - Literature Review

Travel time is a critical factor in determining mode choice. For pedestrians, cyclists and motorists, travel time is quite simple. Travel time for transit users, however, has multiple components: access time, waiting time, in-vehicle time, egress time and, in many cases, transfer time. (Currie, 2005; Guo & Wilson, 2004; Horowitz, 1981; Iseki & Taylor, 2009) In attempting to encourage auto-to-transit mode shifts, transit providers often seek to minimize transit trip times, usually focusing on In-Vehicle Time (IVT).

2.1 Travel Time Perceptions

Time, in general, has long been understood to be perceived indirectly based on observed events, rather than directly experienced. (Andersen & Grush, 2009) This indirect experience leads to individual perceptions of time which can vary significantly from any externally measurable “objective” time. (Block, 2014; Fraisse, 1984) Events experienced can either moderate or exacerbate these errors. In particular, events occurring at regular intervals lead to underestimates, while events occurring at irregular intervals produce overestimates. (Yarmey, 2000) In addition, intense experiences—positive or negative—tend to produce overestimates of duration. (Ariely & Zakay, 2001)

2.1.1 Transit Travel Time Components

Travel is understood as a derived demand—an activity tolerated in furtherance of a specific goal rather than undertaken for its own sake. As a result, transportation planners often approach travel time from the perspective of mitigating the intensity of an inherently unpleasant experience. (Cervero & Knockelman, 1997) Much of the transportation planning literature takes travel time—not direct financial expense—to be the key cost associated with travel. (Ortuzar & Willumsen, 1994; M. Wardman, 1998b; M. Wardman, 2004b) In addition, the travel time associated with different modes is commonly assumed to be a critical determinant of mode choice. (El-Geneidy, Hourdos, & Horning, 2009)

Table 2-1: Waiting Time Ratios in Existing Research

Study	Ratio	Notes
(Henderson & Engineers, 1972)	3:1	Perceived waiting time vs. perceived IVT.
(Cherlow, 1981)	1.5:1—7:1	Valuation of wait time/IVT savings in mode choice.
(Horowitz, 1981)	1.9:1—13:1	Perceived waiting time vs. perceived IVT; found non-linear relationship by length of wait and trip.
(Parsons Brinkerhoff Quade and Douglas, Inc., 1993)	4.4:1	Perceived waiting time vs. perceived IVT.
(M. Wardman, 1998a)	1.2:1—1.7:1	Perceived waiting time vs. perceived IVT.
Wardman, 2004	2.5:1	Recommendation for wait time:IVT ratio assumption in ridership modeling.
(Dziekhan & Kottenhoff, 2007)	1.2:1	Perceived vs. actual wait time before implementation of real-time info on high-frequency streetcar line; 1:1 after implementation.
(Watkins, Ferris, Borning, Rutherford, & Layton, 2011)	1.2:1	Perceived vs. actual time in at-stop survey after ~5min wait time, without real-time departure mobile app. Difference with app statistically insignificant.

Transit users often perceive their waiting time as considerably longer than it actually is. As shown in **Error! Reference source not found.**, Wardman finds that a 2.5:1 ratio of waiting time to in-vehicle time is appropriate for schedule planning and ridership forecasting, more appropriate even than the traditional British 2:1 assumption. (M. Wardman, 2004b) Horowitz finds that any wait at all is perceived as equivalent to an extra 8.4 minutes' IVT in a 30 minute trip and 13 minutes' IVT in a 45 minute trip, and that a ten-minute wait is equivalent to an extra 18.9 or 23.2 minutes of IVT, respectively. (Horowitz, 1981) A 1993 study of the Twin Cities transit system found that an average rider perceived one minute of waiting time as equal to 4.36 minutes of IVT—albeit without analyzing perceived waiting time under varying conditions. (Parsons Brinkerhoff Quade and Douglas, Inc., 1993) These perceptions can have negative implications for users' overall feelings about transit as a mode: St. Louis, et al find that the waiting and transferring segments of a bus or metro trip significantly reduce commuters' overall satisfaction with these modes. (St-Louis, Manaugh, van Lierop, & El-Geneidy, 2014)

2.2 Reducing Perceived Waiting Time

High-amenity transit stops and stations have become an increasingly popular strategy for mitigating the perceived burden of waiting time and transfers—to the point of becoming a more-or-less standard feature of new and proposed transit improvements ranging from billion-dollar light rail lines to much more modest, mixed traffic rapid bus projects. (*Denver Union Station Master Plan*.2004; Metropolitan Council, 2012; Transit Planning Board, 2008)

Numerous bus and multimodal transit centers exist in the Twin Cities and more are planned, including the major Saint Paul Union Depot and Minneapolis Target Field projects. Existing research, however, has yet to adequately explore how effective station and stop amenities are at reducing transit users' perceptions of travel time, as well as about which specific transit station and stop design features contribute most to the overall effect.

Perceptions of waiting time may vary depending on circumstances including transit service factors, such as on-time performance and service information, as well as stop/station factors, such as surroundings, perceived security, and amenities such as enclosed waiting areas, seating or restrooms. (Evans et al., 2004; M. Wardman, 1998a) Employing a hedonic modeling approach, Cascetta and Carteni find that Neapolitan commuters will accept an additional seven minutes of waiting time and ten minutes of access time in order to use a new rail line with markedly more attractive stations than an older line serving similar trips. (Cascetta & Carteni, 2014)

These findings do not directly address time perception, but do suggest that transit users find waiting in high-amenity stations significantly less burdensome than waiting in less pleasant environments. The pedestrian-oriented design field outlines methods for assessing similar environmental factors as experienced by pedestrians in the form of pedestrian environment audits. These tools consider factors such as surrounding land uses, availability of shade/shelter from sun or wind, safety from traffic and personal security—offering some guidance for assessing transit station and stop environments. (K. Clifton & Rodriguez, 2004; K. J. Clifton, Livi Smith, & Rodriguez, 2007; Day, Boarnet, Alfonzo, & Forsyth, 2006; Landis, Vattikuti, Ottenberg, McLeod, & Guttenplan, 2001)

2.2.1 Transfers

Transfers seem to be perceived even more negatively than the initial wait at the start of a transit trip. (Guo & Wilson, 2004; Horowitz & Zloesel, 1981; Horowitz, 1981) At first glance, these findings appear to support the recent popularity of high-amenity bus transfer centers as strategies for improving the experience of using transit. (Iseki & Taylor, 2009; Iseki & Taylor, 2010) Liu, Pendyala and Polzin find a transfer penalty three times as great for intermodal transfers as for intramodal transfers, (Liu, Pendyala, & Polzin, 1997) while Iseki and Taylor identify ease of access and wayfinding between routes' boarding and alighting areas as crucial to reducing the perceived disutility of transfers. (Iseki & Taylor, 2010) In a study of Boston subway passengers, Guo and Wilson find that passengers are more reluctant to transfer at certain stations, and that this reluctance cannot be explained by service or access factors, indicating an importance for some qualities of stations themselves. (Guo & Wilson, 2004)

2.2.2 Specific Design Characteristics

Despite these findings, little research exists on what specific aspects of a transit station or stop are effective in shortening perceived waiting and transfer times. (Iseki & Taylor, 2009) Diab and El-Generidy find average waiting time perception changes as great as 4.4 minutes following a variety of improvements to a major bus corridor in Montreal, QC, but do not focus specifically on stops. (Diab & El-Generidy, 2014) One exception to this rule is in the area of real-time, at-stop information, which has been found to significantly reduce perceived waiting times, even when no other improvements to a route are made. In

conjoint analysis based on a 1994 survey of transit users in Ann Arbor, Michigan, Reed finds that:

[A] change from “printed schedule only” to “real-time arrival information via telephone” is roughly three times as important as making the bus on time instead of 5 minutes late and more than twice as important as reducing the in vehicle travel time from 30 minutes to 15 minutes. (Reed, 1995)

Dziekian and Kottenhoff find that adding real time departure information signs to streetcar stops reduced perceived waiting times by more than twenty percent based on a longitudinal, before/after survey of passengers. They contend this improved the experience of using transit as much as reducing headways from ten to eight minutes, at less than one-fifth the cost. (Dziekian & Kottenhoff, 2007) Watkins, et al reached nearly identical results for perceived versus measured waiting time for bus passengers in King County, Washington using an at-stop, in person survey. (Watkins et al., 2011) In a 2014 follow-up study, Gooze, Watkins and Borning find continued effects of shortened time perceptions, as well as self-reported more frequent transit use due to real-time information availability by nearly 30% of respondents. They also find that inaccurate real-time information increases waiting time estimates. (Gooze, Watkins, & Borning, 2013)

With the proliferation of mobile technology and the development of standardized real-time transit information feed formats, real-time departure information apps have become a popular low cost complement and alternative to electronic real-time information signs. Brakewood, et al's work on real-time information via mobile devices support this trend; they find: a decrease in reported wait times of (on average) 1-2 minutes for Boston commuter rail riders and Tampa bus riders, respectively, who use real-time information apps, and that the apps in question are popular with transit users. (Brakewood, Barbeau, & Watkins, 2014; Brakewood, Rojas, Zegras, Watkins, & Robin, 2015) Perhaps more notably, the more heavily-used routes in a New York real-time information pilot program saw a median 2.3% increase in ridership after implementation. (Brakewood, Macfarlane, & Watkins, 2015)

Fan and Guthrie, as well as Iseki and Taylor, find station and stop characteristics to be less important than travel times, service frequency, and reliability in shaping users' overall perceptions of transit service quality based on stated preference surveys. Neither of their studies, however, considered how stop and station characteristics influence riders' perceptions of the travel and waiting times they did find important. (Fan & Guthrie, 2012; Iseki & Taylor, 2010)

2.3 Waiting Time Perception Research Methods

All primary research on waiting time perceptions the authors are aware of includes some form of survey focused on transit passengers. This component is likely difficult to avoid, as individuals' perceptions of time—by definition—cannot be externally observed. Most existing research compares perceived waiting time with perceived in-vehicle time, (Cherlow, 1981; Henderson & Engineers, 1972; Horowitz, 1981; Parsons Brinkerhoff Quade and Douglas, Inc., 1993; M. Wardman, 1998b; M. Wardman, 2004a) though some more recent studies compare perceived waiting time with a direct measurement of actual waiting time. (Dziekian & Kottenhoff, 2007; Watkins et al., 2011) A number of variations in

methods are present, however, within this basic research framework. Fan and Guthrie, as well as Iseki and Taylor, find station and stop characteristics to be less important than travel times, service frequency, and reliability in shaping users' overall perceptions of transit service quality based on stated preference surveys. Neither of their studies, however, considered how stop and station characteristics influence riders' perceptions of the travel and waiting times they did find important. (Fan & Guthrie, 2012; Iseki & Taylor, 2010)

Table 2-2: Research Methods—Waiting Time Perceptions

Study	Perceived Wait Time vs.:	Research Approach
(Cherlow, 1981)	IVT*	Compared hypothetical waiting time savings with hypothetical IVT savings.
(Horowitz, 1981)	IVT*	Compared self-reported magnitude estimates (by burden) of trips with varied walking/waiting/IVT components.
(M. Wardman, 1998b)	Perceived IVT	Meta-analysis of common variables in 35 British studies dealing with waiting time valuations.
(M. Wardman, 2004a)	Perceived IVT	Regression models stemming from meta-analysis of common variables from 171 British studies of travel time valuation.
(Dziedkan & Kottenhoff, 2007)	Mean actual wait time†	Longitudinal survey of passengers' perceived waiting times before and after implementation of real time info signs. Cost comparison with achieving similar effect through schedule changes.
(Watkins et al., 2011)	Actual wait time	Regression analysis on ratio of perceived:actual waiting time. Asked respondents to estimate wait time at stops after roughly 5min actual waiting. Treatment (with real time info mobile app) and control (without app) groups.

*Framed as actual IVT in various hypothetical scenarios.

†Defined as ½ headway, a common assumption for high-frequency services.

Studies comparing perceived waiting time to perceived IVT have the practical data collection advantage of not requiring an external measurement of subjects' actual waiting time. (Heggie, 1976; Horowitz, 1981; Parsons Brinkerhoff Quade and Douglas, Inc., 1993; Reed, 1995; M. Wardman, 1998a) This fact can significantly simplify and speed data collection, making it a simple task of recruiting transit users to participate in a brief survey. Perceived waiting time-to-IVT comparisons have the additional benefit of allowing for direct comparisons between a variety of different strategies for improving the overall experience of using transit in specific circumstances. (Reed, 1995)

Studies comparing perceived waiting time to actual waiting time offer the ability to compare results based on a standard, external reference point. They also offer a direct

focus on the waiting experience, regardless of the quality of in-vehicle experience provided. This type of research requires an objective, external measurement of how long subjects actually wait. (Dziekan & Kottenhoff, 2007; Reed, 1995; Watkins et al., 2011)

This research adopts the recently prominent approach of comparing subjects' estimates of waiting times to external measures of their actual waiting times. Our approach stands apart from the studies described above, however, in using an onboard survey and at-station/stop video footage to consider participants' entire waiting experiences. The following chapter relates our research methods in detail.

3 - Methods

The research revolved around comparing transit riders' actual and self-estimated waiting times at 36 light rail, commuter rail and bus rapid transit stations, bus transit centers and curbside bus stops in the Twin Cities region. The authors then used regression analysis to explain the variation in riders' waiting time estimates as a function of their objectively observed waiting times, as well as station and stop amenities, while controlling for weather, time of day, self-reported and observed socio-demographic characteristics and trip characteristics.

3.1 Data Collection

Data collection comprised three primary tasks: an onboard survey of Twin Cities transit riders, a series of observations made from video footage of respondents' waiting time, and an audit of station and stop amenities, design characteristics, and surrounding environments. Each task produced one of three interconnected datasets. In addition, recognizing the importance of weather to the experience of using transit in Minnesota, each task was performed twice: once in winter/early spring and once in late spring/early summer.

3.1.1 Site Selection

The researchers selected 36 sites for data collection from around the Twin Cities regional transit system. Sites were chosen from a complete list of all 12,382 bus stops, 19 light rail stations, 7 commuter rail stations and 5 BRT stations in service in the Twin Cities as of the start of data collection.

The first step in site selection began with removing all bus stops with less than 50 average weekday boardings to allow for sufficient responses in a reasonable timeframe. This left a total of 703 transit stops and stations. The research also requires sites offering a full range of amenity levels from light rail stations to curbside bus stops, as well as a mix of urban and suburban locations, attractive and unattractive surrounding environments. The second step in the selection process comprised the development of a classification scheme based upon station/stop type, neighborhood type, urban vs. suburban location, and pleasantness:

Station/Stop Type Starting from a combined shapefile of bus stops and transitway stations, we created a set of dummy variables to identify each record as a transitway station (including LRT, commuter rail and online BRT stations), a transit center (a site-built building served by multiple bus routes but not a transitway), an unimproved curbside stop (with no amenities provided; also known as a "pole-in-the-ground" stop) or an improved curbside stop (a bus stop located on a public street, but with at least some amenity such as a shelter or bench provided as part of the stop). We also identified stops located at park-and-ride facilities and added variables identifying modes for the transitway stations.

Saint Paul Union Depot was considered a transit center for the purposes of this study as the Metro Green Line was not yet in operation. In addition, due to physical separation of

local bus, light rail, and BRT waiting/boarding areas, each transit mode at the Mall of America was considered a separate site.

