Final Site Report

# EVALUATION OF TRAVEL TIME METHODS TO SUPPORT MOBILITY PERFORMANCE MONITORING

## BLUE WATER BRIDGE

To

Office of Freight Mgt. and Operations

Federal Highway Administration

U.S. Department of Transportation

Washington, DC 20590

Battelle

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April 2002

## Border Crossing Freight Delay Data Collection and Analysis
## FY 2001 Data Collection – Blue Water Bridge

### Site Description

The Blue Water Bridge connects Port Huron, Michigan with Point Edward and Sarnia, Ontario and crosses the Saint Clair River. The bridge is near the intersection of I-94 and I-69 in the U.S., connecting with Detroit and Flint, Michigan and Chicago, Illinois. In Canada, the bridge connects with Highway 402, a major highway that connects to Highway 401 in London, Ontario, which extends from Detroit, Michigan through Toronto, Ontario and into the Eastern Provinces. The bridge facilitates the movement of many commodities between the U.S. and Canada, with the automotive and agricultural industries the most notable. The bridge operates 24 hours a day, seven days a week.

The Blue Water Bridge comprises two spans, each with three lanes. The original bridge, built in 1938, was refurbished in 1999 and handles westbound traffic into the U.S. The second span, opened in 1997, handles outbound traffic into Canada. The bridge is open for both passenger and commercial vehicle traffic 24 hours a day. The bridge is unique in that it is not jointly owned by entities on both sides but, rather, the U.S. side of the bridge is owned by the State of Michigan and operated by the Michigan Department of Transportation and the Canadian side is owned and operated by the Blue Water Bridge Authority. These two organizations seem to cooperate quite well with each other but need to maintain separate operations and maintenance staffs.


**Figure 1. Area Map – The Blue Water Bridge**

Data collection activities at the Blue Water Bridge occurred during June 12-14, 2001 and August 14-16, 2001. Truck travel times across the bridge in both directions were recorded on Tuesday through Thursday each week, for approximately 12 hours each day. The times of the data collection were staggered somewhat to obtain a broader picture of activity at the bridge.

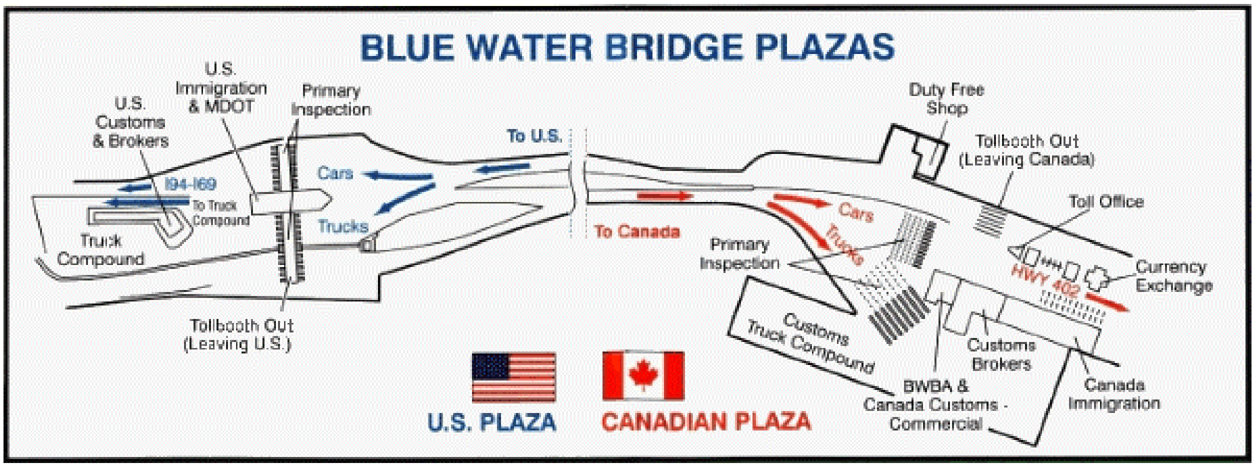


**Figure 2. Blue Water Bridge Plazas**

Eastbound traffic (outbound to Canada) approaches the bridge either from I-94 or from a local road. The Duty Free Store is located at the intersection of the local road and the ramp to the bridge. All vehicles exiting the Duty Free Store must proceed across the bridge to Canada. Often, drivers must meet with their brokers prior to leaving the U.S. and will park along the right shoulder before the toll booths and cross the travel lanes to the brokerage building on the inbound side of the U.S. plaza. The toll booth on the U.S. side has five booths, one of which is reserved for autos with exact change or tokens. The other four booths can process either autos or trucks. Once across the bridge, autos are directed to the left and trucks veer off to the right to pass through one of four primary Customs inspection booths. Trucks are either released from primary or must continue on to secondary inspection, which could include simply completing brokerage paperwork or physical inspections of the cargo. Trucks requiring physical inspections enter an area adjacent to the buildings on the left as they exit; whereas trucks whose drivers must interact with their broker park in the areas to the right and behind the primary inspection booths. When these trucks are finally ready to depart, they must use the same roadway that trucks released from primary must use to exit the Customs compound.

Westbound (inbound to the U.S.) traffic approaches the bridge from Highway 402. During both data collection visits, there was construction work on Highway 402 in both directions beginning several miles from the bridge. Highway 402, which is a divided highway, was reduced to a single lane in each direction for a stretch of many miles. A currency exchange and public restrooms are conveniently located on the Canadian plaza and trucks often stop along the right shoulder of the road and cross the travel lanes to visit these facilities. There are typically two toll booths open for all vehicles (primarily used by trucks), one for cars and trailers, and two automated car booths. As the U.S. plaza requires trucks to stay to the left and autos to stay to the right, the Canadian Blue Water Bridge Authority restricts the flow of cars and trucks after the toll booths to the leftmost lane. This forces trucks into their desired position and allows cars to move to the right side of the bridge safety and eliminates all conflicting crossing maneuvers. This essentially creates a one-lane bottleneck on the three-lane bridge, but this did not seem to impact vehicle movement significantly. There are five booths to process commercial vehicles for U.S. Customs primary inspection; however, typically only two to four are used at any one time. Any truck not released from primary must enter the same secondary inspection compound. There are areas to park for drivers who need to visit their brokers as well as docks where physical secondary inspections can be conducted. As with the Canadian side, trucks exiting from secondary must pass through the area used by trucks exiting the primary inspection booths. Anecdotal information indicated that the limited physical space in the U.S. import compound occasionally fills up and trucks requiring secondary inspection or clearance must be held at the primary booths.

**Data Collection Process**

For this study, two data collection locations were used in each direction. The “number 1” location was immediately before the toll booths and the “number 2” location was immediately after the primary inspection booths. For consistency among all border crossings visited as part of the overall project, the data collection positions were distinguished by the direction of travel that they were measuring (outbound or inbound). Eastbound movement from the U.S. into Canada was referred to as outbound. Conversely, inbound was used to refer to westbound movement from Canada to the U.S. The Outbound 1 (OB-1) position; therefore, is in the U.S. plaza, before the toll booths. The Outbound 2 (OB-2) position was after the Canadian Customs booths. Inbound positions (IB-1 and IB-2) were similarly positioned. All four positions are identified in Figures 3 and 4 and shown in Figures 5 through 8.

Each data collector would use a handheld computer to record partial license plate information of all commercial vehicles that passed their location. The computer would also store the time that each license plate was entered. The data from the two locations in each direction would be combined, allowing the determination of the travel time for each vehicle that was recorded at *both* locations.