Neighborhood type In addition to a variety of stop types, we also selected stops to obtain a balance of primarily residential and primarily commercial surrounding areas, so as to account for any differences in perceptions based on neighborhood activity character or level. This step involved aggregating the specific residential, commercial and industrial land use categories in the Metropolitan Council's current land use shapefile into overall "Residential" and "Commercial" categories, then producing a 100m buffer around each stop and station (chosen as a rough measure of immediate surroundings within sight), and calculating the largest land use within each buffer. Due to the areas taken up by transitway alignments and the major roads that are often beside them, many transitway stations end up with "Transportation Infrastructure" as the dominant land use, even though the surrounding neighborhoods are arguably more defined by the non-transportation uses waiting passengers see. For these stations, the largest non-transportation land use was substituted.

Urban vs. suburban All sites were also classified as either urban or suburban based on the bus stops/transitway stations layer and the municipality they are located in. Urban stops are located in Minneapolis or Saint Paul. Suburban stops are located in any other municipality in the 7 county metro area.

Pleasantness The final classification step involved identifying the specific central city neighborhood or suburb each site is located in. We then assigned a simple, "Low", "Medium" or "High" pleasantness score based on the general character of the neighborhood or suburb. This is not a precisely calculated audit, (done in detail once sites were selected) but a rough, at-a-glance assessment to speed the selection process. Factors including sidewalk presence/width, amount and location of off-street parking, tree cover, enclosure of street scenes, architectural variety and ground floor windows were considered generally, and in more detail in cases of difficult decisions. To obtain the maximum pleasantness variation possible, we excluded neighborhoods and suburbs with a medium pleasantness score and focused on those with either high or low pleasantness.

All sites were then organized into a single spreadsheet, with one worksheet for each stop type/neighborhood type combination. Each sheet was sorted first by boardings, then by pleasantness, producing three pleasantness categories, each in order of ridership. The example of each type/neighborhood/pleasantness combination with the highest ridership was placed in the site matrix, with its direction (if applicable), its city and its average daily boardings. At this point, the authors employed Google street view to verify the applicability of neighborhood-level pleasantness categories for each highest-ridership example, with the scene at a particular site allowed to override the neighborhood level category if appropriate. Table 3-1 shows the final classification of sites; Figure 3-1 shows the distribution of study sites across the region.

Table 3-1: Site selection matrix

		Pleasant-ness	Station/Stop Types - Sub-categories roughly based on degree of integration with/insulation from surrounding street scene.						
			Transitway Station		Bus transit center		Curbside Stop		
			Walk-up	Park-and-ride	Walk-up	Park-and-ride	Unimproved	Improved	
Surrounding Land Use	Downtown	High	Urban	Nicollet Mall LRT	n/a	Union Depot	n/a	7th St & Nicollet (NB, Mpls)	8th St S & Lasalle St/Nicollet Mall (EB, Mpls)
		Mid	Urban	Target Field	n/a	Minnesota & 6th St (StP)	n/a	Smith Ave & Ramp Exit/Kellog (WB, StP)	LaFayette Rd & University Ave (SB, StP)
		Low	Urban	Downtown East-Metrodome LRT	n/a	n/a	n/a	10th St N & Twins Way (Mpls)	4th St S & Chicago Ave/Kirby Puckett Dr (EB, Mpls)
	Residential Neighborhood	High	Urban	50th St LRT (NB)	n/a	n/a	n/a	Como Ave SE & 22nd Ave SE (WB, Mpls)	University Ave SE & 25th/26th Ave (WB, Mpls)
			Suburban	n/a	n/a	n/a	117th Ave P & R (Champlin)	Harding St & 39th Ave N (SB, St Anthony)	n/a
		Mid	Urban	n/a	n/a	n/a	n/a	7th St N & Girard Ave (SB, Mpls)	7th St W & W Maynard Dr (NB, StP)
			Suburban	140th St BRT	Cedar Grove BRT	n/a	n/a	n/a	Minnetonka Bvd & Louisiana Ave (EB, St Louis Pk)
		Low	Urban	46th St & 35W BRT	n/a	n/a	n/a	n/a	n/a
			Suburban	n/a	Coon Rapids CR (SB)	n/a	n/a	Oakdale Ave & Wentworth Ave (NB, W StP)	University Ave & Mississippi St (SB, Fridley)
	Commercial/ Industrial	High	Urban	46th St LRT	Lake St LRT	Uptown TC (NB, Mpls)	n/a	Franklin Ave E & Chicago Ave (WB, Mpls)	University Ave & Snelling Ave (EB, StP)
			Suburban	n/a	28th Ave LRT	n/a	n/a	n/a	n/a
		Mid	Urban	Cedar-Riverside LRT	n/a	n/a	South Bloomington TC (Bloomington)	Lyndale Ave N & W Broadway (NB, Mpls)	Emerson Ave N & W Broadway (NB, Mpls)
			Suburban	Bloomington Central LRT	AVTS BRT (NB)	Robbinsdale TC (190)	n/a	n/a	Nicollet Ave S & 66th St (NB, Richfield)
		Low	Urban	Franklin Ave LRT	n/a	Sunray TC (StP)	n/a	Olson Mem Hwy & 7th St N (WB, Mpls)	1st Ave S & Lake St (NB, Mpls)
			Suburban	MOA LRT	Ramsey CR	MOA (Bus Transit Center)	Louisiana Ave TC (St Louis Pk)	American Blvd @ Walmart (WB)	Snelling Ave & CR B (SB, Roseville)

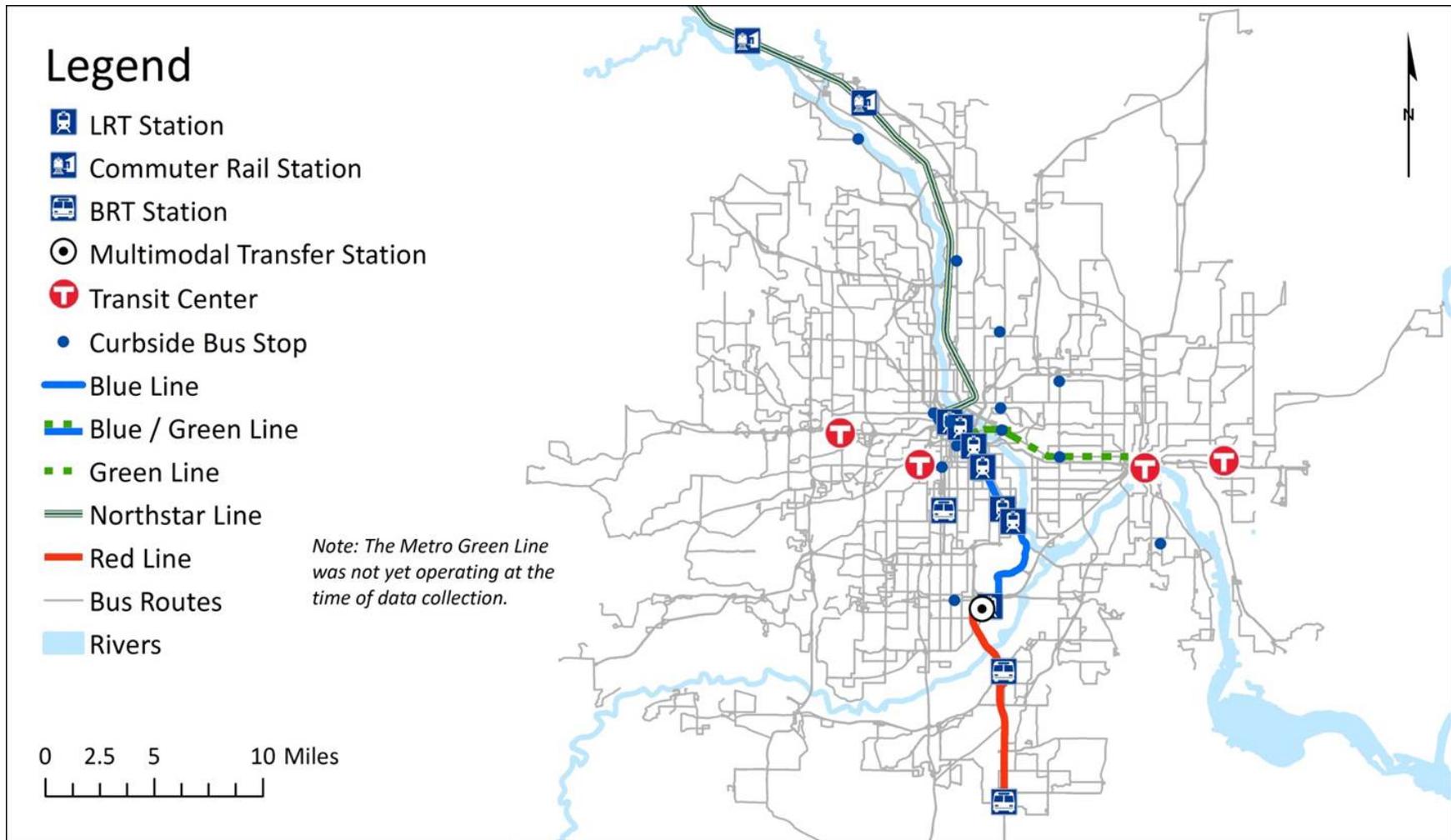


Figure 3-1: Data collection sites

3.1.2 Onboard Survey

The first primary data collection task was a brief survey of Twin Cities transit riders who boarded trains or buses at study sites. The survey was conducted during July and August, 2013, and February, March and April, 2014.

To allow respondents to complete their entire waiting period as they normally would, recruiting and survey administration took place on board transit vehicles after all passengers had boarded. Survey team members waited unobtrusively at the station/stop, positioned themselves at the back of the boarding queue, and boarded with passengers. Once on board they recruited as many passengers who had just boarded as possible.

The survey questionnaire began with the key question “How many minutes do you think you waited at the station/stop before you boarded this train/bus?” This question captured the respondent’s estimated waiting time—used a measure of their perception. (Please see Appendix A for the full survey questionnaire.) Where applicable, questions used wordings and answer choices/formats based on the Metropolitan Council’s onboard survey. The questionnaire was self-administered in writing, and also collected basic information on:

- Perceptions of the “pleasantness” of the station/stop,
- Forms of schedule information used (pocket schedules, real-time information app, etc.),
- Approximate trip origin and destination,
- Primary activities at origin and destination,
- Access and planned egress modes,
- General travel behavior, and
- Basic demographic information.

Upon collecting each completed questionnaire, surveyors (with respondents’ permission) took a photograph of each respondent holding up their questionnaire, with a preprinted ID number visible. These photographs enabled the visual identification of respondents without the need to collect any information from which their names could be determined. (Please see Appendix B for the survey protocol used during data collection.)

Each site was surveyed during each of four time periods as defined by Twin Cities Metro Transit: Morning Peak (6:00-9:00am), Mid-day Off-Peak (9:01am-2:59pm), Evening Peak (3:00-6:30pm) and Late Evening Off-Peak (after 6:30pm). Each site was visited in each time period until either four responses had been obtained for that site/time combination or three visits had been made.

In preparation for data collection, transit police were informed of the research, and drivers on routes effected were notified via a drivers’ bulletin from either Metro Transit or MVTA, as appropriate. Survey teams were issued a letter of introduction on either Metro Transit or MVTA letterhead (depending on the route involved) which detailed the purpose of the research, that it was being conducted with the transit provider’s full support and permission,

and making clear that participation was strictly voluntary. This letter was offered to all respondents, and any member of the public with questions about the research. (Please see Appendix C for an example letter of introduction.)

3.1.3 Respondent Observations

The second data collection task involved unobtrusively recording video footage of potential respondents during their wait for the train or bus, and making a series of observations about those who elected to participate from the video. Videographers were instructed to be “unobtrusive, not surreptitious”, and to freely identify themselves and the purpose of the research if asked by a member of the public. (Please see Appendix D for the video recording protocol used during data collection.)

The photographs taken of respondents with their questionnaires were used to connect survey responses with observations, and to assign each set of observations an ID number later used to merge the two data sets. Once a respondent was identified arriving at the station or stop, a researcher recorded the counter time in the video file. During video playback, the researcher made a series of observations about the respondent, including:

- Demographics—gender, race, approximate age, etc,
- Manner of dress,
- Items carried,
- Mobility devices, if any,
- Activities engaged in while waiting, and
- Travelling companions, if any.

Finally, the researcher recorded the counter time at which the respondent boarded the train or bus. The difference between this observation and the initial arrival time observation provided the observed waiting time for use in analysis. (Please see Appendix E for the observation protocol used during data collection.)

3.1.4 Waiting Environment Audit

To obtain a standardized list of amenities and design features present at data collection sites, as well as information on surrounding environments, the researchers also conducted a waiting environment audit of each data collection site. Based on the common practice of pedestrian environment audits, the audit tool included both quantitative information (identifying the presence/absence/prevalence of features) and qualitative information (identifying the auditor’s perception of a given quality using a four-part Likert scale ranging from “Not at all”, “Somewhat”, “Mostly”, to “Very” for each quality). Specific topics covered by the audit included:

- The physical layout of the waiting area (separation from surrounding pedestrian flow, boarding from curb vs. transit platform, etc.),
- Shelter provided,

- Seating,
- Other amenities such as water fountains or restrooms,
- Overall physical comfort,
- Route and schedule information provided,
- Maintenance,
- Visual appeal,
- Traffic level,
- Neighborhood security,
- Noise and air quality, and
- Overall perception of pleasantness.

The audit was conducted concurrently with the other data collection tasks, and was repeated during the winter for sites at which winter survey data collection took place with snow on the ground. The winter audit also included questions on snow removal. To lessen the influence of individual bias, each site was audited by two members of the research team, one male and one female; each site received the average of both auditors' responses in the final data. (Please see Appendix F for the full audit instrument used during data collection.)

3.2 Connecting the Data

The analysis forming the heart of the research hinged on connecting the onboard survey data and video observation data at the individual level, and connecting the result to the audit data at the site/season level. The former task (by far the most difficult) depended on the photograph of the respondent holding up their questionnaire. This photograph linked the respondent's appearance to the unique ID number printed on the front of the questionnaire. Through this link, we were able to connect each respondent's answers to our observations of their waiting time from the video footage. Figure 3-2 shows the process of merging the three data sets.