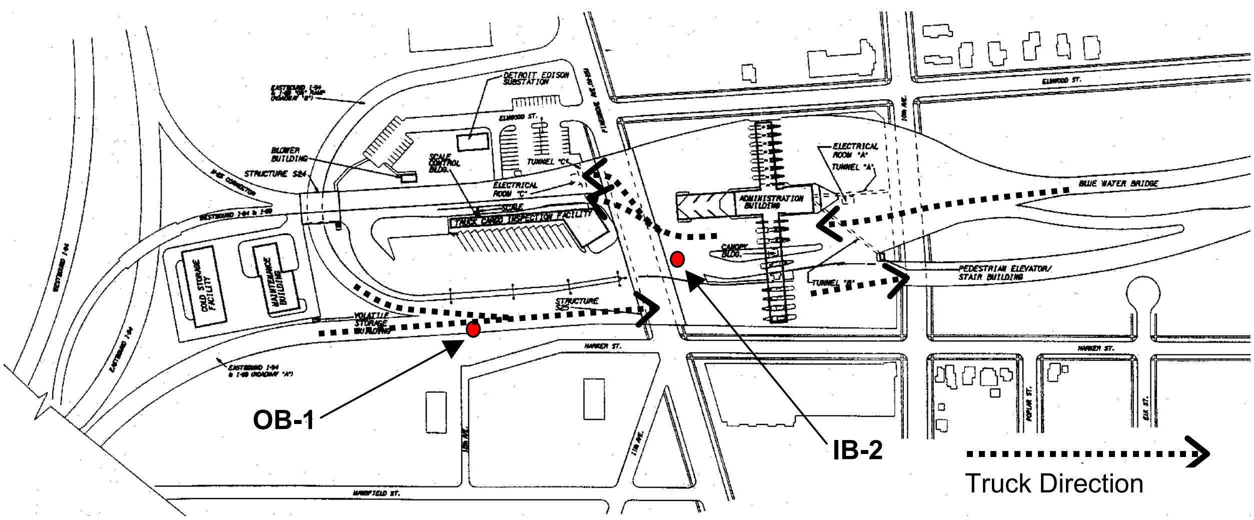


**Figure 3. US Plaza Showing Data Collection Locations**

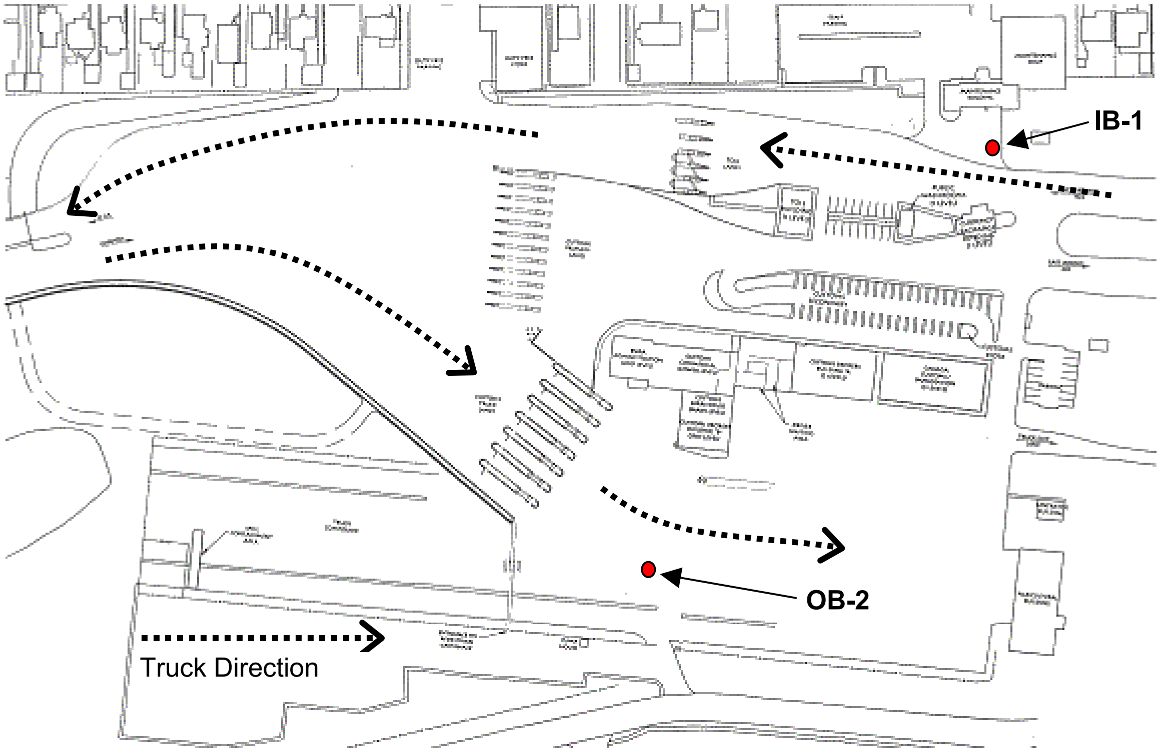


**Figure 4. Canadian Plaza Showing Data Collection Locations**

**Figure 5. U.S. Toll Plaza Showing OB-1 Collection Location**

**Figure 6. U.S. Customs Primary Inspection Booths as Seen from IB-2 Collection Location**

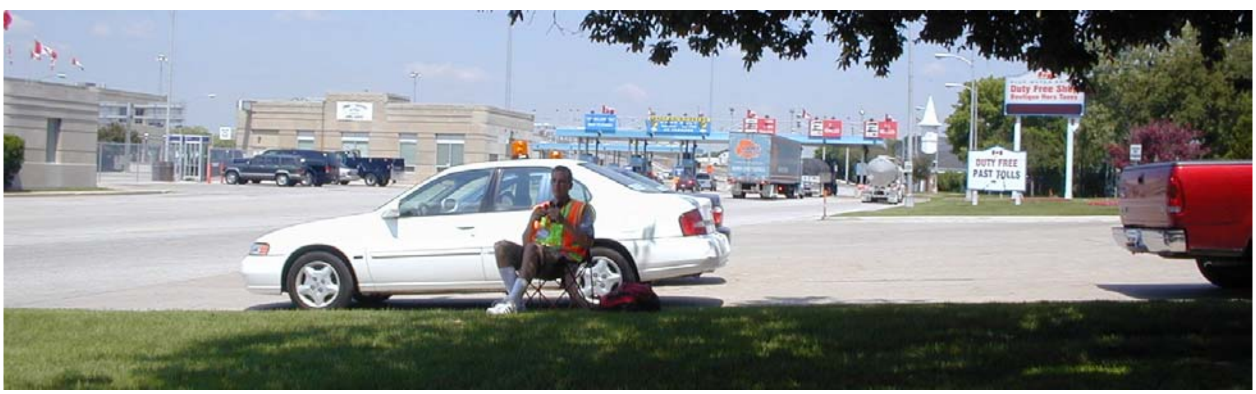


**Figure 7. Canadian Toll Booths as Seen from IB-1 Collection Location**


**Figure 8. OB-2 Collection Location in Canadian Customs Parking Area**

For the first week of data collection, the on-site team included four data collectors and one supervisor. It was later determined that an additional supervisor was necessary to help provide additional security for any collector in a #1 position who had to leave their initial position and move away from the bridge plaza. These secondary locations were often at or near rural highway intersections and were rather isolated. The extra supervisor could also provide additional support to take over data collection when a collector was given a break or lunch.

As previously mentioned, the hours during which data were collected were varied during each week to ensure the greatest possible coverage of conditions, including periods of low and high traffic volume. Table 1 shows the data collection hours for each day during the two site visits. As each data collector actually worked about 12 hours, the supervisor could collect data during their 30-minute meal break during the day, resulting in approximately 12-½ hours of data collection.

**Table 1. Hours of Data Collection**

| Date | Start | End |
|---|---|---|
| 6/12/01 | 6:00 am | 6:30 pm |
| 6/13/01 | 9:00 am | 9:30 pm |
| 6/14/01 | 9:00 am | 9:30 pm |
| 8/14/01 | 6:00 am | 6:30 pm |
| 8/15/01 | 9:00 am | 9:30 pm |
| 8/16/01 | 9:00 am | 9:30 pm |

While an extremely smooth process, it took considerable time to schedule and arrange the initial site visits to coordinate the data collection activities. Two separate meetings were held at the bridge. One meeting was held at the Michigan Department of Transportation facilities at the bridge with the Bridge Manager, the U.S. Customs Port Director, and the U.S. Customs Chief Inspector. Another meeting was held at the Blue Water Bridge Authority offices on the Canadian side. In attendance were the Operations Manager, the Special Projects Manager, and the District Director for Revenue Canada, Customs Border Services. It was determined that U.S. Customs visitor passes would need to be obtained for the data collectors from the shift supervisor when they arrived for the data collection. The names and birth dates of the data collectors also needed to be provided to U.S. Customs for the initial data collection visit. This was not required for the second data collection visit, however. No special passes were required for access to the Canadian Customs facilities.

Initial contacts with Canadian Immigration while at the bridge indicated that work permits were needed to conduct the data collection. However, consultations with Canadian Consular officials in Buffalo in preparation for data collection at the Peace Bridge indicated that that would not be necessary. The Canadian Consul General in Detroit was contacted and his staff determined that Annex 1603.A.1 of the North American Free Trade Agreement would allow our staff to enter Canada as Business Visitors without requiring work permits. All data collectors carried a copy of the e-mail from the Vice Consul as authorization for our activities. In addition, the Blue Water Bridge Authority staff communicated with the Canadian Customs and Immigration supervisors to ensure that their staff were aware of our visit.

Permission was obtained from the Michigan Department of Transportation Bridge Manager for any data collection on I-94, should that be necessary due to the formation of a queue. On the Canadian side, the Ontario Provincial Police (OPP) is responsible for monitoring activity along Highway 402, and the Blue Water Bridge Authority contacted the Sergeant in charge of the area to ensure that he was aware of the study and to obtain his permission to collect data along the highway. An additional item that required attention during the first data collection visit was contacting the foreman for the construction on Highway 402 to obtain his permission to be within the construction site.