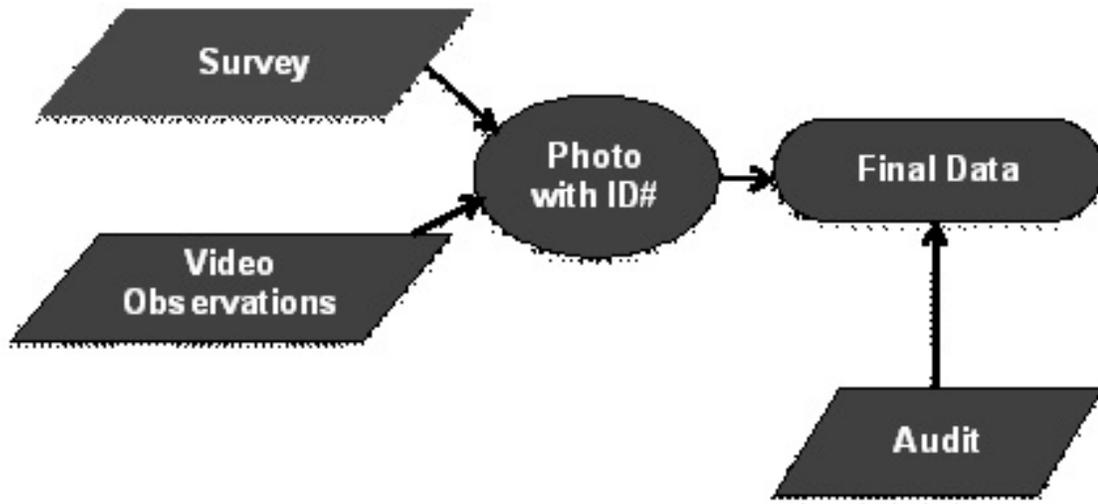


Figure 3-2: Data organization

4 - Results

The survey produced a total of 986 responses—482 collected in the summer, and 504 in the winter/early spring. Of these cold weather responses, 325 were collected with persistent snow cover on the ground, and 179 after the first thaw of the season. (See Figure 4-1.)

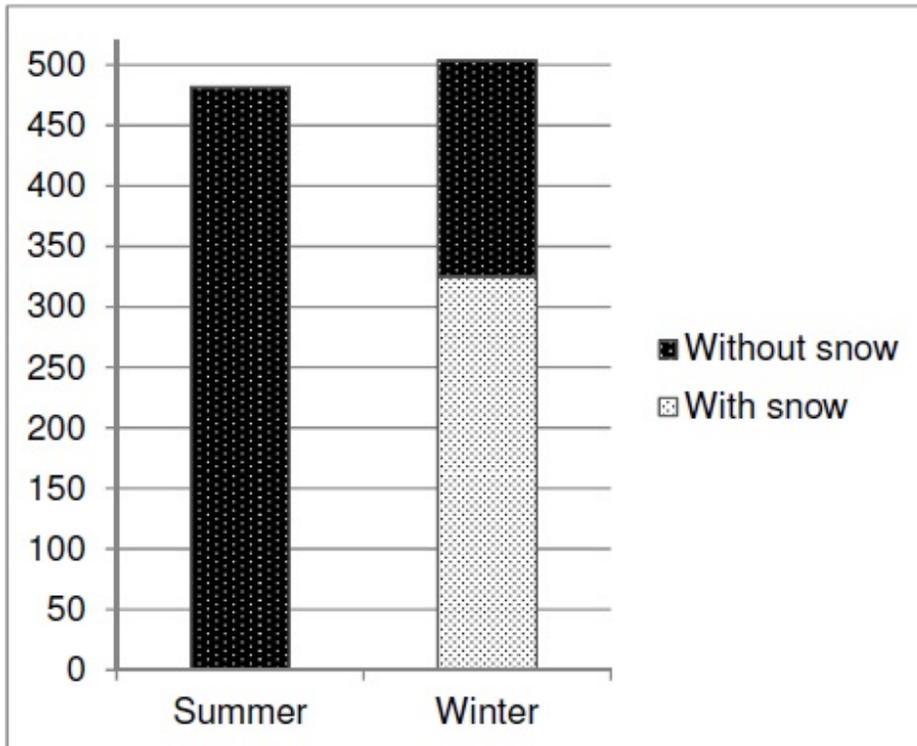


Figure 4-1: Responses by season

Connecting these responses to their corresponding surveys frequently proved difficult. The layouts of some data collection sites (particularly the Mall of America bus transit center) are inherently difficult to cover adequately with video, even using multiple cameras. Some survey respondents failed to hear (or simply ignored it) when survey team members invited only passengers who had boarded at the previous stop to participate. As a result, these respondents' survey responses are unusable. Other respondents left the crucial "How long do you think you waited" question blank, also rendering their remaining responses unusable for lack of a dependent variable.

All this leaves 822 valid responses, for which the respondent was successfully identified in video footage, and for which the questionnaire was substantially complete, including an estimate of waiting time. Figure 4-2 to Figure 4-5 provide a sample distribution. The sample is, perhaps not surprisingly, composed heavily of population groups likely to use transit, particularly low-income riders, people belonging to minority racial or ethnic groups and riders without cars.

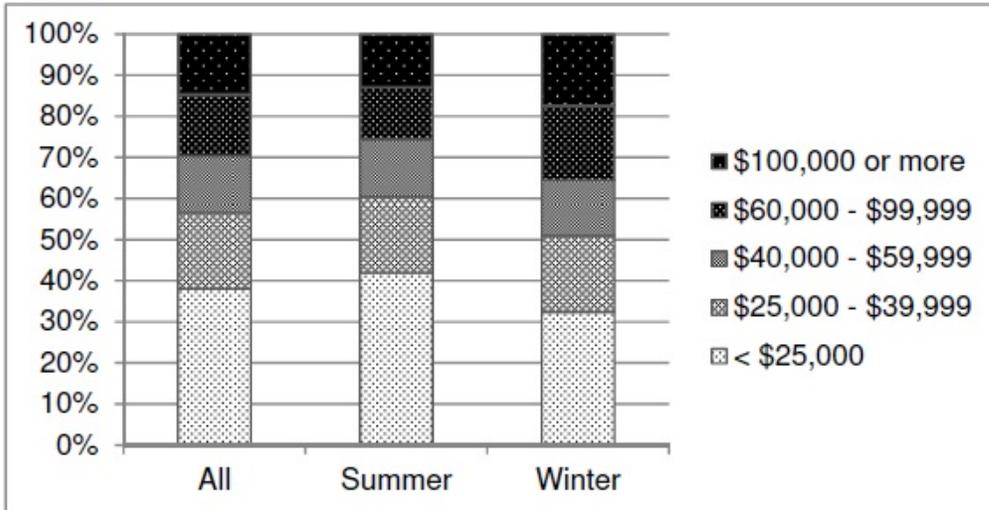


Figure 4-2: Household income

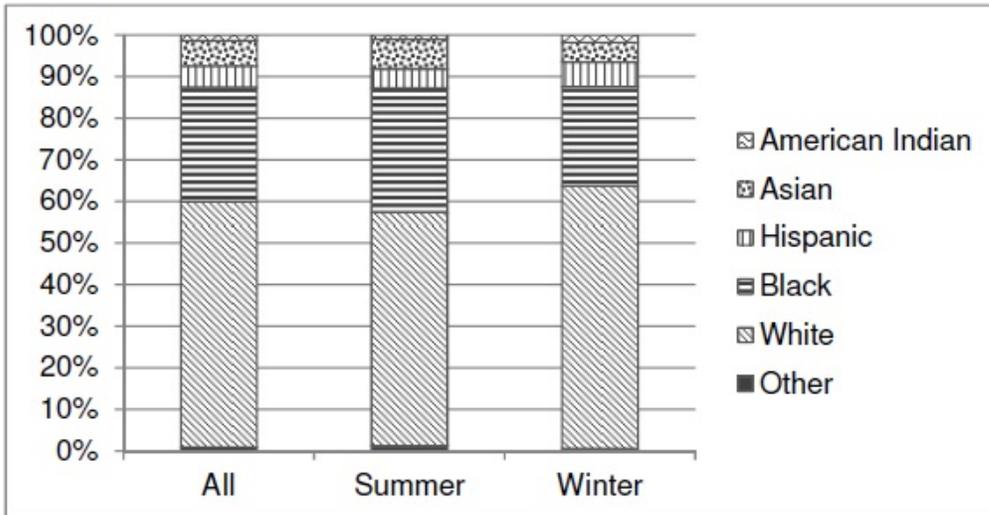


Figure 4-3: Respondents' race

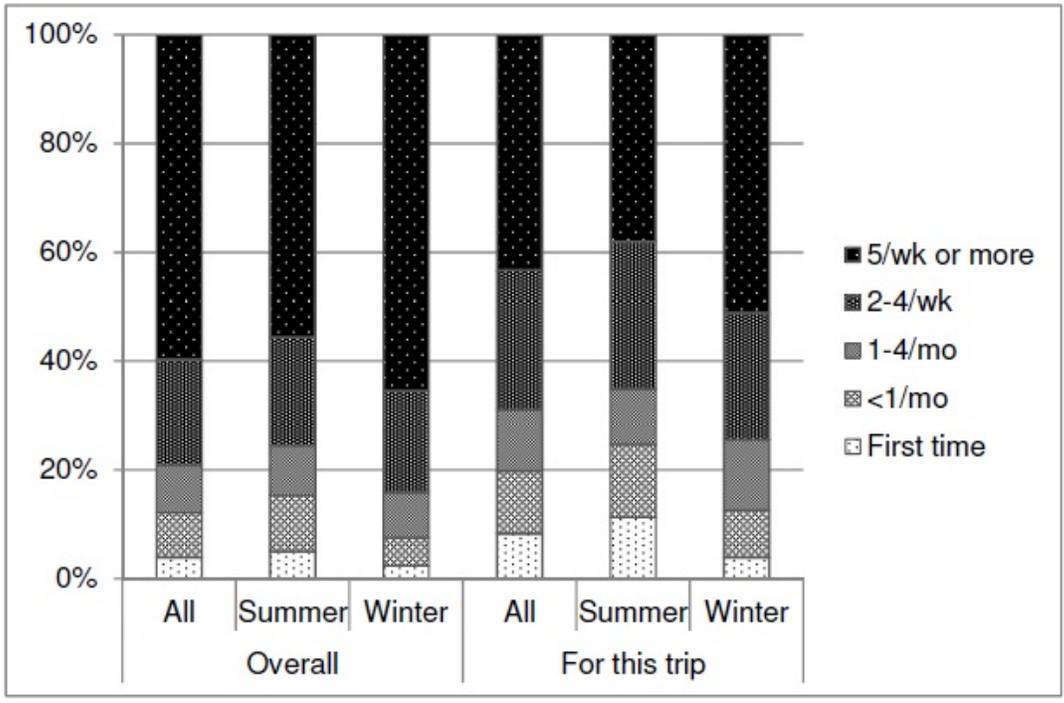


Figure 4-4: Frequency of transit use

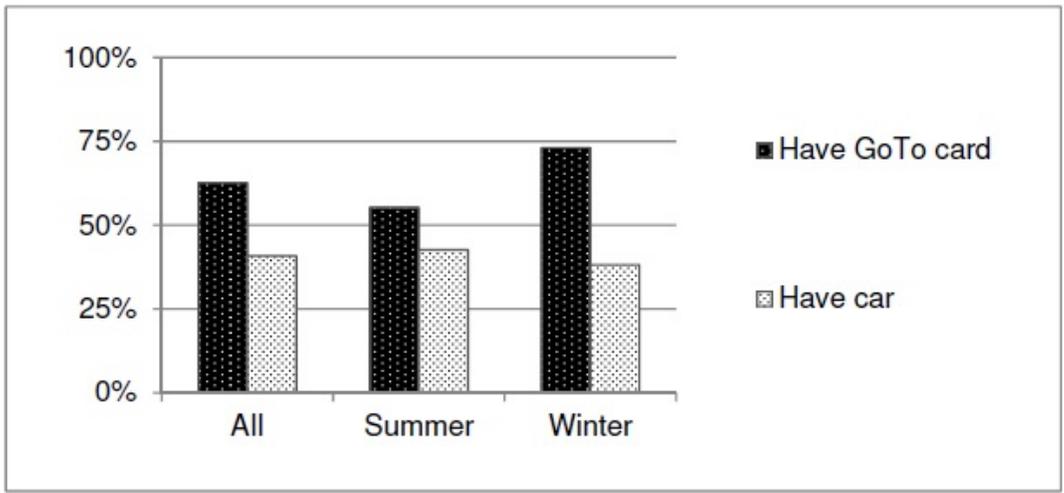


Figure 4-5: Transit pass/auto ownership

Figure 4-6 is a histogram showing percentages of Observed Wait Time in five-minute increments. Significantly, just over half of all responses have observed waiting times between zero and five minutes. Roughly a third of responses have Observed Wait Time values in the five-to-ten minute range, with much smaller percentages for Observed Wait Time values of greater than ten minutes.

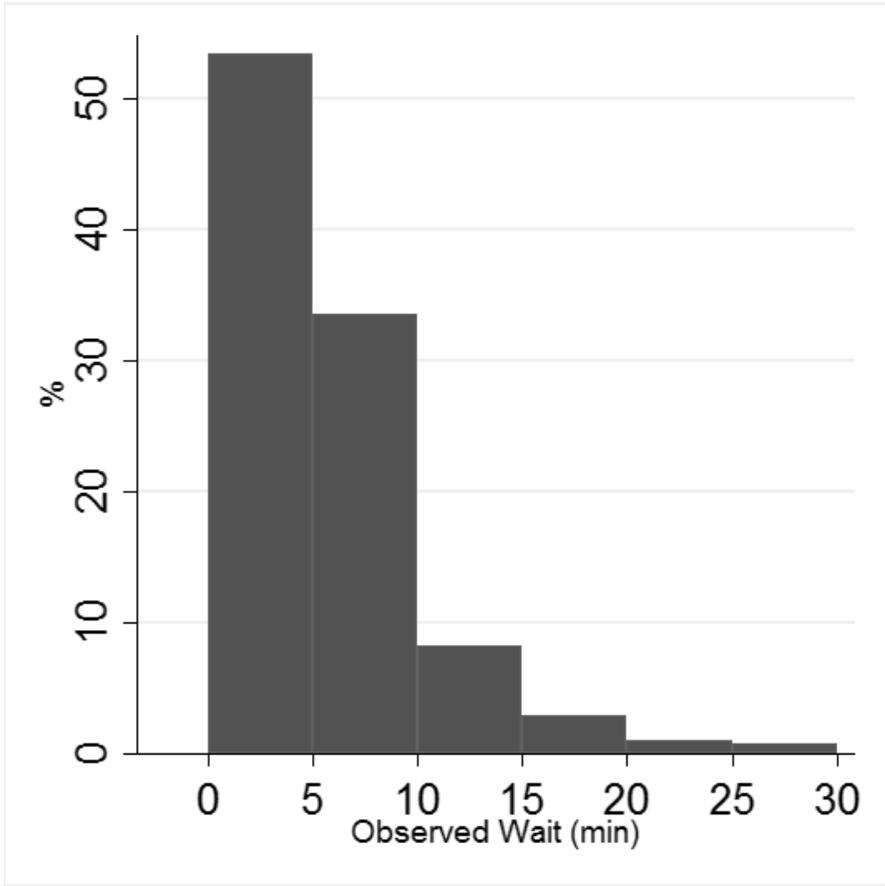


Figure 4-6: Histogram of observed waiting time

Figure 4-7 shows the observed (on the x-axis) versus estimated (on the y-axis) waiting times of each individual respondent. There appears to be significant variation in the relationship between estimated and observed waiting times. Overall, the trend appears to be one of passengers overestimating their waiting times, with heavy clustering of points above and to the left of the $x = y$ line—which supports the basic premise of the research. It is also interesting to note the clusters of estimates at 5, 10 and 15 minutes. This trend is likely due to a tendency to use round numbers in estimation.

Figure 4-8 shows a box plot of the ratio of Estimated Wait Time to Observed Wait Time in five-minute increments of Observed Wait Time. For each increment, the box shows the Inter-Quartile Range (IQR) and the “whiskers” above and below the box indicate values within 1.5 IQR of the near quartile; points show values outside this range. For zero to five minutes of Observed Wait Time (a majority of the sample), Estimated Wait Time shows a significant trend of over-estimates, with a low near-quartile of 1, a median of roughly 1.3 and

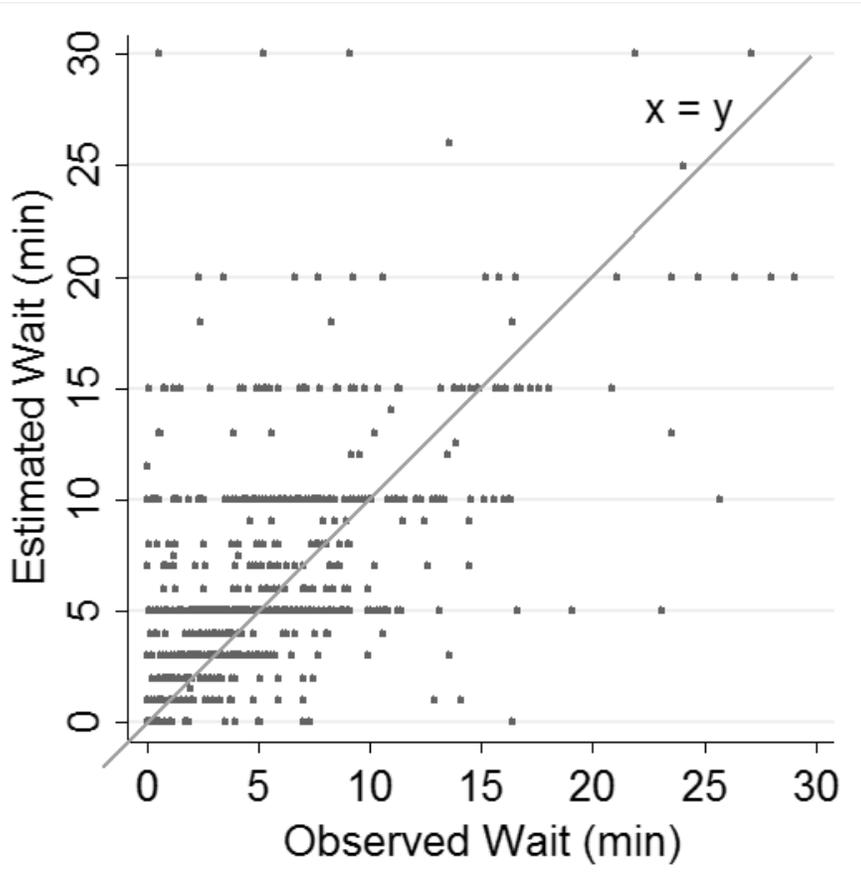


Figure 4-7: Estimated waits versus observed waits

an upper near quartile of nearly 2. The upper whisker reaches nearly to 3.5, indicating a significant minority of large overestimates. Estimates tend to be more accurate for longer observed waits: 5-10 minutes of observed waiting time produces a median ratio close to 1, though the high near quartile extends considerably farther from the median than the low near quartile. Longer observed waits produce even more accurate estimates, but, as shown in Figure 1a, account for only a small percentage of responses.

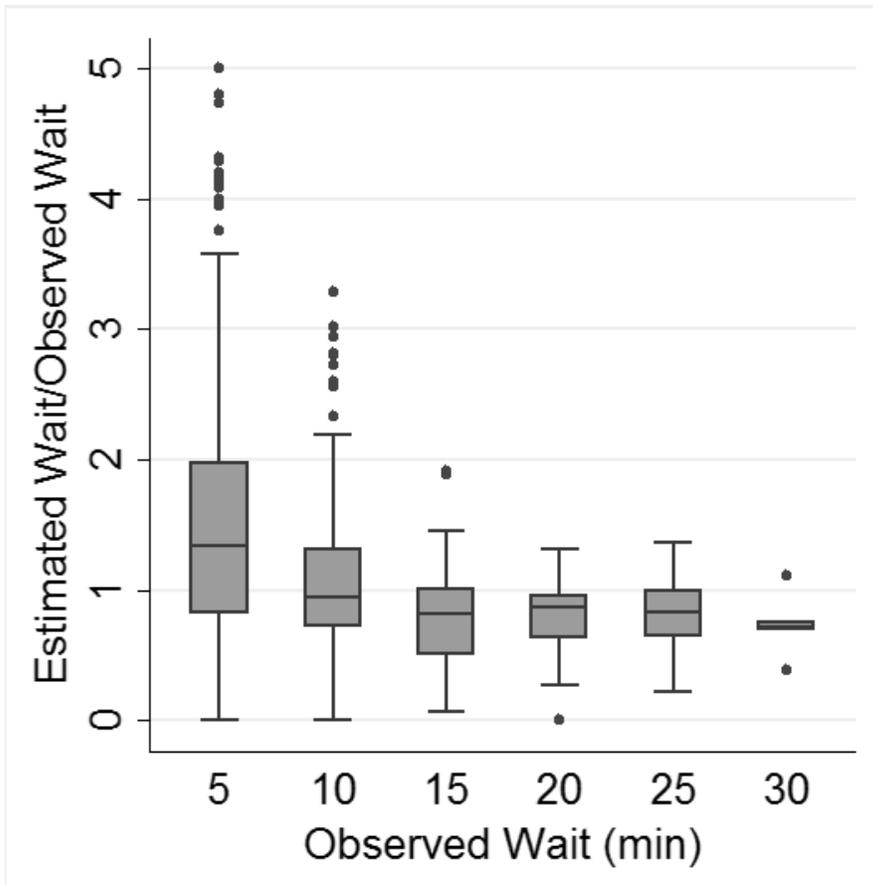


Figure 4-8: Estimated/observed wait ratios by observed waits

4.1 Regression Models

The three data sets were merged and used to estimate a log-log regression model with interaction terms using the equation: $y = c + \beta_1 x_1 + \beta_2 x_2 + \beta_1 x_1 \beta_2 x_2 + \dots + \beta_i x_i + \beta_{1i} (x_1 \cdot x_i) + e$, where y equals the natural logarithm of Estimated Wait Time (with 0.01 added to the raw variable to avoid losing 0 values), x_1 equals the natural logarithm of Observed Wait Time (also with 0.01 added), and x_2 through x_i equal a set of binary explanatory variables.

4.1.1 Original Model

The first model we estimated included the following explanatory variables:

Fun Destination—A respondent who identified the primary activity at their destination as “Social”, “Recreation” or “Eat Out”.

Other Personal Destination—A respondent who identified the primary activity at their destination as “Personal Business”, “Shopping” or any other non-commute destination besides returning home.

Home Destination—A respondent who identified the primary activity at their destination as “Return Home”. Included (along with the two above) to account for potential differences in waiting time estimates by trip purpose. Commutes to work or school are omitted as the reference category.

Transfer—A respondent who arrived at the station or stop by train or bus and transferred to the route on which he/she was surveyed. Included due to existing research indicating high perceived disutility of transfers.

Mid-Day—A trip made between 9:01am and 2:59pm, the mid-day, off-peak service period, as defined by Metro Transit.

Evening Peak—A trip made between 3:00pm and 6:30pm, the evening peak service period, as defined by Metro Transit.

Late Evening—A trip made after 6:30pm, the late-evening, off-peak service period, as defined by Metro Transit. Included (along with the two above) to account for potential differences in perceptions of time throughout the service day. “Morning Peak”, 6:00am to 9:00am, was omitted as the reference.

Above 85-degree High—Response collected on a date with a daytime high ambient temperature greater than 85 degrees Fahrenheit. Included to account for potential differences in perceptions due to unpleasant temperatures. (Note earlier model runs also included a variable for sub-freezing high temperatures. Neither it nor its interaction term was significant.)

Real-time Information Sign—An electronic display giving passengers real-time arrival/departure information. Included due to existing research on time perception impacts of real-time information.

Posted Schedule—A full, detailed schedule displaying scheduled departure times for the routes serving the station or stop. Included due to the greater prevalence of printed schedules (compared with real-time signs) in the Twin Cities.

Bus Shelter—A free standing, pre-fabricated metal bus shelter. Included as an amenity.

Premium Shelter—A large, site-built shelter, either fully or partially enclosed. Included as an amenity.

Bench—A bench provided as part of the transit station or stop. Included as an amenity.

Route Map—A posted map showing where routes serving the station or stop go. Included as an amenity

Female—Female respondent. Included to account for potential gender differences in time perceptions.

Not/Somewhat Safe—A station or stop rated as “Not safe at all” or “Somewhat safe”. Included due to research showing users place high importance on security at transit stations and stops.

Female & Not/Somewhat Safe—The interaction of “Female” and “Not/Somewhat Safe”. Included to account for gender differences in perceptions of personal security.

Minority—Non-white and/or Hispanic respondent. Included to account for cultural differences in transit use and perceptions of transit. (Note: Variables identifying individual minority groups were insignificant in early model runs.)

Age 35-49—A respondent estimated to be between 35 and 49 years old.

Age 50-64—A respondent estimated to be between 50 and 64 years old.

Age 65+—A respondent estimated to be 65 years or older. Included (along with the preceding two) to account for generational differences in transit use patterns. “Young” (18-34) was omitted as the reference.

Each base variable was also interacted with $\ln(\text{Observed Wait})$ (i.e., x_1) to capture the change in its relationship with $\ln(\text{Estimated Wait})$ over objective time, with the exception that “Young” (age 18-34) and was omitted as the reference age group. Young is the modal age group of the survey sample; omitting this category allows us to consider the most common respondent (in terms of age) as a baseline, and compare other respondent to that baseline.

Female and Not/Somewhat Safe were not interacted with $\ln(\text{Observed Wait})$ individually in the final model to avoid potential multicollinearity issues. The raw Estimated Wait variable has a mean of 6.86 minutes, with a median of 5 minutes. Raw values of Observed Wait are shorter as a group, with a mean of 5.81 minutes and a median of 4.62 minutes. That is, the estimated wait time on average is about 1.18 times longer than the observed wait time. All dummy variables except Posted Schedule, Premium Shelter and Bench have a mode of zero.

The model (as shown in Table 4-1) includes 729 observations and achieves an adjusted R^2 of 0.328. $\ln(\text{Observed Wait})$ is significant, and, as expected, has a positive coefficient, indicating that longer observed waiting times are related to longer estimated waiting times. The Fun and Other Personal trip destination categories are significant, along with their interaction terms. In both cases, the base variable’s coefficient is positive, with a negative interaction coefficient, indicating a higher intercept, but lower slope with a value of 1 than with a value of zero. Mid-day is significant, with a positive coefficient; while Evening Peak is not significant, its interaction term is, with a negative coefficient. The interaction term of Above 85-degree High is also significant, with a positive coefficient.

Among the station/stop amenities considered, Posted Schedule, Bus Shelter and Premium Shelter are significant, along with their interaction terms. Posted Schedule has a positive base coefficient and a negative interaction coefficient, while Bus Shelter and Premium Shelter both produce negative base and positive interaction coefficients. The interaction term of Bench, and the base term of Route Map are also significant, with negative coefficients.

Table 4-1: Initial regression model

Response Variable: ln(Estimated Wait)		N=	729
		Adj R-	0.3279
		β	
ln(Observed Wait)			0.5934***
Trip Characteristics	Fun Destination	-	0.3676*
	Fun Destination*ln(Observed Wait)		0.2235*
	Other Personal Destination	-	0.8032***
	Other Personal Destination*ln(Observed Wait)		0.5208***
	Home Destination		0.3072
	Home Destination*ln(Observed Wait)	-	0.062
	Transfer		0.2266
	Transfer*ln(Observed Wait)		0.0018
	Mid-Day		0.3178*
	Mid-Day*ln(Observed Wait)	-	0.0914
	Evening Peak		0.3217
	Evening Peak*ln(Observed Wait)	-	0.2493**
	Late Evening	-	0.2093
	Late Evening*ln(Observed Wait)		0.1224
Above 85-degree High	-	0.1355	
Above 85-degree High*ln(Observed Wait)		0.1914*	
Amenities	Real-time Information Sign	-	0.1267
	Real-time Information Sign*ln(Observed Wait)		0.0439
	Posted Schedule		1.0041***
	Posted Schedule*ln(Observed Wait)	-	0.4365**
	Bus Shelter	-	1.9796***
	Bus Shelter*ln(Observed Wait)		0.8761***
	Premium Shelter	-	1.4202***
	Premium Shelter*ln(Observed Wait)		0.6081***
	Bench		0.254
	Bench*ln(Observed Wait)	-	0.2064**
Route Map	-	0.4231**	
Route Map*ln(Observed Wait)		0.2117	
Respondent Characteristics	Female	-	0.0415
	Not/Somewhat Safe		0.0326
	Female & Not/Somewhat Safe	-	0.5240**
	Female & Not/Somewhat Safe*ln(Observed Wait)		0.2662**
	Minority		0.4397***
	Minority*ln(Observed Wait)	-	0.2677***
	Aqe 35-49		0.1812
	Aqe35-49*ln(Observed Wait)	-	0.1104
	Aqe 50-64		0.4575**
	Aqe 50-64*ln(Observed Wait)	-	0.2607*
Aqe 65+		1.2765***	
Aqe 65+ *ln(Observed Wait)	-	0.7181***	
Constant		0.7743***	

Legend: * p<.1; ** p<.05; ***p<.01

Among the respondent characteristics variables, it appears particularly notable that Female and Not/Somewhat Safe are both insignificant on their own, but that their interaction is significant, along with its interaction with $\ln(\text{Observed Wait})$. Minority and its interaction term are significant, with positive base and negative interaction coefficients. Age 50-64 and Age 65+ and their interactions are also significant.

4.1.2 Revised Model

The initial model was highly complex, due in part to the large number of interaction terms. In addition, common “amenity mixes”—sets of stop features, such as a shelter and a posted schedule, that commonly occur together—raised concerns about possible multicollinearity among the explanatory variables. Apart from these issues, the initial model did not take into account aspects of the waiting experience, such as an activity engaged in while waiting or traveling companion, that might alter respondents’ perceptions of time.

To address these concerns, we estimated a revised model, with fewer interaction terms, less correlation among amenity variables and a more even balance of physical and experiential variables. The revised model keeps the same response variable $\ln(\text{Estimated Wait})$, and also includes $\ln(\text{Observed Wait})$ as an explanatory variable, along with the following:

Rail†—A response collected on a light rail or commuter train. Included to account for modal differences in passengers’ perceptions.

Hi-Frequency—A response collected on a route included in Metro Transit’s Hi-Frequency network of arterial routes with all-day guaranteed short headways.

Shelter†—A stop or stop/station with some form of shelter provided for waiting passengers. Included as an amenity. (The original model showed very little difference in the effects of “basic” and “premium” shelters; in addition, Real-time Information Sign was strongly correlated with Premium Shelter, potentially accounting for its failure to achieve significance. In the revised model, we combine all shelter types

Bench†—A bench provided as part of the transit station or stop. Included as an amenity.

Real-time Information Sign†—An electronic display giving passengers real-time arrival/departure information. Included due to existing research on time perception impacts of real-time information.