Table 2 contains a list of the individuals who were contacted and their telephone and e-mail information. Future data collection for this project should be able to be organized and authorized with much less effort.  However, any new project would require additional time to explain the data collection objectives to the involved parties and gain their approval.

**Table 2.  Agency Contacts**

| Contact | Agency | Phone/Fax | E-mail |
|---|---|---|---|
| Bruce Campbell<br>Engineer/Bridge Manager | Michigan DOT<br>Blue Water Bridge | 810-984-3131<br>810-984-1810 (fax) | campbell5@<br>mdot.state.mi.us |
| Russell Day<br>Port Director | U.S. Customs | 810-985-7125 ext.131<br>810-985-3516 (fax) | Russell.h.day@<br>customs.treas.gov |
| Robert Prause<br>Chief Inspector | U.S. Customs | 810-985-9541 ext.117 | |
| Joe Lopetrone<br>Operations Manager | Blue Water Bridge<br>Authority | 519-337-8721<br>519-337-5877 (fax) | jlopetrone@bwba.org |
| Ed Teft<br>Special Projects & Bridge<br>Technology Manager | Blue Water Bridge<br>Authority | 519-336-2720<br>519-336-7622 (fax) | |
| W.L. (Bill) Elliott | Revenue Canada<br>Customs Border Services | 519-344-7351<br>519-336-5742 (fax) | billelliott@<br>ccra-adrc.gc.ca |
| John Tennant<br>Consul General | Consulate General of<br>Canada (Detroit) | 313-446-7010 ext.3200<br>313-567-2164 (fax) | |
| Bob Genereux<br>Vice Consul | Consulate General of<br>Canada (Detroit) | 313-446-4732<br>313-567-2125 (fax) | b.genereux@<br>dfait-maeci.gc.ca |
| Stan Korosek<br>Sergeant | Ontario Provincial Police<br>Point Edward Detachment | 519-336-8691<br>519-336-5011 (fax) | |
| Ken Doussept<br>Project Manager | BOT Construction Limited<br>(Highway 402 Project) | 905-827-4167<br>905-827-0458 (fax)<br>519-330-9306 (cell) | doussept@<br>botconstruction.ca |

## Data Collection Details

Both the Michigan Department of Transportation and the Blue Water Bridge Authority provided border crossing statistical data.  This data was evaluated for an assessment of the variability in travel conditions at the Blue Water Bridge.  The goal of this analysis process was to obtain statistically useful data with as few data collection days as possible.  In order to customize the data collection activities to the Blue Water Bridge, the following steps were conducted:

- ♦ Define significant “seasonal” variations,
- ♦ Define significantly different days of the week,
- ♦ Identify traffic streams that experience significantly different conditions, and
- ♦ Estimate the number of days needed for the data collection survey.

As shown in Table 3, there is some variation in the commercial traffic by month, which was most pronounced in 2000.  Due to project constraints, data collection needed to occur between late May and early September 2001.  From Table 3, the two months with the greatest average volumes during this data collection window were June and August.

**Table 3. Monthly Traffic Distribution of Commercial Vehicles**

| Month | 1998 | 1999 | 2000 | 1998-2000 Average |
|---|---|---|---|---|
| January | 105,313 | 111,071 | 122,961 | 113,115 |
| February | 105,919 | 114,652 | 126,796 | 115,789 |
| March | 117,456 | 132,440 | 144,109 | 131,335 |
| April | 115,129 | 124,457 | 127,224 | 122,270 |
| May | 114,844 | 126,057 | 143,081 | 127,994 |
| June | 111,183 | 132,783 | 148,134 | 130,700 |
| July | 91,459 | 105,845 | 111,411 | 102,905 |
| August | 113,546 | 130,042 | 144,027 | 129,205 |
| September | 119,176 | 133,327 | 132,295 | 128,266 |
| October | 124,852 | 134,384 | 140,891 | 133,376 |
| November | 121,358 | 133,504 | 132,846 | 129,236 |
| December | 110,625 | 116,763 | 103,064 | 110,151 |
| **Total** | 1,350,860 | 1,495,325 | 1,576,839 | 1,474,341 |

Source: Texas Transportation Institute

Tables 4 and 5 show that there is a significant difference in commercial traffic between weekdays and weekends and, further, there is a significant difference between Monday and Friday and the three mid-week days. Weekend traffic is 39 percent of typical weekday traffic and Monday/Friday traffic is 85 percent of typical Tuesday/Wednesday/Thursday traffic. In general, it was noted that outbound traffic increased from Tuesday through Thursday and inbound traffic decreased from Tuesday through Thursday. It was determined that collecting three days of data, from Tuesday through Thursday, would provide an adequate number of data samples to represent "typical" conditions.

**Table 4. Sample Month – Daily Traffic Distribution of Commercial Vehicles for June 2000**

| Day | Day of Week | Outbound | Inbound |
|---|---|---|---|
| 1 | Thursday | 3290 | 3230 |
| 2 | Friday | 3074 | 2638 |
| 3 | Saturday | 1327 | 1347 |
| 4 | Sunday | 879 | 1887 |
| 5 | Monday | 2616 | 3438 |
| 6 | Tuesday | 3014 | 3536 |
| 7 | Wednesday | 3158 | 3485 |
| 8 | Thursday | 3234 | 3231 |
| 9 | Friday | 2759 | 2491 |
| 10 | Saturday | 1031 | 1177 |
| 11 | Sunday | 788 | 1441 |
| 12 | Monday | 2408 | 3109 |
| 13 | Tuesday | 2996 | 3267 |
| 14 | Wednesday | 3003 | 3365 |

| Day | Day of Week | Outbound | Inbound |
|---|---|---|---|
| 15 | Thursday | 3170 | 3148 |
| 16 | Friday | 2785 | 2426 |
| 17 | Saturday | 970 | 1111 |
| 18 | Sunday | 805 | 1398 |
| 19 | Monday | 2442 | 3177 |
| 20 | Tuesday | 2878 | 3375 |
| 21 | Wednesday | 2883 | 3321 |
| 22 | Thursday | 3103 | 3104 |
| 23 | Friday | 2670 | 2401 |
| 24 | Saturday | 964 | 1113 |
| 25 | Sunday | 824 | 1386 |
| 26 | Monday | 2426 | 2999 |
| 27 | Tuesday | 2856 | 3164 |
| 28 | Wednesday | 2994 | 3225 |
| 29 | Thursday | 2754 | 2886 |
| 30 | Friday | 2278 | 1879 |
| **Total** | | 70,379 | 77,755 |

Source: Michigan Department of Transportation, Blue Water Bridge

**Table 5. Averages for Sample Month – Daily Traffic Distribution of Export Commercial Vehicles for June 2000**

| Day of Week | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Average |
|---|---|---|---|---|---|---|
| Sunday | | 2766 | 2229 | 2203 | 2210 | 2352 |
| Monday | | 6054 | 5517 | 5619 | 5425 | 5654 |
| Tuesday | | 6550 | 6263 | 6253 | 6020 | 6272 |
| Wednesday | | 6643 | 6368 | 6204 | 6219 | 6359 |
| Thursday | 6520 | 6465 | 6318 | 6207 | 5640 | 6230 |
| Friday | 5712 | 5250 | 5211 | 5071 | 4157 | 5080 |
| Saturday | 2674 | 2208 | 2081 | 2077 | | 2260 |

Source: Michigan Department of Transportation, Blue Water Bridge

From discussions with the Michigan Department of Transportation and the Blue Water Bridge Authority, it was learned that backups typically did not occur on the U.S. side and, when they did, they did not grow very long. However, on the Canadian side, backups occurred on a regular basis and could stretch for many miles along Highway 402. On the Canadian side, the backups could occur as early as 8 am.

## Data Collection Procedures

The data collection stations selected for the crossing were chosen because of the particular actions that occur at each site. Segments defined by the data collection stations were used to determine the commercial vehicle travel times and freight delay. As illustrated in Figures 3 through 8, the data collection sites were located at:

- An advance station located upstream of the commercial vehicle queue – OB-1 and IB-1.
- The import station (primary inspection booths before detailed, or secondary, inspection) – OB-2 and IB-2.

Data collection was conducted by recording commercial vehicle license plates as vehicles crossed fixed points within the data collection sites. Survey individuals or teams, were placed at each of the four data collection sites to record commercial vehicle license plate data. Figures 3 and 4 contain diagrams of the facilities on both sides of the border, including station locations and major points of inspection.

Collectors at these locations would record the last five characters of the front, lower-left license plate of as many trucks as possible that passed their location. When trucking firms register many vehicles at once, they often get assigned sequential license plate numbers. Using the last five characters helps to ensure that as different trucks operated by the same firm travel across the bridge that they are uniquely identified. License plate information was entered into Handspring Visor PDAs (handheld computers) with a special application designed for this project. Each entry was time-stamped with the current date and time. Prior to each day's collection, all PDAs were synchronized to the same time. Prior experience indicated that recording the entire license plate was too time consuming and that entering only the last four characters did not provide adequate distinction between different vehicles, so the project team chose to record the last five characters.