Senior†—A respondent estimated to be 65 years or older. Included (along with the preceding two) to account for generational differences in transit use patterns.

Female—Female respondent. Included to account for potential gender differences in time perceptions.

Not/Somewhat Safe—A station or stop rated as “Not safe at all” or “Somewhat safe”. Included due to research showing users place high importance on security at transit stations and stops.

Female & Not/Somewhat Safe†—The interaction of “Female” and “Not/Somewhat Safe”. Included to account for gender differences in perceptions of personal security.

Minority†—Non-white and/or Hispanic respondent. Included to account for cultural differences in transit use and perceptions of transit. (Note: Variables identifying individual minority groups were insignificant in early model runs.)

Knew Schedule†—A respondent who reported having known the schedule in advance of boarding. Included to account for the potential effects of a known length of wait on time perceptions.

Transfer—A respondent who arrived at the station or stop by train or bus and transferred to the route he/she was surveyed on. Included due to existing research indicating high perceived disutility of transfers.

Utilitarian Personal Destination—A respondent who identified the primary activity at their destination as “Personal Business”, “Shopping” or any other non-commute destination besides returning home.

Recreational Destination—A respondent who identified the primary activity at their destination as “Social”, “Recreation” or “Eat Out”.

Mid-Day—A trip made between 9:01am and 2:59pm, the mid-day, off-peak service period, as defined by Metro Transit.

Evening Peak—A trip made between 3:00pm and 6:30pm, the evening peak service period, as defined by Metro Transit.

Late Evening—A trip made after 6:30pm, the late-evening, off-peak service period, as defined by Metro Transit. Included (along with the two above) to account for potential differences in perceptions of time throughout the service day. “Morning Peak”, 6:00am to 9:00am, was omitted as the reference.

Traveled Alone—A respondent who had no traveling companions according to observations made from video footage. Included to account for time perception impacts of solitude versus companionship.

Activity—A respondent who engaged in some type of activity while waiting other than sitting, standing, looking for the bus, etc. Included to account for the time perception impacts of diversion.

Winter—A response collected during the winter data collection period, spanning early February through early April, 2014. (Though temperatures and continuity/depth of snow cover vary, this entire period can functionally be considered winter in Minnesota.) Included to account for weather-linked differences in perceptions.

Variables identified by † were also interacted with $\ln(\text{Observed Wait})$ (i.e., x_1) to capture the change in its relationship with $\ln(\text{Estimated Wait})$ over objective time. The raw Estimated Wait variable has a mean of 6.79 minutes, with a median of 5 minutes. Raw values of Observed Wait are shorter as a group, with a mean of 5.66 minutes and a median of 4.5 minutes. That is, the estimated wait time on average is about 1.18 times longer than the observed wait time. All dummy variables except Hi-Frequency, Shelter, Bench, Knew Schedule and Traveled Alone have a mode of zero.

Table 4-2: Revised regression model

Response Variable:		N=703
ln(Estimated Wait)		Adi. R2: 0.32
Explanatory Variables:		β
	ln(Observed Wait)	0.6797***
Transit Service	Rail	- 0.3049
	Rail*ln(Observed Wait)	0.0989
	Hi-Frequency Network Route	0.1784
Amenities	Shelter	- 0.6227***
	Shelter*ln(Observed Wait)	0.3392***
	Bench	0.2584
	Bench*ln(Observed Wait)	- 0.2064**
	Real-time Sign	- 0.2942**
	Real-time Sign*ln(Observed Wait)	0.0804
Respondent Characteristics	Senior Respondent	1.1554***
	Senior Respondent*ln(Observed Wait)	- 0.5810**
	Female Respondent	- 0.0526
	Not/Somewhat Safe Environment	- 0.1105
	Female & Not/Somewhat Safe Enviro.	- 0.6740**
	Female & Not/Somewhat Safe Enviro.*ln(Observed Wait)	0.4334***
	Minority Respondent	0.4637***
	Minority Respondent*ln(Observed Wait)	- 0.2988***
Trip Characteristics	Knew Schedule in Advance	0.6395***
	Knew Schedule in Advance*ln(Observed Wait)	- 0.2985***
	Transferred from Another Route	0.2643**
	Utilitarian Personal Destination	- 0.1687
	Recreational Destination	- 0.2526
	Mid-Day Trip	0.3414**
	Evening Peak Trip	0.2415*
	Late Evening Trip	0.2505
	Traveled Alone	0.3031***
	Engaged in an Activity while Waiting	- 0.0941
	Winter Trip	- 0.1758
Cons.	0.3089	

Legend: * $p < .1$; ** $p < .05$; *** $p < .01$

The revised model (as shown in Table 4-2) includes 703 observations (16 fewer than the original model due to some passengers' activity while waiting being unobservable from the video footage) and achieves an adjusted R^2 of 0.32—very similar to the original model. $\ln(\text{Observed Wait})$ is significant, and, as expected, has a positive coefficient, indicating that longer observed waiting times are still related to longer estimated waiting times. None of the transit service variables is significant, indicating that, as intended, the model explains variations in estimated wait time as a function of physical and environmental characteristics of stops.

Among the station/stop amenities considered, Shelter is significant and negative, though with a positive, significant interaction term. Bench is insignificant, but produces a significant,

negative interaction, indicating that seating has little initial effect on waiting time perceptions but serves to moderate perceptions of longer waits. Real-time Sign has a significant, negative base term, but an insignificant interaction, indicating an initial shortening of perceived waits but no effect on the rate of increase for longer waits.

Mid-day and Evening Peak are significant, with positive coefficients. Interestingly, considering Minnesota weather, Winter Trip is insignificant.

Among the respondent characteristics variables, it is particularly notable that Female and Not/Somewhat Safe are both insignificant on their own, but that their interaction is significant, along with its second-order interaction with $\ln(\text{Observed Wait})$. Minority and its interaction term are significant, with positive base and negative interaction coefficients. Senior Respondent and its interaction is also significant.

4.2 Model Predictions

Due to the complexity of the equation produced by a Log-Log model specification with multiple interaction terms, key results are more conveniently interpreted graphically than via the raw regression coefficients. Figure 4-9 and Figure 4-10 shows the model's predictions of Estimated Wait Time under amenity and environment scenarios over values of Observed Wait Time from zero to 10 minutes. (87% of participating responses have an Observed Wait Time of 10 minutes or less.) In each case, the named dummy variable is set equal to one, and $\ln(\text{Observed Wait Time})$ and the dummy variable's interaction term (the product of 1 and $\ln(\text{Observed Wait Time})$) are set equal to the natural logarithm of each x-axis value shown on the graph. Unless stated otherwise, all other dummy variables are held at their modal values. Graphed y-values are the exponential of the model's prediction of $\ln(\text{Estimated Wait Time})$, with 0.01 subtracted; they represent the model's prediction of Estimated Wait Time on an arithmetic scale.

Figure 4-9 shows predicted values of Estimated Wait Time for Bench, Bench with Shelter and Real-time Sign, as well as the combination of all three. (All studied stops with a shelter also have a bench; it would not be appropriate to predict the impacts of a shelter without a bench.) The baseline scenario is No Amenities—with all stop amenity variables set equal to zero. Specifically, this scenario predicts estimated wait times for an 18-64 year old, white male traveling to work or school in the morning peak time period, from a station or stop with no amenities and a "Mostly Safe" or "Very Safe" surrounding environment, who knew the schedule ahead of time, is traveling alone, not transferring from another transit route and did not engage in another activity while waiting on a summer day. The baseline scenario produces a notable overestimate of waiting time. For example, a 10 minute wait is perceived as 21 minutes (a ratio generally in line with existing research), while even a brief 2.5 minute wait is perceived as 8 minutes. All of the amenity scenarios considered, however, significantly moderate the predicted overestimate. A bench alone has little impact on short waits, but has a progressively larger impact on longer waits, with a 10 minute wait perceived as 13 minutes. Both a bench with a shelter and a real-time information sign alone yield larger reductions in the perceptions of short waits but smaller reductions in perceptions of longer waits. It seems especially noteworthy that a real-time information sign alone yields almost the same reduction in perceived waiting time as both a bench and a shelter. The combination of all three amenities has by far the largest impact on perceived waiting time, reducing it to consistently within a minute or so of observed waiting time. In other words, our

model indicates that with only the provision of seating, shelter and real-time information, the time perception penalty incurred as passengers wait for a bus or train can be nearly erased.

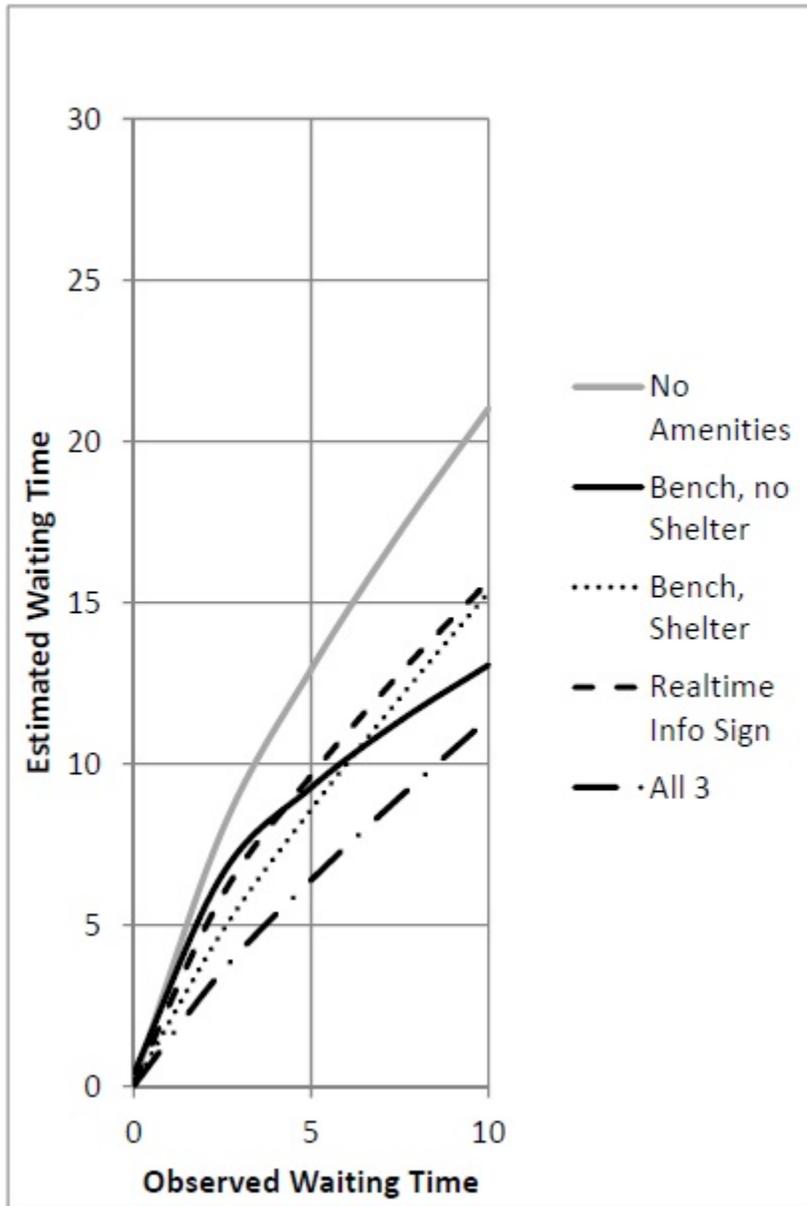


Figure 4-9: Model predictions, stop amenities

Figure 4-10 shows how estimates of waiting time based on respondents' gender and perceived security of stop surroundings with different amenity levels. The baseline scenario considers a male respondent and/or a "mostly safe" or "very safe" surrounding environment with no stop amenities. The prediction line for a female respondent *and* a "somewhat safe"

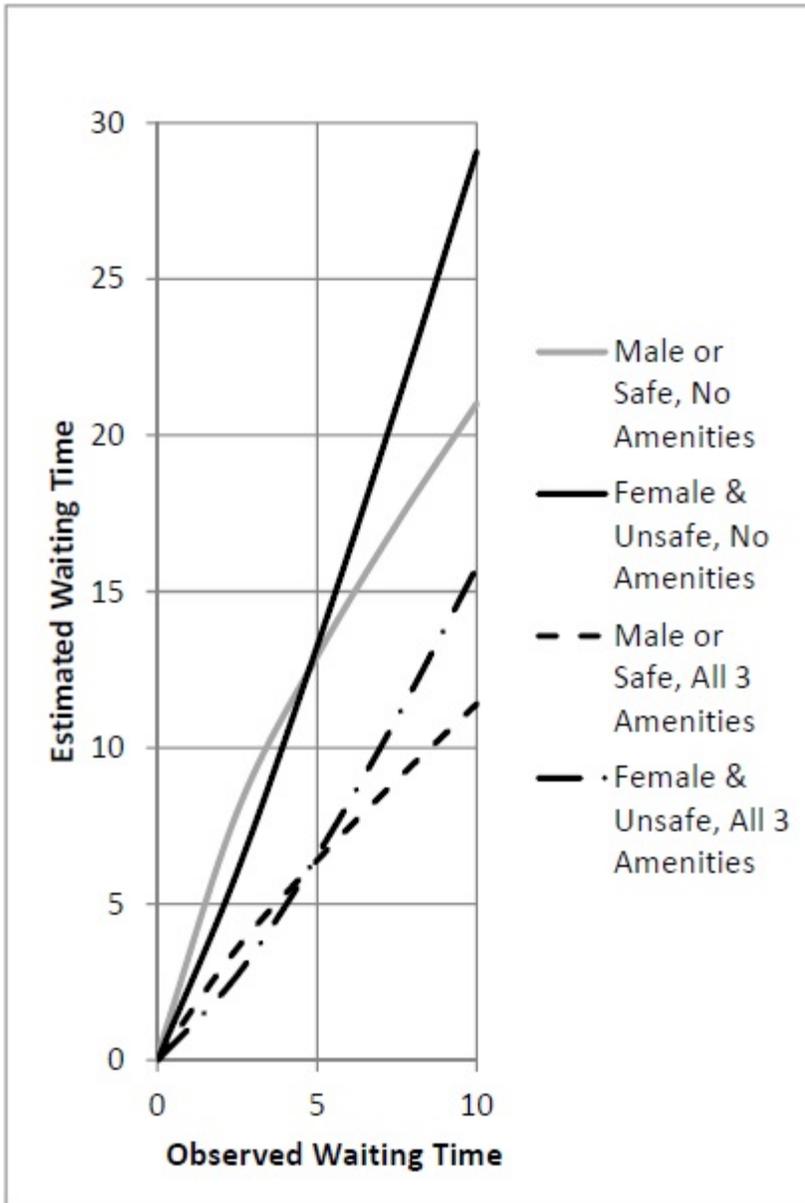


Figure 4-10: Model predictions, gender and security

or “not safe at all” surrounding environment tracks the baseline fairly closely for the first five minutes of observed waiting time, then diverges increasingly sharply upward. For a woman waiting at a simple “pole-in-the-ground” curbside stop with perceived insecure surroundings, a 10 minute wait seems to take nearly half an hour. Stop amenities dramatically moderate this effect, however. A female respondent waiting in perceived insecure surroundings at a stop with a bench, shelter and real-time information sign still has similar perceptions to a male respondent or perceived secure surroundings with the same amenities for the first five minutes, and diverges upward afterwards, but now only perceives a 10 minute wait as taking 15 minutes. This is a significantly smaller difference between actual and perceived waits than for a male respondent or secure perceived surroundings with no amenities.