Typically, the queue of trucks crossing the border would not extend beyond the bridge plaza. However, on occasion the queue would extend onto the highway system. When this occurred, the data collector at the #1 location would have to move further from the bridge to a point beyond the end of the queue. In this way, they could continue to record trucks before they began their wait at the end of the line. When this or any other event of interest occurred, the collectors would use an "EVENT" feature of the PDA software to record it.

For each #1 location, the supervisor would record the distance from any data collection point other than the original position (which would be in the bridge plaza). During post-processing, the data from all locations nearer to the bridge than the *farthest* location would be adjusted to include the additional travel time from the farthest location to the original location. The travel time would be computed at free-flow speeds, since there would have been no queue at the times that the data were collected at these closer locations. In this way, the data all would appear to be collected from the same location, the one most distant from the bridge.

The data collection team used both cell phones and hand-held, two-way radios to maintain in touch with each other. This was particularly important when the queues lengthened such that a collector had to move farther upstream. The supervisor could be kept informed without repeated trips to each data collection location. This was also useful at the end of the day when the #1 collectors would inform the #2 collectors of the last truck they recorded, so the #2 collectors would know when to stop. While interference and cell tower locations created some problems with reception, each collector was usually able to use either their radio or cell phone to reach whomever they needed to speak with.

**Data Collection Sample Size**

Sample sizes are typically not a concern with videotape or handheld data entry devices, because the data collection includes a large number of vehicles. However, minimum sample sizes should be verified with variability values from field data. Early research found that sample sizes from 25 to 100 license matches were necessary for a given roadway segment and time period (Turner, et. al.). In all but one case at the beginning of a day of collection, there were sufficient records *each day* to meet this requirement.

**Data Collection Equipment**

As outlined in the "Data Collection Procedures" section above, Handspring Visor PDAs were used as the data entry device and proved adequate to the task. Low-end models with 2 Mb of storage capacity were selected as the application and data size were projected to be well below this limit. The Handspring Visors use the Palm OS (operating system) and have faster processing speeds (at least in side-by-side comparison with this application) and larger screen sizes than comparable models from Palm Computing.

A custom application was developed for the Palm OS that allowed the data collectors to identify their locations (e.g., OB-1, IB-2), the number of open booths (primarily used for the customs inspection booths), special events or other comments, and license plate information. A screen shot of the application interface is shown in Figure 9.


**Figure 9. Data Collection Device and Software Application**

The data were downloaded via a serial cable directly from the application into a text file on the field laptop computer, which was a Dell Latitude CPx H running with a 500 MHz Pentium III processor.

**Data Collection Summary**

Table 6 shows the number of commercial vehicle license plates recorded for each of the stations on each of the data collection days. Table 7 shows the average daily traffic volume as recorded by the Blue Water Bridge Authority (inbound direction) and the Michigan Department of Transportation (outbound direction). Hourly volumes are used in the calculation of delay; those are shown with the delay calculations in Tables 8 through 19.

**Table 6. Number of Commercial Vehicle License Plates Collected**

| Station | 6/12/01 | 6/13/01 | 6/14/01 | 8/14/01 | 8/15/01 | 8/16/01 |
|---|---|---|---|---|---|---|
| OB-1 | 1470 | 1712 | 1695 | 1334 | 1592 | 1656 |
| OB-2 | 1545 | 1858 | 1841 | 1445 | 1669 | 1655 |
| IB-1 | 1396 | 1745 | 1550 | 1469 | 1623 | 1461 |
| IB-4 | 1679 | 1800 | 1695 | 1584 | 1787 | 1556 |
| Total | 6090 | 7115 | 6781 | 5832 | 6671 | 6328 |

**Table 7. Average Daily Traffic at the Blue Water Bridge**

| Direction | 6/12/01 | 6/13/01 | 6/14/01 | 8/14/01 | 8/15/01 | 8/16/01 |
|---|---|---|---|---|---|---|
| Inbound | 3335 | 3305 | 3029 | 3056 | 3041 | 2771 |
| Outbound | 2626 | 2981 | 2973 | 2668 | 2768 | 2844 |
| Total | 5961 | 6286 | 6002 | 5724 | 5809 | 5615 |

## Data Quality Steps

At the end of each day of data collection, the supervisor would collect the PDAs and download the data into the field laptop computer where it was stored on the hard drive. The data would be examined for any anomalies and transferred across the Internet to a secondary location for backup purposes. The OB-1 and OB-2 data would be merged together and license plates from the two locations would be "matched" using a spreadsheet developed in Microsoft Excel. As it is easy to mistake certain characters, particularly letters that looked like numbers, the license plate data was pre-processed. All 'I's were replaced with '1's; all 'O's, 'D's, and 'Q's were replaced with '0's; all 'S's were replaced with '5's; and all 'Z's were replaced with '2's. In addition, the data collectors were instructed to always use '1's for 'I's and '0's for 'O's (i.e., to use the digit, rather than the letter).

Occasionally, collectors would be unsure about a license plate and would append "QQQ" to their entry. This would typically occur when several trucks passed the collector in rapid succession or if one truck blocked the license plate of another and he or she could only manage a quick glimpse. This would allow the supervisor to search the downloaded data for a potential match by using the travel times of other trucks that were recorded in the same general time frame. During this process, the supervisor could also identify the few records in which the data collector forgot to press "ENTER" after recording a license plate before recording the next one. These ten-character entries could be split into two and the time for the first interpolated from the adjacent entries if they were less than a minute or so apart.

Data post-processing also included a step to identify any anomalies in the data, including outliers. Outliers, records that indicated travel times significantly greater than typical for that time period, were most often caused by recording the license plate of a vehicle only some of the time as it made repeated trips across the border during a single day. This is because the matching algorithm uses the most recent time at the #1 position when matching to a record from a #2 location. For example, if the vehicle was recorded as it headed from Canada to the U.S. early in the morning, later returned to Canada, was missed as it re-entered the U.S. later in the day, and then recorded on its subsequent return to Canada, the #1 time from its first trip would be matched with it #1 time from the first trip (for a valid travel time) an also matched to the #2 time from its second trip (an invalid travel time). This invalid travel time would be easily identified by manual inspection of the data, aided by highlighting those travel times above a specific, but variable, threshold.

## Freight Delay Analysis

The measure for the freight transportation system at international roadway border crossings is travel delay per truck trip through the first inspection point in the import country. Delay is measured relative to the travel time at low volume conditions, which will allow the processing time of the inspection to be accommodated outside of the measure. Estimating the average delay per truck for each hour where congestion is present and then applying the average hourly truck volume produces an estimate of total delay.

The average delay per truck for each hour is the difference between the travel time at low volume conditions and the travel time each hour. Travel time is also affected by the number of open inspection booths and this information was recorded on all days as it changed. To determine the average travel time for each road segment, the matched license plate data in the database is used. The number of matches are noted for statistical analysis and the travel time is noted for each hour. The travel time for each truck was assigned to the hour when they passed through the primary customs inspection location as this was the only location that remained consistent throughout the data collection. It should be noted, however, that the hourly volumes are obtained from the bridge operators and are measured at the toll booths.

The data are presented in Tables 8 through 19. The columns illustrate the key elements for estimating delay:

- No Delay Travel Time – The time through the system at low volume conditions. For this report, the value used was that of the lowest hourly travel time in that direction for each three-day data collection period.
- Average Number of Open Booths – The average number of primary Customs commercial vehicle inspection booths open and available for processing trucks. This figure is not used to compute delay but is useful to help understand the relationship between booths, traffic volume, and delay.
- Number of Matched Vehicles – The number of vehicle observation used to estimate the travel time for each hour.
- Average Travel Time – The amount of travel time from entry to exit for trucks entering the system each hour (use the time the vehicle passes the advance point as the determinant of the time period label).
- Delay per Trip – The difference between the average travel time and the “no delay” time.
- Average Traffic Volume – The average hourly truck volume for the “season” or time of year being analyzed.
- Total Delay – The product of the hourly truck volume and delay per trip.

## Table 8. Total Delay – 6/12/2001 – Outbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 6:00 – 7:00 AM | 4.80 | 2.12 | 41 | 5.40 | 0.60 | 72.00 | 43.20 |
| 7:00 – 8:00 AM | 4.80 | 2.15 | 52 | 5.20 | 0.40 | 95.75 | 38.30 |
| 8:00 – 9:00 AM | 4.80 | 4.00 | 94 | 5.82 | 1.02 | 135.25 | 137.50 |
| 9:00 – 10:00 AM | 4.80 | 4.00 | 114 | 5.18 | 0.38 | 143.75 | 55.10 |
| 10:00 – 11:00 AM | 4.80 | 4.00 | 96 | 5.45 | 0.65 | 153.25 | 99.61 |
| 11:00 – 12:00 PM | 4.80 | 4.00 | 111 | 5.77 | 0.97 | 157.75 | 152.49 |
| 12:00 – 1:00 PM | 4.80 | 4.05 | 98 | 5.42 | 0.62 | 155.75 | 96.05 |
| 1:00 – 2:00 PM | 4.80 | 4.00 | 111 | 6.83 | 2.03 | 155.25 | 315.68 |
| 2:00 – 3:00 PM | 4.80 | 4.00 | 112 | 5.98 | 1.18 | 158.50 | 187.56 |
| 3:00 – 4:00 PM | 4.80 | 4.00 | 100 | 5.38 | 0.58 | 162.75 | 94.94 |
| 4:00 – 5:00 PM | 4.80 | 4.00 | 116 | 5.57 | 0.77 | 152.50 | 116.92 |
| 5:00 – 6:00 PM | 4.80 | 4.00 | 101 | 4.98 | 0.18 | 155.75 | 28.55 |
| 6:00 – 7:00 PM | 4.80 | 2.95 | 51 | 5.08 | 0.28 | 153.75 | 43.56 |

## Table 9. Total Delay – 6/13/2001 – Outbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 4.80 | 4.00 | 75 | 6.20 | 1.40 | 143.75 | 201.25 |
| 10:00 – 11:00 AM | 4.80 | 4.00 | 130 | 7.22 | 2.42 | 153.25 | 370.35 |
| 11:00 – 12:00 PM | 4.80 | 4.00 | 132 | 7.22 | 2.42 | 157.75 | 381.23 |
| 12:00 – 1:00 PM | 4.80 | 4.00 | 91 | 9.95 | 5.15 | 155.75 | 802.11 |
| 1:00 – 2:00 PM | 4.80 | 4.00 | 133 | 9.08 | 4.28 | 155.25 | 664.99 |
| 2:00 – 3:00 PM | 4.80 | 4.00 | 137 | 9.22 | 4.42 | 158.50 | 700.04 |
| 3:00 – 4:00 PM | 4.80 | 4.00 | 123 | 6.57 | 1.77 | 162.75 | 287.53 |
| 4:00 – 5:00 PM | 4.80 | 4.00 | 110 | 4.80 | 0.00 | 152.50 | 0.00 |
| 5:00 – 6:00 PM | 4.80 | 4.00 | 126 | 5.60 | 0.80 | 155.75 | 124.60 |
| 6:00 – 7:00 PM | 4.80 | 4.00 | 127 | 5.75 | 0.95 | 153.75 | 146.06 |
| 7:00 – 8:00 PM | 4.80 | 3.66 | 121 | 5.63 | 0.83 | 145.00 | 120.83 |
| 8:00 – 9:00 PM | 4.80 | 3.00 | 102 | 10.02 | 5.22 | 137.00 | 714.68 |
| 9:00 – 10:00 PM | 4.80 | 3.00 | 47 | 14.62 | 9.82 | 126.75 | 1,244.26 |

## Table 10. Total Delay – 6/14/2001 – Outbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 4.80 | 4.00 | 101 | 6.63 | 1.83 | 143.75 | 263.54 |
| 10:00 – 11:00 AM | 4.80 | 4.00 | 114 | 5.25 | 0.45 | 153.25 | 68.96 |
| 11:00 – 12:00 PM | 4.80 | 4.00 | 111 | 6.88 | 2.08 | 157.75 | 328.65 |
| 12:00 – 1:00 PM | 4.80 | 4.00 | 131 | 6.00 | 1.20 | 155.75 | 186.90 |
| 1:00 – 2:00 PM | 4.80 | 4.00 | 147 | 5.93 | 1.13 | 155.25 | 175.95 |
| 2:00 – 3:00 PM | 4.80 | 4.00 | 148 | 5.17 | 0.37 | 158.50 | 58.12 |
| 3:00 – 4:00 PM | 4.80 | 4.00 | 117 | 6.37 | 1.57 | 162.75 | 254.98 |
| 4:00 – 5:00 PM | 4.80 | 4.00 | 121 | 5.10 | 0.30 | 152.50 | 45.75 |
| 5:00 – 6:00 PM | 4.80 | 4.00 | 126 | 5.47 | 0.67 | 155.75 | 103.83 |
| 6:00 – 7:00 PM | 4.80 | 4.00 | 101 | 5.47 | 0.67 | 153.75 | 102.50 |
| 7:00 – 8:00 PM | 4.80 | 3.71 | 117 | 6.87 | 2.07 | 145.00 | 299.67 |
| 8:00 – 9:00 PM | 4.80 | 3.84 | 115 | 8.62 | 3.82 | 137.00 | 522.88 |
| 9:00 – 10:00 PM | 4.80 | 4.00 | 30 | 5.55 | 0.75 | 126.75 | 95.06 |

## Table 11. Total Delay – 8/14/2001 – Outbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 6:00 – 7:00 AM | 4.98 | 2.00 | 38 | 5.03 | 0.05 | 69.75 | 3.49 |
| 7:00 – 8:00 AM | 4.98 | 2.12 | 61 | 6.68 | 1.70 | 92.25 | 156.83 |
| 8:00 – 9:00 AM | 4.98 | 4.00 | 97 | 5.13 | 0.15 | 129.25 | 19.39 |
| 9:00 – 10:00 AM | 4.98 | 4.00 | 65 | 5.33 | 0.35 | 137.50 | 48.13 |
| 10:00 – 11:00 AM | 4.98 | 4.00 | 80 | 5.18 | 0.20 | 155.00 | 31.00 |
| 11:00 – 12:00 PM | 4.98 | 4.00 | 80 | 5.68 | 0.70 | 155.00 | 108.50 |
| 12:00 – 1:00 PM | 4.98 | 4.00 | 77 | 6.02 | 1.03 | 152.50 | 157.58 |
| 1:00 – 2:00 PM | 4.98 | 4.00 | 102 | 5.65 | 0.67 | 156.00 | 104.00 |
| 2:00 – 3:00 PM | 4.98 | 4.00 | 109 | 4.98 | 0.00 | 153.25 | 0.00 |
| 3:00 – 4:00 PM | 4.98 | 4.00 | 107 | 5.28 | 0.30 | 158.75 | 47.63 |
| 4:00 – 5:00 PM | 4.98 | 4.00 | 102 | 5.17 | 0.18 | 157.25 | 28.83 |
| 5:00 – 6:00 PM | 4.98 | 4.00 | 83 | 5.00 | 0.02 | 147.50 | 2.46 |
| 6:00 – 7:00 PM | 4.98 | 4.00 | 36 | 5.07 | 0.08 | 146.25 | 12.19 |

**Table 12. Total Delay – 8/15/2001 – Outbound**

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 4.98 | 4.00 | 34 | 5.68 | 0.70 | 137.50 | 96.25 |
| 10:00 – 11:00 AM | 4.98 | 4.00 | 96 | 5.45 | 0.47 | 155.00 | 72.33 |
| 11:00 – 12:00 PM | 4.98 | 4.00 | 102 | 5.43 | 0.45 | 155.00 | 69.75 |
| 12:00 – 1:00 PM | 4.98 | 4.00 | 111 | 5.67 | 0.68 | 152.50 | 104.21 |
| 1:00 – 2:00 PM | 4.98 | 4.00 | 120 | 7.23 | 2.25 | 156.00 | 351.00 |
| 2:00 – 3:00 PM | 4.98 | 4.00 | 130 | 6.70 | 1.72 | 153.25 | 263.08 |
| 3:00 – 4:00 PM | 4.98 | 4.00 | 136 | 6.15 | 1.17 | 158.75 | 185.21 |
| 4:00 – 5:00 PM | 4.98 | 4.00 | 118 | 5.47 | 0.48 | 157.25 | 76.00 |
| 5:00 – 6:00 PM | 4.98 | 4.00 | 107 | 5.28 | 0.30 | 147.50 | 44.25 |
| 6:00 – 7:00 PM | 4.98 | 4.00 | 92 | 5.43 | 0.45 | 146.25 | 65.81 |
| 7:00 – 8:00 PM | 4.98 | 4.00 | 100 | 5.55 | 0.57 | 143.25 | 81.18 |
| 8:00 – 9:00 PM | 4.98 | 3.93 | 76 | 7.62 | 2.63 | 141.00 | 371.30 |
| 9:00 – 10:00 PM | 4.98 | 3.99 | 32 | 8.28 | 3.30 | 123.75 | 408.38 |