5 - Conclusions

The results of this study strongly support the basic hypotheses that transit users perceive their waiting time as longer than it really is, and that characteristics of stations, stops and their surroundings shape those perceptions. Both conclusions are especially true of the zero to five minute waits that account for a majority of responses.

The presence of a bench dramatically reduces perceptions of all but the shortest waits. This effect is especially notable because it appears in the absence of any other amenities. The addition of a shelter strengthens this effect, at least for 0-5 minute wait times experienced by most respondents. (Bear in mind that a majority of responses were collected either during a mostly fair and mild Minnesota summer [during which data collection was cancelled on days with forecast high temperatures above 90 degrees Fahrenheit] or after the snow melted on the cusp of the following spring. An open-air bench may actually have been more pleasant in some cases than a sheltered one.)

The time perception impacts of real-time information are striking, especially when combined with a bench and shelter. Even with no other amenities present, a real-time information sign reduces a transit user's perception of waiting time almost as much as both a bench and a shelter. With the increasing prevalence and declining cost of technology, the broader provision of real-time information offers an attractive way to significantly improve the user experience. This finding also has important implications for stops with space constraints: it may be possible to significantly improve the experience of using transit by providing real-time information signs in locations where space and/or pedestrian traffic considerations do not allow for a bench or shelter. High-ridership locations that cannot accommodate adequate seating and/or shelter capacity for all riders may benefit as well. Moreover, when a bench, shelter and real-time information sign are combined—with no further changes—they produce nearly accurate estimates of waiting time: the time perception penalty of waiting nearly vanishes. Our model does not differentiate between different bench or shelter types or designs—indeed, early attempts to distinguish between “basic” and “premium” shelters found little difference. This conclusion echoes the findings of existing stated-preference research on the relative importance of service frequency and station amenity levels. (Iseki & Taylor, 2010; Liu et al., 1997) In practice, these findings suggest the broad provision of basic stop amenities and departure information can dramatically reduce the perceived burden of transit use. The findings also suggest that the simpler, more standardized light rail stations on the Metro Green Line should not provide a materially different user experience from the more elaborate and distinctive stations along the Metro Blue Line. In addition, our results indicate that the stop designs currently proposed by the Arterial Transit Corridor Study for use on future Arterial BRT lines can be expected to significantly decrease perceptions of waiting time compared with current conditions. This conclusion has important implications for routes such as the 84/future A Line: even a route that is already part of the Hi-Frequency Network may see a meaningful decrease in *perceived* waiting times with the implementation of ABRT.

At present, broad deployment of real-time information signs may face cost limitations. However, other methods of communicating departure information may offer benefits as well. Unfortunately, our survey respondents appeared to conflate online schedules, trip planner apps and real-time information apps based on common responses to a question about mobile device use. As a result, we do not believe our survey yielded reliable data on the use

of “next bus” apps, which may offer a low-cost alternative to real-time signs, at least for transit users with access to a mobile device. In addition, a strong correlation between the presence of a shelter and the presence of a posted schedule prevented the inclusion of posted schedules in the final model, though early analysis showed promise in reducing perceptions of longer waits. More detailed comparative study of different methods for communicating departure information may present a valuable direction for further research. It could be highly beneficial to determine, for example, what percentage of Twin Cities transit users have mobile devices and use/are aware of various real-time information apps, as well as how real-time information via mobile device access varies by income, race, gender and age. Specifically comparing the waiting time perception impacts of traditional posted schedules, the improved information signs Metro Transit is testing in North Minneapolis and Brooklyn Park, real-time information signs, and real-time information mobile apps could also be helpful in planning for improved communication of departure information.

The significance and gentle slope of the minority variable may capture important community-level differences in familiarity with and attitudes towards transit. Compared to the white, non-Hispanic population, racial/ethnic minority groups have relatively high transit use rates and may be less likely to associate social stigma with transit use. These differences may be responsible for the shorter perception of waiting time among minority transit users than white, non-Hispanic transit users. If correct, this situation speaks to the importance of social perceptions in shaping the experience of transit use. Broadening social acceptance of transit use may reduce perceived waiting times for all users. It is also important to note that model results compare the perceptions of white and minority respondents, *all else equal*. Minority riders, however, are disproportionately likely to live in areas (such as North Minneapolis) with relatively low rates of amenity provision at stops, and lower perceived security of surroundings—in such cases, all else is not, in fact, equal. Stop/station area upgrades planned via Metro Transit’s Ladders of Opportunity program could be expected to improve these settings.

Finally, the stark difference from the baseline found for the Female Respondent in Unsafe Environment scenarios points to an important direction for improving the experience of using transit. In the Twin Cities region, women already account for a majority of transit commutes, (United States Bureau of the Census, 2014). It appears that, in some locations, their experience of waiting for a train or a bus differs substantially from men’s—and not in a good way. This research cannot directly establish the specific mechanism behind the link between insecure surroundings and women’s perceptions of waiting time, but the presence of that link is clear. To refine and target responses to this problem, further qualitative study may be warranted to determine specific issues such as fear of crime, street harassment, etc. Still, focusing on basic security improvements around less-safe transit stops appears to be an important gender equity measure, and one with the potential, at least, for significant returns in terms of perceived waiting times. In addition, the striking moderating effect of a bench, shelter and real-time sign on gender disparities in perceived insecure surroundings suggests basic transit stop improvements as another important gender equity measure in such circumstances. Further, the finding that the provision of basic stop amenities is highly effective at reducing gender disparities in waiting time perceptions may justify such amenities at lower ridership levels than elsewhere in less safe areas. This study is not able to show direct ridership impacts of differences in perceived waiting times. Still, the long estimated waits for women in not or somewhat safe environments appear to indicate a needlessly stressful passenger experience which at least seems unlikely to help ridership. These findings suggest perceptions of personal security in some locations may currently be a major impediment to women adopting a transit-oriented lifestyle.

The results of this analysis indicate the potential for transit stations and stops and the waiting environments they create to significantly influence passengers' perceptions of waiting time under certain circumstances. In particular, they point to the importance of seating, shelter and information, as well as the importance of providing a basic complete package of amenities where possible and increasing perceptions of personal security around the least safe stops, particularly from the perspective of female passengers. Each of these suggest promising avenues for further analysis using these data and/or topics for more tightly focused research on each topic identified.

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Appendix A

Survey Questionnaire

TRANSIT USER SURVEY

Thank you for agreeing to participate. Your answers will improve stop and station design for Twin Cities transit users. Your participation will be confidential and will not be identified in any report we publish. Your participation is completely voluntary, and a decision not to participate will not affect any relationship you may have with the University of Minnesota, Metro Transit or any other transit provider.

For Interviewer:

Station: _____ Date: _____ Time: _____ Route: _____

While you were waiting:

1) How many minutes do you think you waited at the station before you boarded this train? ____ min

2) Did the train arrive later than expected, sooner than expected or on time?

MUCH LATER SOMEWHAT LATER ON TIME SOMEWHAT SOONER MUCH SOONER

3) Did you know the schedule for this train, or did you simply show up at the station and wait?

KNEW SCHEDULE SHOWED UP

4) Did you use NexTrip for real-time train departure information via phone, web, mobile device or on information display signs while planning or on this trip?

YES NO

5) Did you use any other transit info application while planning or on this trip? If yes, which one?

YES, WHICH ONE? _____ NO

6) How pleasant was the environment at the station you just boarded at?

VERY PLEASANT SOMEWHAT PLEASANT NOT VERY PLEASANT NOT PLEASANT AT ALL

Your Starting Point

7) What was your primary activity at the starting point of this trip?

I WAS AT HOME WORK ATTEND COLLEGE/SCHOOL PICK UP/DROP OFF SOMEONE

SHOPPING PERSONAL BUSINESS (BANKING, MEDICAL, SALON, ETC)

SOCIAL (SEE FRIENDS/RELATIVES) RECREATION (SEE MOVIE, PLAY SPORTS, ETC)

EAT OUT OTHER _____

8) What are the nearest cross streets to your starting point?

_____ & _____

9) How did you get from your starting point to the station you boarded at?

- WALK BIKE TRANSFER FROM ANOTHER BUS OR TRAIN
 CAR, AS DRIVER CAR, AS PASSENGER OTHER: _____

Your Destination

10) Where will you get off this train? Please write names of the station or cross streets:

11) How will you get to your final destination after getting off this train?

- WALK BIKE TRANSFER TO ANOTHER BUS OR TRAIN
 CAR, AS DRIVER CAR, AS PASSENGER OTHER: _____

12) What will be your primary activity at your final destination for this trip?

- RETURN HOME WORK ATTEND COLLEGE/SCHOOL PICK UP/DROP OFF SOMEONE
 SHOPPING PERSONAL BUSINESS (BANKING, MEDICAL, SALON, ETC)
 SOCIAL (SEE FRIENDS/RELATIVES) RECREATION (SEE MOVIE, PLAY SPORTS, ETC)
 EAT OUT OTHER _____

Your Other Transit Use Behavior

13) On average, how often do you ride transit?

- 5 OR MORE DAYS PER WEEK 2 – 4 DAYS PER WEEK 1 – 4 DAYS PER MONTH
 LESS THAN ONCE A MONTH THIS IS THE FIRST TIME

14) On average, how often do you make this particular trip using transit?

- 5 OR MORE DAYS PER WEEK 2 – 4 DAYS PER WEEK 1 – 4 DAYS PER MONTH
 LESS THAN ONCE A MONTH THIS IS THE FIRST TIME

15) Do you have a Go-To card or pass?

- YES NO

16) Was there a motor vehicle available to you for this trip?

- YES NO

Your Background

17) Where do you live? Please write ZIP code, city, and if possible, cross streets near your home.

ZIP: _____ CITY _____
CROSS STREETS: _____ & _____

18) What is your race? Please mark all that apply.

- WHITE BLACK/AFRICAN AMERICAN HISPANIC/LATINO ASIAN
 AMERICAN INDIAN/NATIVE AMERICAN OTHER _____

19) In 2012, what was the combined, total income of everyone who lived in your household?

- LESS THAN \$25,000 \$25,000-39,999 40,000-\$59,999
 \$60,000-\$99,999 \$100,000 OR MORE

Thank you for your time and participation!

Appendix B

Survey Protocol

Survey Protocol

Transit Stops and Stations and Travel Time Perceptions

The survey will be conducted in teams of three, one of whom will manage the videorecording (“Videographer”) of the waiting area, and two who will collect survey responses (“Surveyors”). All team members will be provided with U of M logo shirts and name badges identifying them as survey interviewers working with the knowledge and permission of the transit providers involved. These should be worn at all times during data collection. Team members will also be provided with a letter of introduction from Metro Transit, which should be freely offered to anyone who inquires after team members’ activities. The surveyors will have primary responsibility for their survey materials and for the completed questionnaires they collect.

1) Before Setting Out

Careful and complete preparation will be crucial to accomplishing our data collection effectively. Go through the entire list below every time before you set out for data collection. You should always have with you:

- 1) U of M shirt and ID badge.
- 2) This document, site assignment sheet, route list. Pocket schedules for routes serving each site to be visited, or a smartphone.
- 3) Letter of introduction, ≥ 20 copies
- 4) Blank questionnaires, ≥ 50 copies
- 5) Research information sheets, ≥ 50 copies
- 6) Box of golf pencils, $\geq \frac{1}{2}$ full
- 7) Camera phone or camera—*with fully charged batteries*

You may pick up additional materials from Cube 3 in HHH 295 as needed. Andy will keep supplies stocked, but if you notice anything starting to run low, *please warn him*.

2) Data Collection

Make sure to arrive at the data collection site at least 15 minutes early, to allow for any delay in getting there, and to assist with video setup if needed.

- 1) Work out ahead of time which surveyor on the team will board the first transit vehicle, which the second, etc. For buses, one surveyor should board each vehicle. For trains, each surveyor should board a different car, determined ahead of time.
- 2) Once data collection begins, wait quietly, if possible in an out-of-the-way part of the waiting area. It is important to avoid any potential impact on waiting passengers’ perceptions of time whenever possible.
- 3) Write the stop/station and date in the list of your boardings on the last page of this protocol. Attach additional sheets as needed.

- 4) Be unobtrusive, not secretive. Plainly and concisely identify yourself and your purpose if asked, but avoid attracting attention to yourself. (See *Dealing with the public*, below, for more detailed information on handling questions at the stop/station or aboard transit vehicles.)
- 5) When the transit vehicle arrives, write the route and time in the list of your boardings, then board along with passengers. For buses, position yourself last in the boarding cue.
- 6) As you board, identify yourself to the driver. Drivers will have been notified by Metro Transit/MVTA, but you should answer any questions the driver has. You may also show the driver our letter of introduction as needed.
 - a. On light rail, you will not have direct contact with the operator. If transit police board the train for a fare inspection, identify yourself to them.
 - b. On Northstar commuter trains, locate and identify yourself to the conductor before beginning the survey.
- 7) As soon after boarding as possible, stand in the aisle and use the following script to recruit respondents:

“May I have everyone’s attention for a moment please? My name is [name], and I’m a researcher with the University of Minnesota. We’re working with [Metro Transit/MVTA] on a very short, confidential survey aimed at helping improve transit stop and station designs in the Twin Cities. Would anyone who boarded at the last stop like to participate?”
- 8) If you are not certain a prospective respondent is at least 18 years of age, ask: *“Are you at least 18? We’re only able to survey people 18 and older.”*
- 9) Hand each respondent a blank questionnaire and a pencil. Ask the respondent the following: *“May I take a picture of you with the questionnaire to ensure we have unique individuals participating? We will destroy the pictures at the end of the study.”*
 - a. If the respondent agrees, photograph the respondent framed shoulders-up, making sure the ID number on the questionnaire is clearly visible in the photograph.
 - b. If the respondent refuses, inform him/her that we will be unable to use their response without a photograph. Continue to the next potential respondent.
- 10) As each respondent finishes writing, collect their questionnaire.
- 11) Once you have collected all completed questionnaires, alight from the bus/train at the next stop, copy the stop/station, route, date and time from your list of boardings onto the front page of *every* completed questionnaire you collected, and return to the data collection site.

3) Dealing with the public

Our survey team should be unobtrusive, not secretive. We do not want to draw attention to the fact that we are observing passengers before recruiting for the survey begins, but we do not want to create uneasiness by being surreptitious, either. If someone asks who you are or what you are doing either at the stop/station or on the transit vehicle, you should:

- 1) Identify yourself by name as from the U of M, conducting research on improving transit stop and station design for Metro Transit/MVTA. Show you ID badge.
- 2) Offer a copy of the letter of introduction.
- 3) Answer all questions fully and truthfully.
- 4) Keep your voice clearly, comfortably audible to the person with whom you are speaking, but no louder than necessary to avoid potentially influencing other passengers' perceptions of time where possible.

Remember you are acting as an ambassador for the research team, the Humphrey School and the University. ***Always be polite and friendly!***

Appendix C

Letter of Introduction



To Whom it May Concern:

Researchers from the University of Minnesota are working with Metro Transit on a study of how to improve the waiting experience for Twin Cities transit passengers. These researchers have the permission and support of Metro Transit. As the region's largest transit provider, we understand the importance of waiting time in shaping the overall experience of using our services. We hope and believe the results of this study will help us continue to improve that experience throughout the region.