**Table 13. Total Delay – 8/16/2001 – Outbound**

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 4.98 | 4.00 | 71 | 5.57 | 0.58 | 137.50 | 80.21 |
| 10:00 – 11:00 AM | 4.98 | 4.00 | 98 | 5.93 | 0.95 | 155.00 | 147.25 |
| 11:00 – 12:00 PM | 4.98 | 4.00 | 119 | 7.47 | 2.48 | 155.00 | 384.92 |
| 12:00 – 1:00 PM | 4.98 | 4.00 | 106 | 6.47 | 1.48 | 152.50 | 226.21 |
| 1:00 – 2:00 PM | 4.98 | 4.00 | 106 | 6.70 | 1.72 | 156.00 | 267.80 |
| 2:00 – 3:00 PM | 4.98 | 4.00 | 110 | 5.55 | 0.57 | 153.25 | 86.84 |
| 3:00 – 4:00 PM | 4.98 | 4.00 | 119 | 5.50 | 0.52 | 158.75 | 82.02 |
| 4:00 – 5:00 PM | 4.98 | 4.00 | 132 | 6.07 | 1.08 | 157.25 | 170.35 |
| 5:00 – 6:00 PM | 4.98 | 4.00 | 114 | 5.87 | 0.88 | 147.50 | 130.29 |
| 6:00 – 7:00 PM | 4.98 | 4.00 | 84 | 5.67 | 0.68 | 146.25 | 99.94 |
| 7:00 – 8:00 PM | 4.98 | 4.00 | 117 | 8.47 | 3.48 | 143.25 | 498.99 |
| 8:00 – 9:00 PM | 4.98 | 4.00 | 67 | 6.13 | 1.15 | 141.00 | 162.15 |
| 9:00 – 10:00 PM | 4.98 | 4.00 | 33 | 5.78 | 0.80 | 123.75 | 99.00 |

## Table 14. Total Delay – 6/12/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 6:00 – 7:00 AM | 8.67 | 2.76 | 24 | 30.57 | 21.90 | 133.71 | 2,927.84 |
| 7:00 – 8:00 AM | 8.67 | 3.00 | 109 | 34.53 | 25.86 | 136.67 | 3,534.82 |
| 8:00 – 9:00 AM | 8.67 | 3.00 | 140 | 27.35 | 18.68 | 144.79 | 2,704.65 |
| 9:00 – 10:00 AM | 8.67 | 3.00 | 110 | 23.42 | 14.75 | 152.06 | 2,242.34 |
| 10:00 – 11:00 AM | 8.67 | 3.00 | 114 | 24.32 | 15.65 | 150.52 | 2,355.12 |
| 11:00 – 12:00 PM | 8.67 | 3.00 | 86 | 32.38 | 23.71 | 141.06 | 3,344.95 |
| 12:00 – 1:00 PM | 8.67 | 3.00 | 123 | 36.30 | 27.63 | 137.08 | 3,787.44 |
| 1:00 – 2:00 PM | 8.67 | 3.00 | 98 | 38.22 | 29.55 | 153.54 | 4,536.55 |
| 2:00 – 3:00 PM | 8.67 | 3.00 | 113 | 43.75 | 35.08 | 153.87 | 5,397.60 |
| 3:00 – 4:00 PM | 8.67 | 3.80 | 25 | 41.03 | 32.36 | 152.50 | 4,935.41 |
| 4:00 – 5:00 PM | 8.67 | 4.00 | 128 | 28.93 | 20.26 | 157.06 | 3,182.51 |
| 5:00 – 6:00 PM | 8.67 | 3.92 | 79 | 20.02 | 11.35 | 157.69 | 1,789.28 |

## Table 15. Total Delay – 6/13/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 8.67 | 3.00 | 74 | 18.10 | 9.43 | 152.06 | 1,433.90 |
| 10:00 – 11:00 AM | 8.67 | 3.00 | 121 | 18.67 | 10.00 | 150.52 | 1,504.69 |
| 11:00 – 12:00 PM | 8.67 | 3.00 | 82 | 30.32 | 21.65 | 141.06 | 3,053.43 |
| 12:00 – 1:00 PM | 8.67 | 3.00 | 122 | 39.78 | 31.11 | 137.08 | 4,264.92 |
| 1:00 – 2:00 PM | 8.67 | 3.75 | 173 | 30.07 | 21.40 | 153.54 | 3,285.21 |
| 2:00 – 3:00 PM | 8.67 | 3.83 | 122 | 14.42 | 5.75 | 153.87 | 884.21 |
| 3:00 – 4:00 PM | 8.67 | 3.00 | 120 | 17.48 | 8.81 | 152.50 | 1,344.03 |
| 4:00 – 5:00 PM | 8.67 | 2.89 | 138 | 23.18 | 14.51 | 157.06 | 2,279.43 |
| 5:00 – 6:00 PM | 8.67 | 3.00 | 150 | 21.38 | 12.71 | 157.69 | 2,004.79 |
| 6:00 – 7:00 PM | 8.67 | 3.00 | 131 | 17.37 | 8.70 | 145.44 | 1,264.86 |
| 7:00 – 8:00 PM | 8.67 | 3.00 | 141 | 18.95 | 10.28 | 136.56 | 1,403.81 |
| 8:00 – 9:00 PM | 8.67 | 3.00 | 108 | 14.87 | 6.20 | 125.12 | 775.30 |
| 9:00 – 10:00 PM | 8.67 | 3.00 | 50 | 18.68 | 10.01 | 125.81 | 1,259.75 |

## Table 16. Total Delay – 6/14/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 8.67 | 3.45 | 76 | 27.17 | 18.50 | 152.06 | 2,812.56 |
| 10:00 – 11:00 AM | 8.67 | 3.00 | 162 | 28.85 | 20.18 | 150.52 | 3,037.48 |
| 11:00 – 12:00 PM | 8.67 | 3.00 | 127 | 15.55 | 6.88 | 141.06 | 970.48 |
| 12:00 – 1:00 PM | 8.67 | 3.00 | 103 | 16.22 | 7.55 | 137.08 | 1,034.47 |
| 1:00 – 2:00 PM | 8.67 | 3.00 | 138 | 17.82 | 9.15 | 153.54 | 1,404.37 |
| 2:00 – 3:00 PM | 8.67 | 3.00 | 106 | 18.82 | 10.15 | 153.87 | 1,561.22 |
| 3:00 – 4:00 PM | 8.67 | 2.95 | 109 | 18.30 | 9.63 | 152.50 | 1,468.58 |
| 4:00 – 5:00 PM | 8.67 | 2.09 | 99 | 25.63 | 16.96 | 157.06 | 2,664.22 |
| 5:00 – 6:00 PM | 8.67 | 3.00 | 133 | 36.90 | 28.23 | 157.69 | 4,451.65 |
| 6:00 – 7:00 PM | 8.67 | 3.00 | 100 | 19.77 | 11.10 | 145.44 | 1,613.92 |
| 7:00 – 8:00 PM | 8.67 | 3.00 | 124 | 12.32 | 3.65 | 136.56 | 497.98 |
| 8:00 – 9:00 PM | 8.67 | 3.00 | 98 | 8.67 | 0.00 | 125.12 | 0.00 |
| 9:00 – 10:00 PM | 8.67 | 2.00 | 43 | 14.68 | 6.02 | 125.81 | 756.94 |

## Table 17. Total Delay – 8/14/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 7:00 – 8:00 AM | 15.05 | 3.00 | 15 | 58.08 | 43.03 | 138.76 | 5,971.27 |
| 8:00 – 9:00 AM | 15.05 | 3.00 | 55 | 60.15 | 45.10 | 146.26 | 6,596.29 |
| 9:00 – 10:00 AM | 15.05 | 2.93 | 57 | 57.05 | 42.00 | 142.81 | 5,998.22 |
| 10:00 – 11:00 AM | 15.05 | 3.00 | 71 | 57.62 | 42.57 | 142.83 | 6,079.94 |
| 11:00 – 12:00 PM | 15.05 | 3.00 | 55 | 63.75 | 48.70 | 146.56 | 7,137.26 |
| 12:00 – 1:00 PM | 15.05 | 3.00 | 78 | 72.65 | 57.60 | 139.04 | 8,008.53 |
| 1:00 – 2:00 PM | 15.05 | 3.00 | 12 | 75.13 | 60.08 | 148.24 | 8,906.80 |
| 2:00 – 3:00 PM | 15.05 | 3.00 | 72 | 80.63 | 65.58 | 156.89 | 10,289.30 |
| 3:00 – 4:00 PM | 15.05 | 3.00 | 55 | 90.73 | 75.68 | 148.56 | 11,243.18 |
| 4:00 – 5:00 PM | 15.05 | 3.00 | 65 | 83.90 | 68.85 | 152.37 | 10,490.70 |
| 5:00 – 6:00 PM | 15.05 | 2.99 | 67 | 80.10 | 65.05 | 155.20 | 10,096.00 |
| 6:00 – 7:00 PM | 15.05 | 3.00 | 50 | 83.92 | 68.87 | 145.57 | 10,025.20 |