If you have been asked to participate in the study, please bear in mind that this is on a purely voluntary and confidential basis. Your name will not be recorded, Metro Transit will not be informed of your decision to participate or not, and a decision not to participate will not impact any relationship you have with Metro Transit or the University. We do very much hope you will choose to participate, however, in the interest of improving the experience of riding transit in the Twin Cities.

If you are participating, you will be provided with a more detailed information sheet about the research. If you have any questions, please feel free to contact Andrew Guthrie, the project manager, at (612) 625-7311 or guth0064@umn.edu.

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Appendix D

Video Recording Protocol

Recording Protocol

Transit Stops and Stations and Travel Time Perceptions

The survey will be conducted in teams of three, one of whom will manage the videorecording (“Videographer”) of the waiting area, and two who will collect survey responses (“Surveyors”). All team members will be provided with U of M logo shirts and name badges identifying them as survey interviewers working with the knowledge and permission of the transit providers involved. These should be worn at all times during data collection. Team members will also be provided with a letter of introduction from Metro Transit, which should be freely offered to anyone who inquires after team members’ activities. The videographer will have primary responsibility for the camera and video footage.

6 - Before Setting Out

It will be crucial to have our video equipment prepared beforehand. Follow this procedure before every data collection session:

- 1) Fully charge the camera’s battery *the night before data collection*.
- 2) If any of the sites you will be visiting will require multiple cameras, make arrangements with Andy and/or the other videographers to pick up the additional camera.
- 3) Before leaving for data collection, check the camera’s memory space/run time remaining. This should be at least double the total length of data collection you will be doing before your next definite opportunity to download footage. If not, ensure all existing footage has been downloaded, and delete old footage to free up space.
- 4) Check for all equipment before setting out, every time. You should have with you:
 - a. This document.
 - b. Schematics of all sites to be visited (The schematic will specify the equipment and number of cameras required.)
 - c. Camera(s)
 - d. Spare charged battery/empty memory card (if required)
 - e. Mini tripod (if required)
 - f. Gaff tape
 - g. U of M shirt
 - h. Name badge
 - i. Letter of introduction (at least 50 copies)
 - j. Laptop with charged battery, needed cable and flash drive with sufficient free space (if you will be downloading during the day).

7 - Data collection

Arrive at the data collection site at least 15 minutes before you are scheduled to begin collecting data.

- 1) Set up the camera(s) as shown in the site schematic.
 - a) Make sure you zoom to a focal length matching the landmarks shown as in frame on the schematic.
 - b) Once set up, confirm you have an unimpeded view of the waiting area; the situation may have changed since the schematic was produced.
- 2) Wait until a bus or train arrives, then start recording. This practice ensures that the recording begins with a full, usable waiting cycle.
- 3) In the list of video files on the last page of this document, write down the stop/station, date, start time (the exact time [hh:mm:ss] you pressed Record), and camera number. Use a 24-hour clock—1:21pm=13:21. For sites requiring two cameras, there should be two entries, each with a unique time (since you won't press Record at the same moment), one for camera 1 and one for camera 2, as listed on the schematic.
- 4) Check the camera(s) periodically to ensure:
 - a) It/they is/are still recording
 - b) Sufficient battery life remains
 - c) Sufficient memory remains
- 5) Continue recording until the surveyor making the last data collection attempt in your session boards a transit vehicle; stop the recording.
- 6) In the list of video files on the last page of this document, write down the end time (the exact time [hh:mm:ss] you pressed Stop on the/each camera). Use a 24-hour clock—1:21pm=13:21.
- 7) Correctly power down the camera(s).
- 8) Pack up all equipment; leave the site exactly as you found it.

8 - Dealing with the public

Our recording is intended to be unobtrusive, not secretive. We do not want to draw attention to the fact that we are videorecording passengers, but we do not want to create uneasiness by being surreptitious, either. *Avoid attracting attention to yourself to the greatest degree possible.* You should not volunteer information about what you are doing, but if someone asks, you should:

- 5) Identify yourself by name as from the U of M, conducting research on improving transit stop and station designs in the Twin Cities. Show your ID badge.
- 6) Offer a copy of the letter of introduction.

- 7) Answer all questions fully and truthfully.
- 8) Keep your voice clearly, comfortably audible to the person with whom you are speaking, but no louder than necessary to avoid potentially influencing other passengers' perceptions of time where possible.
- 9) Remember you are acting as an ambassador for the research team, the Humphrey School and the University. **Always be polite and friendly!**

Appendix E

Observation Protocol

Observation Protocol

Transit Stops and Stations and Travel Time Perceptions

All survey team members should make their observations based on waiting area video and respondent photographs as a group at the end of every day of data collection.

Division of Respondents:

This stage involves all three team members working together to divide respondents for observation. Subsequent stages may be done individually, but should always be completed on the day of data collection.

STEP 1) Download all video to the HHH-Projects folder. Create a new folder for the video in ...Projects\YINGLING\TIRP_Hubs\Data\Video following this naming convention: [site]_[month]-[day]_[period] “Site” is the stop/station name—exactly as it appears on your assignment sheet. “Period” refers to period of the service day. Your choices are:

- a. MP (Morning Peak—6:00-9:00am)
- b. MD (MidDay off-peak—9:00am-3:00pm)
- c. EP (Evening Peak—3:00-6:30pm)
- d. LE (Late Evening off-peak—6:30pm-1:00am)

STEP 2) Download all respondent photographs to the HHH-Projects folder. Create a new folder for the video in ...Projects\YINGLING\TIRP_Hubs\Data\Photos following this naming convention: [site]_[month]-[day]_[period], as above.

STEP 3) Print all photos on individual pages. Lay them out on a table, in order of time stamp. Divide the photos into thirds by time; one team member will observe the earliest third, another the middle third and the last the latest third.

Input:

The following instructions are for each individual survey team member.

You will need to be on a computer, logged in to U of M Google apps with your x.500.

STEP 1) Open a new web browser window, and copy and paste the following link into the address bar to bring up the data entry form:

<https://docs.google.com/a/umn.edu/forms/d/1dQ2ErOokhfp-QUFaVVmqso9pf9JitL8qEgZq9AF6lO0/viewform>

STEP 2) Input the date and site of data collection in the first two items at the top of the Google form.

- STEP 3) Start the video. When the respondent in your first photograph arrives, pause the video, input the questionnaire ID number into item A on Google form, then input the time the respondent arrived, reached the waiting area, and sat or stopped in item B. (If you are observing the middle or latest third of respondents, you may fast-forward the video to roughly the time on the earliest photograph you have, minus the total time generally spent on each transit vehicle that day, minus the headway of the least frequent route surveyed at that site. Starting at an earlier point may save time by saving you from having to go back to find a first respondent.)
- STEP 4) Observe the respondent's gender (Item C) based on the photograph. (You may refer to the video footage as needed, but individual still photograph should generally be quicker and create less possibility for confusion.) Input your observation into the Google form.
- STEP 5) Observe the respondent's race (Item D) based on the photograph. (You may refer to the video footage as needed, but individual still photograph should generally be quicker and create less possibility for confusion.) If the respondent appears to be multiracial, you may check multiple boxes, consistent with your best estimate.
- STEP 6) Estimate the respondent's age (Item E) based on the photograph. (You may refer to the video footage as needed, but individual still photograph should generally be quicker and create less possibility for confusion.) Base your selection on your best estimate of whether the respondent would be *best* described as Young (18-34), Early Middle-Aged (35-49), Late Middle-Aged (50-64) or as a Senior (65+).
- STEP 7) Observe the respondent's personal appearance/dress code (Item F) based on the video. (You may refer to the photograph as needed, but you need a full-height image.) Refer to the following category definitions:
- a. Business—Formal: Full business suit. Jacket and trousers/skirt are from the same cloth; worn over a dress shirt/blouse with dress shoes.
 - b. Business—Casual: Office or white-collar work attire, but less formal than Business—Formal. Includes anything from a dress shirt/blouse and dress slacks/skirt to a polo shirt and khaki slacks/skirt. May include a sport jacket and/or some suit pieces, but not a full suit.
 - c. Blue-Collar Work Clothes: Clothing—often heavy and/or protective—worn for a dirty job or a job involving manual labor. Examples include overalls, work-boots, uniform shirts for a blue-collar occupation (such as a mechanic), hard hats. Everything the respondent is wearing should appear appropriate for working in a blue-collar occupation.
 - d. Casual: At-home, evening or weekend attire. Examples include jeans, tee shirts, flannel shirts, shorts.
 - e. Athletic: Clothing worn to participate in sports and/or for exercise. Examples include running, jogging or cycling clothes.

- f. Fashion: Clothing that is formal, or at least "dressed up", but is not something one would wear to work. Dressing nicely to attend a party or social occasion, or to go out on a Friday night would be examples. Definitely not business clothing, but not casual either—chosen for appearance and making an impression, not mainly for comfort and/or mobility. Dressing to impress members of one's peer group in a social setting, rather than to impress one's supervisor and coworkers in a professional situation.
- STEP 8) Observe what carryon (Item G) items the respondent has with him/her, if any, from the video. Check as many categories as apply. Use the "Other" category—and fill in what he/she is carrying—if the respondent has an item not specified in any of the defined answer categories.
- STEP 9) Observe what, if any, mobility aid (Item H) the respondent uses from the video. Check as many categories as apply. Use the "Other" category—and fill in what aid he/she is using—if the respondent has a mobility aid not specified in any of the defined answer categories.
- STEP 10) Observe the respondent's posture (Item I) while waiting from the video. Check all postures the respondent holds while waiting. There is no minimum time for a posture to be held, but it must be a stable state in its own right, not a gradual movement between two others. For example, "Leaning" does not describe a respondent gradually shifting from standing to sitting.
- STEP 11) Observe what activities the respondent engaged in while waiting (Item J). Check all that apply. Use the "Other" category—and fill in what activity he/she engages in—if the respondent engages in an activity not specified in any of the defined answer categories.
- STEP 12) Observe how many traveling companions (Item K) the respondent has; input numbers in the fields provided. People may be considered "traveling companions" if they arrive at the stop/station and board the transit vehicle together. Use the following categories:
- a. Number of children (whether infants, toddlers or mobility challenged) dependent upon mobility assistance from another person.
 - b. Number of children who are fully mobile independent of any other person.
 - c. Number of adults not using a mobility aid, not including the respondent.
 - d. Number of adults using a mobility aid, not including the respondent.
- STEP 13) Continue playing back the video until the respondent boards. As the respondent boards, pause the video, and input the timecode in item L.
- STEP 14) Review your answers for completeness and accuracy.
- STEP 15) Submit the form.

STEP 16) Before agreeing to the collection of your x.500, review your answers again for completeness and accuracy.

STEP 17) Submit the form. Do not close the browser tab until you see the message “Your response has been recorded.”

STEP 18) Close the form; open a new form for observations of the respondent in the next photograph.

Appendix F

Waiting Environment Audit Instrument

WAITING ENVIRONMENT AUDIT

Transit Stops and Stations and Travel Time Perceptions

This audit instrument will evaluate station/stop characteristics and surrounding environments, providing the physical context for respondents' answers and observed characteristics in the TIRP study "Transit Stops and Stations and Travel Time Perceptions". It is crucial that you follow the directions for each item in this audit *exactly* to ensure comparable results from site to site and from auditor to auditor. Do not leave any question blank.

For every audit session, bring the following:

- ID badge
- Letter of introduction (at least 10 copies)
- Blank audit instruments for all sites to be visited (plus 2 extras)
- Notebook or scratch paper
- Clip board
- At least 3 sharpened pencils with erasers
- Pencil sharpener
- Itinerary with maps to all audit sites
- Camera

If driving to data collection sites, park in a legal space in a safe location. All data collection should be conducted on foot, in the waiting area of the stop or station in question. All questions asking about the surrounding neighborhood refer *only* to the area within view of the waiting area.

For the entire audit:

Instructions for a section appear in regular-face, italic serif type in normal case.

Q[section][number] Questions appear in boldface, roman, sans-serif type in normal case. (Instructions for each specific question appear in parentheses.)

ANSWERS APPEAR IN REGULAR-FACE, ROMAN, SANS-SERIF TYPE IN UPPER CASE.

Fill in the following information before beginning:

Name of auditor: _____

Date: ____ / ____ / ____

Time: ____:____ AM PM

Likert Scale Descriptions

Refer to the following explanations in responding to all questions employing Likert scales.

Evaluation

All evaluation questions in this survey, including qualitative and quantitative ones, use the following 4-point, one-tailed Likert scale:

NOT ____ AT ALL	The quality being evaluated is not present at all.
SOMEWHAT ____	The quality is present, but it is not a defining feature of the stop/station/surroundings.
MOSTLY ____	The quality is a defining feature of the stop/station/surroundings, but there are significant exceptions.
VERY ____	The quality is a defining feature of the stop/station/surroundings, with no significant exceptions.

Estimation

All questions asking for an estimate of a quantity use the following 4-point, one-tailed Likert scale:

NONE	The item being measured is not present at all.
A LITTLE/FEW	The item is present, but uncommon.
SOME	The item is common, but not common enough to be a defining feature of the station/stop/surroundings.
A LOT	The item is common enough to be a defining feature of the station/stop/surroundings.

Photographs

Take a 360-degree series of photographs of the waiting environment. While standing in the waiting area, take a photograph, then turn in place and take the next photograph, overlapping slightly: making sure that an object visible at one side of the frame in the last photograph is still visible at the other side of the frame in the next photograph. Continue until you have an entire 360-degree series of photographs.

Section A: Station/Stop Waiting Area

Answer the questions in the following section standing in the waiting area. Remember that the questions in this section only refer to conditions within the waiting area itself. Do not include conditions in the station's or stop's surroundings.

QA0) Select the name of the site from the following list. (Select only one answer choice.)