## Table 18. Total Delay – 8/15/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 10:00 – 11:00 AM | 15.05 | 3.00 | 32 | 62.32 | 47.27 | 142.83 | 6,751.26 |
| 11:00 – 12:00 PM | 15.05 | 3.94 | 125 | 51.25 | 36.20 | 146.56 | 5,305.31 |
| 12:00 – 1:00 PM | 15.05 | 3.98 | 110 | 36.33 | 21.28 | 139.04 | 2,959.17 |
| 1:00 – 2:00 PM | 15.05 | 4.00 | 92 | 29.12 | 14.07 | 148.24 | 2,085.25 |
| 2:00 – 3:00 PM | 15.05 | 3.41 | 95 | 40.55 | 25.50 | 156.89 | 4,000.67 |
| 3:00 – 4:00 PM | 15.05 | 3.00 | 121 | 37.50 | 22.45 | 148.56 | 3,335.07 |
| 4:00 – 5:00 PM | 15.05 | 3.00 | 127 | 30.53 | 15.48 | 152.37 | 2,359.20 |
| 5:00 – 6:00 PM | 15.05 | 3.00 | 131 | 26.10 | 11.05 | 155.20 | 1,715.00 |
| 6:00 – 7:00 PM | 15.05 | 2.69 | 126 | 16.75 | 1.70 | 145.57 | 247.48 |
| 7:00 – 8:00 PM | 15.05 | 2.38 | 114 | 19.97 | 4.92 | 139.48 | 685.78 |
| 8:00 – 9:00 PM | 15.05 | 2.08 | 92 | 23.47 | 8.42 | 125.93 | 1,059.88 |
| 9:00 – 10:00 PM | 15.05 | 2.92 | 55 | 30.67 | 15.62 | 133.07 | 2,078.17 |

## Table 19. Total Delay – 8/16/2001 – Inbound

| Time Period | (a) "No Delay" Travel Time | (b) Average No. of Open Booths | (c) Number of "Matched" Vehicles | (d) Average Travel Time | (e) Delay Per Trip (d - a) | (f) Average Traffic Volume | (g) Total Delay (f x e) |
|---|---|---|---|---|---|---|---|
| 9:00 – 10:00 AM | 15.05 | 3.00 | 2 | 21.40 | 6.35 | 142.81 | 906.87 |
| 10:00 – 11:00 AM | 15.05 | 3.00 | 75 | 55.40 | 40.35 | 142.83 | 5,763.33 |
| 11:00 – 12:00 PM | 15.05 | 3.00 | 110 | 49.53 | 34.48 | 146.56 | 5,053.72 |
| 12:00 – 1:00 PM | 15.05 | 3.00 | 87 | 41.52 | 26.47 | 139.04 | 3,679.85 |
| 1:00 – 2:00 PM | 15.05 | 3.00 | 122 | 33.23 | 18.18 | 148.24 | 2,695.51 |
| 2:00 – 3:00 PM | 15.05 | 3.00 | 93 | 26.13 | 11.08 | 156.89 | 1,738.85 |
| 3:00 – 4:00 PM | 15.05 | 3.12 | 96 | 23.48 | 8.43 | 148.56 | 1,252.82 |
| 4:00 – 5:00 PM | 15.05 | 3.68 | 122 | 17.18 | 2.13 | 152.37 | 325.06 |
| 5:00 – 6:00 PM | 15.05 | 2.48 | 82 | 23.35 | 8.30 | 155.20 | 1,288.19 |
| 6:00 – 7:00 PM | 15.05 | 3.00 | 99 | 17.35 | 2.30 | 145.57 | 334.82 |
| 7:00 – 8:00 PM | 15.05 | 2.83 | 85 | 15.05 | 0.00 | 139.48 | 0.00 |
| 8:00 – 9:00 PM | 15.05 | 2.00 | 70 | 15.75 | 0.70 | 125.93 | 88.15 |
| 9:00 – 10:00 PM | 15.05 | 2.00 | 39 | 22.92 | 7.87 | 133.07 | 1,046.85 |

As previously mentioned, the number of open primary Customs inspection booths was also recorded. Examining the previous tables shows the relationship between the volume of trucks moving across the border and the number of open inspection booths on the travel times, particularly in the inbound direction.

At the Blue Water Bridge, data collectors did not have to relocate due to an increasing queue length in the outbound direction, but did have to move in the inbound location. Several different locations along Highway 402 were chosen, depending on the current conditions. Of course, it was the easiest to record data at the initial location in the Canadian plaza as trucks approached the bridge. Here, they were moving slowly and were most often using only the rightmost lane. Two alternate locations were at or near the Indian Road interchange on Highway 402, approximately 1.4 and 1.8 miles from the initial location, respectively. Here, trucks would pass at highway speeds and would often use both lanes, reducing the number of vehicles that could be effectively recorded. Two additional locations were used when the trucks backed up beyond the Indian Road interchange. The first was at the Airport Road interchange, approximately 5.2 miles from the initial location. This area was in the construction zone and traffic was limited to a single lane. While vehicles still passed at full highway speeds, data collection was easier than at Indian Road due to the single lane of traffic. During the final days of data collection, the location was moved the next overpass closer to the bridge (0.55 miles closer than the Airport Road location) because of construction activity at the Airport Road interchange. On one occasion, the queue actually approached within a half mile of the adjusted Airport Road location. On another, the queue was approximately 4 miles long.

Specifically, the IB-1 collector had to move from the initial location around 2:25 pm on 6/12/01 upstream from the bridge. By approximately 2:40 pm, the queue had passed the Indian Road location and the collector had to move to Airport Road. This illustrates how quickly the queue can grow. That day, the collector remained at Airport Road until shortly after 4 pm. There was no queue the entire day on 6/13/01. On 6/14/01, the IB-1 collector moved to Indian Road at around 5:40 and then to Airport Road just before 6 pm. The queue had not yet dissipated by around 9:30 pm when data collection was stopped for the day.

The queue situation was different during the second week of collection. The IB-1 collector began collection at Indian Road at 6:30 am on 8/14/01. Approximately 12:45 pm, the collector moved to the alternate Airport Road location and remained there until the end of the day at 6:30 pm. Also, at around 8:30 am on 8/14/01, there was some construction activity on the roadway in one of the U.S. Customs primary inspection booths. This involved a significant amount of jackhammering and the adjacent booth was also closed because of the noise was too great for an inspector to function effectively. There were significant queues heading into the U.S. that day and the other three available booths were open for most of that time; however, it is unclear whether a fourth or fifth booth would have been opened if the construction were not taking place.

The queues continued on the second day of week two collection, 8/15/01, with the IB-1 collector again beginning at Indian Road (at 9:30 am). However, at 1 pm, the queue completely dissipated and the collector was able to return to the initial location on the bridge plaza. For the first time, however, the auto traffic began to interfere with the commercial vehicle traffic. As mentioned previously, trucks typically use the left two lanes when approaching the primary inspection booths and cars use the right lane. On this day, there was such an increase in auto traffic that impatient drivers were also occupying the center lane and once in a while a car would move into the far left lane. On three occasions between noon and 1:30 pm, the backup of cars extended from the auto inspection booths onto the bridge in all three lanes. This completely blocked truck traffic to the commercial lanes and would result in all the open truck inspection booths being empty for at least five to ten minutes until the next truck in line could pass by the cars in front of it. Also on 8/15/01, a truck became disabled in one of the open booths at 1:37 pm and was not towed away until 2:24 pm.

On 8/16/01, the IB-1 data collection began at Indian Road at 9:15 am and remained there until almost 10:30 am. However, the bridge remained fairly full of trucks and again there were a significant number of passenger cars. These cars temporarily blocked the trucks from approaching the inspection booths on three occasions, around 4:00, 3:45, and 4:40 pm.

For all days of data collection except the last (8/16/01), there were no weather conditions of note. However, there were alternating periods of light and heavy rain for most of the last day of collection until approximately 5 pm. Of particular issue, however, was the difficulty in reading license plates beginning at early dusk. While the locations near the bridge facility provided ample lighting, the illuminated headlights of approaching trucks effectively blinded the data collectors until the split second before the truck passed their location. This proved particularly difficult for the IB-1 collector who was recording trucks passing in excess of 60 miles per hour. The binoculars that all data collectors used to some degree made the glare even more pronounced.