- | | |
|--|---|
| <input type="checkbox"/> 1 ST AVE S & E LAKE ST | <input type="checkbox"/> HARDING ST & 39 TH AVE NE |
| <input type="checkbox"/> 4 TH ST S & CHICAGO AVE S | <input type="checkbox"/> LAKE ST—MIDTOWN LRT |
| <input type="checkbox"/> 7 TH ST S & NICOLLET MALL | <input type="checkbox"/> LOUISIANA AVE TC |
| <input type="checkbox"/> 8 TH ST S & LASALLE ST/NICOLLET MALL | <input type="checkbox"/> MALL OF AMERICA BRT |
| <input type="checkbox"/> 10 TH ST N & TWINS WAY | <input type="checkbox"/> MALL OF AMERICA LRT |
| <input type="checkbox"/> 28 TH AVE LRT | <input type="checkbox"/> MALL OF AMERICA TC |
| <input type="checkbox"/> 46 TH ST & I-35W BRT | <input type="checkbox"/> MARQUETTE AVE & 5 TH ST S (STOP B) |
| <input type="checkbox"/> 46 TH ST LRT | <input type="checkbox"/> NICOLLET MALL LRT |
| <input type="checkbox"/> 50 TH ST—MINNEHAHAPARK LRT | <input type="checkbox"/> OAKDALE AVE & WENTWORTH AVE |
| <input type="checkbox"/> 117 TH AVE P & R | <input type="checkbox"/> OLSON MEMORIAL HWY & 7 TH ST N |
| <input type="checkbox"/> AMERICAN BLVD @ WALMART | <input type="checkbox"/> RAMSEY CR |
| <input type="checkbox"/> APPLE VALLEY TRANSIT STATION BRT | <input type="checkbox"/> SNELLING AVE & CR B |
| <input type="checkbox"/> CEDAR GROVE BRT | <input type="checkbox"/> SUNRAY TC |
| <input type="checkbox"/> COMO AVE SE & 22 ND AVE SE | <input type="checkbox"/> UNION DEPOT |
| <input type="checkbox"/> COON RAPIDS—RIVERDALE CR | <input type="checkbox"/> UNIVERSITY AVE & MISSISSIPPI ST |
| <input type="checkbox"/> DOWNTOWN EAST—METRODOME LRT | <input type="checkbox"/> UNIVERSITY AVE & SNELLING AVE |
| <input type="checkbox"/> E FRANKLIN AVE & CHICAGO AVE S | <input type="checkbox"/> UNIVERSITY AVE SE & 25 TH /26 TH AVE |
| <input type="checkbox"/> FRANKLIN AVE LRT | <input type="checkbox"/> UPTOWN TC |

Physical Layout (QA1-5)

The questions in this subsection refer only to the basic physical design of the station/stop.

Is the waiting area set apart from surrounding pedestrian through-traffic areas? (Select only one answer choice.)

- NO YES

Is there a physical barrier (i.e. railing, wall, plantings, change in grade) between the waiting area and surrounding pedestrian through-traffic areas? (Select only one answer choice.)

- NO YES

Which of the following best describes the boarding area? (Select only one answer choice.)

- REGULAR CURB, NOT PAVED ALL THE WAY TO CURB
- REGULAR CURB, PAVED ALL THE WAY TO CURB
- EXTENDED CURB OR BUMP-OUT (ALLOWS BUSES TO STOP WITHOUT LEAVING THE TRAVEL LANE)
- BUS-BAY (RECESSED PULL-OUT FROM TRAFFIC)
- TRANSIT PLATFORM (RAISED PLATFORM SEPARATED FROM SURROUNDING STREETScape)
- OTHER _____

Is the boarding area cleared of snow all the way to the platform edge or curb? (Select only one answer choice.)

- NO
- PARTLY, WITH A CLEAR PATH TO SOME VEHICLE DOORS
- PARTLY, WITH A CLEAR PATH TO ALL VEHICLE DOORS
- FULLY CLEARD

Which of the following best describes the transit vehicle's runningway in the boarding area? (Select only one answer choice.)

- PUBLIC STREET, MIXED TRAFFIC, IN TRAFFIC
- PUBLIC STREET, MIXED TRAFFIC, PULLED OUT OF TRAFFIC
- PUBLIC STREET, EXCLUSIVE LANE (INCLUDE STREET-RUNNING LRT NOT SEPARATED FROM TRAFFIC BY UNMOUNTABLE CURBS.)
- EXCLUSIVE OR SEMI-EXCLUSIVE TRANSIT RIGHT-OF-WAY (INCLUDE MEDIAN-RUNNING LRT.)

Are transit vehicles prevented from pulling all the way up to the platform edge or curb due to uncleared snow in the runningway? (Select only one answer choice.)

NO YES **WHAT—IF ANY—FORM OF SHELTER IS PROVIDED IN THE WAITING AREA? (SELECT ALL ANSWER CHOICES THAT APPLY.)**

- NO SHELTER
- "ADVERTISING" BUS SHELTER (FLAT-ROOFED SHELTER WITH LARGE NON-TRANSIT ADVERTISING POSTERS)
- "OLD METRO TRANSIT" BUS SHELTER (CURVED-ROOF SHELTER, APEX OF ROOF PARALLEL TO STREET WITH DARK METAL SUPPORTS.)
- "NEW METRO TRANSIT" BUS SHELTER (CURVED-ROOF SHELTER, APEX OF ROOF PERPENDICULAR TO STREET WITH SILVER METAL SUPPORTS AND LARGE METRO TRANSIT LOGO ON BLUE PANEL.)
- RECESSED ALCOVE IN ADJACENT BUILDING
- BUTTERFLY SHELTER (SHELTER COVERING THE WAITING AREA WITH ROOF ONLY—NO WALLS APART FROM POSSIBLE CONNECTION TO STATION OR OTHER SHELTER)

- COMPLEX SHELTER, WITH MULTIPLE, PARTLY-ENCLOSED AREAS AND COMMON ROOF. NOT FULLY ENCLOSED
- STATION/TRANSIT CENTER BUILDING, FULLY ENCLOSED
- ANY OTHER TYPE OF SHELTER _____

Comfort (QA6-9)

The questions in this subsection refer specifically to physical comfort provided by features of the station/stop.

What—if any—form of seating is provided? (Select all answer choices that apply.)

- NO SEATING
- BENCHES, UNCOVERED
- BENCHES, COVERED
- LEANING RAILS, UNCOVERED
- LEANING RAILS, COVERED
- INFORMAL SEATING (LOW WALL, PLANTER, ETC.)

What—if any—forms of protection from the elements are provided? (Select all answer choices that apply.)

- NO PROTECTION FROM THE ELEMENTS
- PROTECTION FROM SUN/RAIN/SNOW
- PROTECTION FROM WIND

What—if any—other comfort/convenience-focused amenities are provided? (Select all answer choices that apply.)

- NO COMFORT/CONVENIENCE AMENITIES
- WATER FOUNTAIN
- RESTROOMS
- GARBAGE CAN(S)
- HEATER(S)
- OTHER _____

Overall, how physically comfortable a place to wait for a train/bus is this station/stop? (Select only one answer choice.)

- NOT COMFORTABLE AT ALL
- SOMEWHAT COMFORTABLE
- MOSTLY COMFORTABLE
- VERY COMFORTABLE

Information (QA10-12)

The questions in this subsection refer only to service information provided by features of the station/stop itself.

What means of obtaining route information are available? (Select all answer choices that apply.)

- NO ROUTE INFORMATION
- LIST OF ROUTE/LINE NUMBERS/NAMES/COLORS
- LIST OF ROUTE/LINE DESTINATIONS
- ROUTE/LINE MAP(S)
- OTHER _____

What means of obtaining schedule information are available? (Select all answer choices that apply.)

- NO SCHEDULE INFORMATION
- HI-FREQUENCY NETWORK SIGN
- POSTED SCHEDULE(S)
- RACK OF POCKET SCHEDULES
- SIGN WITH STOP NUMBER FOR NEXT RIP (REAL TIME DEPARTURE INFORMATION)
- NEXT RIP (REAL TIME DEPARTURE INFORMATION) DISPLAY
- PA ANNOUNCEMENTS
- OTHER _____

Overall, just based on the information provided at the station/stop, how confident are you of knowing transit routes/schedules available at the stop/station? (Select only one answer choice.)

- NOT CONFIDENT AT ALL
- SOMEWHAT CONFIDENT
- MOSTLY CONFIDENT
- VERY CONFIDENT

Security (QA15-16)

The questions in this subsection refer only to security features of the station/stop itself.

What—if any—passenger security measures are present? (Select all answer choices that apply.)

- NO PASSENGER SECURITY MEASURES
- LIGHTING COVERING THE WAITING AREA AND APPROACHES
- VISIBLE SECURITY CAMERAS
- EMERGENCY PHONE
- OTHER _____

How safe would you feel if you were waiting for a train/bus at this station/stop alone, at night? (Select only one answer choice.)

- NOT SAFE AT ALL
- SOMEWHAT SAFE
- MOSTLY SAFE
- VERY SAFE

Condition (Q17-20)

The questions in this subsection refer only to the cleanliness and maintenance of the station/stop itself.

How much—if any—litter or trash is present in the waiting area? (Select only one answer choice.)

- NONE
- A LITTLE
- SOME
- A LOT

How many—if any—places in the waiting area are noticeably damaged or broken, or have parts missing? (Select only one answer choice.)

- NONE A FEW SOME A LOT

How much—if any—uncleared snow impedes movement in or reduces the useable size of the waiting and/or boarding area? (Select only one answer choice.)

- NONE A LITTLE SOME A LOT

Overall, how well-maintained is the station/stop? (Select only one answer choice.)

- NOT WELL-MAINTAINED AT ALL
 SOMEWHAT WELL-MAINTAINED
 MOSTLY WELL-MAINTAINED
 VERY WELL-MAINTAINED

Appeal (QA21-22)

How many—if any—decorative or distinctive design/architectural features does the station/stop have? (Select only one answer choice.)

- NONE A FEW SOME A LOT

Overall, how visually attractive is the physical design of the station/stop itself? (Select only one answer choice.)

- NOT ATTRACTIVE AT ALL
 SLIGHTLY ATTRACTIVE
 MOSTLY ATTRACTIVE
 VERY ATTRACTIVE

Section B: Surrounding Environment

The questions in this section refer only to the surrounding environment within view of the waiting area. Do not include any features in the waiting area itself or any known features that cannot be seen from the waiting area.

Traffic Safety (QB1-8)

The questions in this subsection refer specifically to traffic safety in the immediate surroundings of the station/stop.

How many lanes does the nearest street to the waiting area have? (Include only all travel and turn lanes in both directions. Do not include parking lanes, if present. Write your answer in the space provided.)

_____ LANES

What is the posted speed limit on the nearest street to the waiting area? (Write the speed limit in the space provided. If no speed limit sign is visible from the waiting area, find the nearest speed limit sign upstream of the station/stop. If you cannot determine the speed limit, write -99 in the answer space.)

_____ MPH

What—if any—of the following design features are present on the nearest street to the waiting area? (Select all answer choices that apply.)

- STREET PARKING
- BICYCLE LANE
- SPEED BUMP/RAISED CROSSWALK/RUMBLE STRIPS
- CURB BUMP-OUT (NOT IN BOARDING AREA)
- MEDIAN
- ROUNDABOUT
- NONE OF THESE DESIGN FEATURES

Is the nearest street to the waiting area one-way? (Include highway on/off ramps; do not include boulevards or divided highways. Select only one answer choice.)

- NO YES

Which of the following best describes the sidewalk on the near side of the street nearest to the waiting area? (A complete sidewalk runs the full length of the street segment nearest to the station/stop. Select only one answer choice.)

- NO SIDEWALK
- INCOMPLETE, <5' WIDE
- INCOMPLETE, 5-10' WIDE
- INCOMPLETE, >10' WIDE
- COMPLETE, <5' WIDE
- COMPLETE, 5-10' WIDE
- COMPLETE, >10' WIDE

How much of the sidewalk is cleared and useable on the side of the street nearest to the boarding area? (A cleared, useable sidewalk can be safely, comfortably walked on in low-top shoes. Select only one answer choice.)

- NONE A LITTLE SOME A LOT

Which of the following best characterizes the traffic volume on the nearest street to the waiting area? (Select only one answer choice?)

- NOT HEAVY AT ALL SOMEWHAT HEAVY MOSTLY HEAVY VERY HEAVY

In the waiting area, how aware are you of traffic on the nearest street? (Select only one answer choice.)

- NOT AWARE AT ALL SOMEWHAT AWARE MOSTLY AWARE VERY AWARE

Neighborhood Security (QB9-15)

The questions in this subsection refer specifically to personal security (i.e. safety from crime) in the immediate surroundings of the station/stop.

How many vacant lots or dilapidated/abandoned buildings are there within view of the waiting area? (Select only one answer choice.)

- NONE A FEW SOME A LOT

How many of the buildings within view of the waiting area have broken windows or windows with bars? (Select only one answer choice.)

- NONE A FEW SOME A LOT

How much graffiti is visible from the waiting area? (Select only one answer choice.)

- NONE A LITTLE SOME A LOT

How much litter or trash is visible from the waiting area? (Select only one answer choice.)

- NONE A LITTLE SOME A LOT

How much of the public space (streets, sidewalks, pathways, open space, etc.) within view of the waiting area appears to be covered by streetlights? (Select only one answer choice.)

- NONE A LITTLE SOME A LOT

How many buildings within view of the waiting area have street-level windows? (Do not include windows that clearly cannot be seen out of—painted over, blocked by indoor or outdoor objects, etc. Select only one answer choice.)

- NONE A FEW SOME A LOT

**Overall, how safe an environment are the visible surroundings of the station/stop?
(Select only one answer choice.)**

- NOT SAFE AT ALL SOMEWHAT SAFE MOSTLYSAFE VERY SAFE

Noise and Air Quality (QB16-18)

The questions in this subsection refer to artificial air or noise pollution directly experienced in the waiting area.

Overall, how noisy (due to human activity such as vehicles, machinery or loud music) is the waiting area? (Do not include noise from natural sources such as birds or wind. Select only one answer choice.)

- NOT NOISY AT ALL SOMEWHAT NOISY MOSTLYNOISY VERY NOISY

Overall, how polluted (by vehicular exhaust, industrial activity or other man-made sources) does the air *smell*? (Select only one answer choice.)

- NOT POLLUTED AT ALL
 SOMEWHAT POLLUTED
 MOSTLYPOLLUTED
 VERY POLLUTED

Overall, how polluted does the air in the waiting area *look* based on visual evidence such as diesel exhaust soot or construction dust? (Do not include visible but distant evidence of pollution such as skyline haze. Select only one answer choice.)

- NOT POLLUTED AT ALL
 SOMEWHAT POLLUTED
 MOSTLYPOLLUTED
 VERY POLLUTED

Appeal (QB19-24)

The questions in this subsection refer to the extent to which buildings and other features of the built environment are visually appealing.

**Are any public spaces (i.e. courtyards, plazas or parks) visible from the waiting area?
(Select only one answer choice.)**

- NO YES

Are any major landmarks (i.e. either downtown skyline, the Witch's Hat Tower, etc.) visible from the waiting area? (Select only one answer choice.)

- NO YES

What proportion of the buildings visible from the waiting area have *identifiers*—signs or distinctive architecture that clearly identify the building’s use? (Select only one answer choice.)

- NONE A FEW SOME A LOT

How many mature trees are visible from the waiting area? (Select only one answer choice.)

- NONE A FEW SOME A LOT

How much of the ground visible from the waiting area is covered by landscaped vegetation or other vegetation? (Select only one answer choice.)

- NONE A LITTLE SOME A LOT

Overall, how visually appealing is the surrounding environment of the station/stop? (Select only one answer choice.)

- NOT VISUALLY APPEALING AT ALL
 SOMEWHAT VISUALLY APPEALING
 MOSTLY VISUALLY APPEALING
 VERY VISUALLY APPEALING

Section C: Overall

The questions in this subsection refer to the overall environment of the stop/station.

QC1) Overall, how pleasant an environment to wait for a train/bus is this station/stop? (Select only one answer choice.)

- NOT PLEASANT AT ALL
 SOMEWHAT PLEASANT
 MOSTLY PLEASANT
 VERY PLEASANT

QC2) Overall, how relevant are the station/stop’s visible surroundings to how pleasant the waiting area is? (Select only one answer choice.)

- NOT RELEVANT AT ALL
 SOMEWHAT RELEVANT
 MOSTLY RELEVANT
 VERY RELEVANT