The chosen locations for data collection proved to be well suited to the task. On several occasions, it would have been helpful to have specific written (rather than verbal) authorization from the local Canadian Immigration officials to facilitate processing at the primary auto Customs inspection as we entered Canada. On two occasions, the e-mail from the Vice Consul was insufficient for the Customs inspector and our staff were instructed to speak with the Immigration officials, "just to check". On both occasions, the Immigration staff were aware of our study and cleared us for entry, but we were nonetheless delayed. After the first occasion (our first pre-collection reconnaissance of the site), we requested some form of written documentation from Canadian Immigration and were told that we should not have any further problems, as they were aware of our study. On the second occasion, a Customs shift supervisor forgot to mention our presence to the morning shift of inspectors, which caused the delay.

**Statistics**

Table 20 shows the baseline or "no delay" travel time, the average travel time, and three other measures that indicate the reliability of the travel time estimates. The baseline time (in minutes) is the time needed to travel the study distance (between the starting point in the exporting country and the initial inspection point in the importing country) in free-flow traffic conditions. The average time is computed from all vehicles measured during the data collection period over the study distance. The 95$^{th}$ percentile time is the time (in minutes) within which 95 percent of all trucks can cross the border. The buffer time is the additional time above the average crossing time (in minutes) that it takes for 95 percent of all trucks to cross. The buffer index expresses the buffer time in terms of the average time and is the percentage of extra time that must be budgeted to cross the border within the 95$^{th}$ percentile time. For example, if the average time was 10 minutes and the buffer time was 5 minutes, the buffer index would be 50 percent.

**Table 20. Crossing Times**

| | Baseline Time | Average Crossing Time | 95th Percentile Time | Buffer Time | Buffer Index |
|---|---|---|---|---|---|
| Outbound | 5.0 | 6.2 | 9.1 | 2.9 | 46.8 |
| Inbound | 11.1 | 34.2 | 80.3 | 46.1 | 134.8 |

From the table, it is apparent that both the average travel time and the reliability are significantly more favorable for outbound traffic than for inbound traffic.

Figure 10 illustrates the average travel time experienced for different truck volumes per lane per hour in each direction.

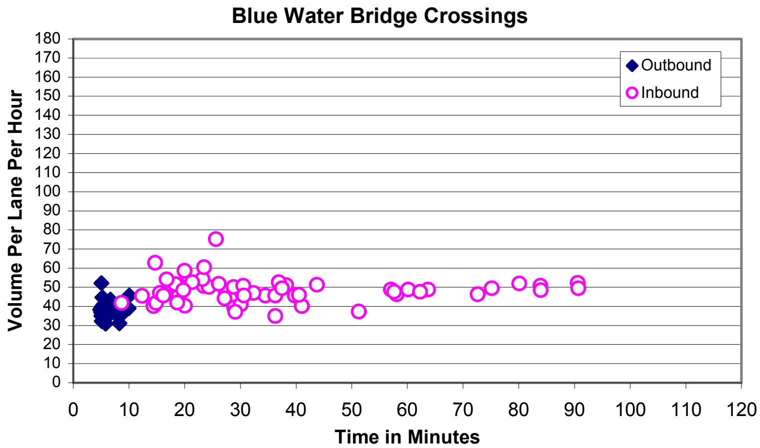


**Figure 10. Average Travel Time for Different Hourly Volumes**

Figures 11 and 12 show typical average hourly traffic volumes per booth for the study period as well as the measured average hourly travel times. In addition, the average number of open primary Customs booths in each direction is shown.

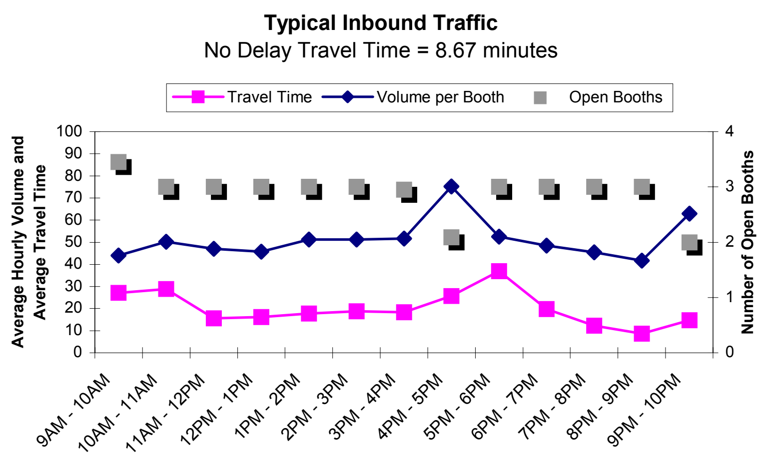

**Figure 11. Typical Inbound Traffic**

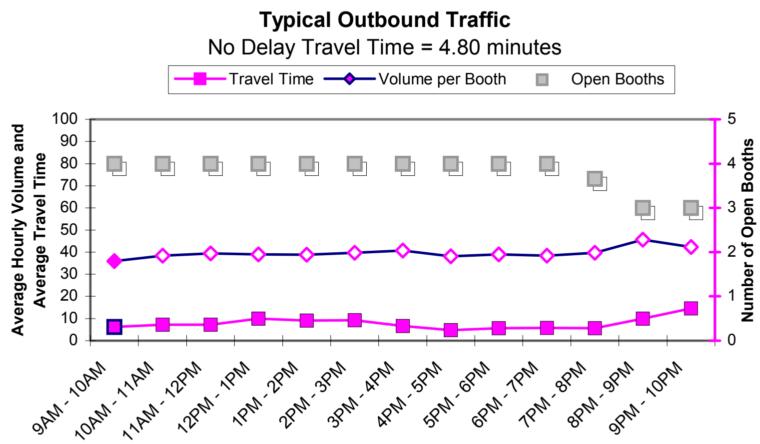


**Figure 12. Typical Outbound Traffic**

## Conclusions

Lessons learned during data collection activities in this project at this site and at others along the Canadian and Mexican borders with the U.S. have identified several issues that should be taken into consideration to assist future data collection efforts. Some apply to advance planning and the initial site visit and others apply more specifically to the data collection activities themselves.

### Planning and Site Visits

- Prior to conducting any data collection project, all jurisdictional and cooperating agencies should be made explicitly aware of the purpose and objectives of the study as well as all the details associated with the data collection project (e.g. dates, times, procedures to be followed during the data collection period, etc.). Failure to do so may result in confusion and possible delay of the study. This has been very time-consuming at some ports and should be adequately accounted for in the schedule. For some agencies, including U.S. Customs, it is important to contact both the federal and local levels. Some entities that should be contacted might not be readily apparent and can include construction companies working on public rights-of-way, state police, city officials, and Thruway Authorities. Some agencies provide verbal approval for the data collection and may even provide supporting documentation to their field staff, yet are reluctant to provide documentation for the data collectors to carry. Every effort should be made to obtain written authorization that can be carried by the data collectors, particularly from bridge authorities and immigration officials. Several times at some sites, the officer at the primary auto inspection booths asked data collectors to go to secondary inspection and speak with immigration officials. Although allowed to continue, this caused some unnecessary delay in the data collection.

- Prior to data collection activities, a general idea of traffic peak periods and conditions should be understood to optimize collection of appropriate traffic data and coverage of the appropriate times. This information should be obtained from discussions with knowledgeable officials and by examining historical traffic data.

- Any additional data needs should be discussed explicitly with the appropriate officials. At some crossings, for example, average hourly truck volumes are not normally recorded and maintained, but can be if special arrangements are made in advance. Alternatively, it may be appropriate to use other means to measure truck volumes, such as roadway counters or having the data collectors indicate the vehicles that pass without their license plates being recorded (assuming continuous data collection during each day). These additional traffic volumes could be used to corroborate data provided by the local authorities or used if their planned data collection did not occur or there was some other problem in providing the data.

- It is also important to be aware of special federal or local holidays on both sides of the border when scheduling data collections as these could affect traffic flows. Some minor holidays that occur on Mondays and Fridays, might not significantly affect traffic for a Tuesday through Thursday data collection period, but may increase the likelihood that key local officials will be on vacation and unavailable should any problems arise.

- When scheduling the data collection times, consider the availability of sunlight or high-powered lighting. It becomes increasingly difficult to read license plates at night as trucks approach with their headlights on (also a problem during rain) and entering the data into the PDAs also becomes more difficult when it is dark.

- Photographs of the border facilities and data collection locations should be taken during the site visits to assist in documenting the collection effort and to better inform the data collectors prior to their arrival on-site.

- Processing, data quality, and analysis of all traffic data require the largest portion of the study time.

<u>Data Collection Activities</u>

- Prior to data collection activities, an explanation and understanding of the procedures to be followed and logistics should be made clear to all members of the study team (e.g., number and location of license plate characters to be recorded, all commercial vehicles should be recorded, when and how to contact the on-site supervisor, etc.).

- Proper identification for all survey members and written documentation of authorization from all jurisdictional agencies should be carried at all times by all members of the study team, especially when conducting business in a foreign country.

- The supervisor should assess all conditions upon arrival for data collection to note any changes from the site visit or prior collection activities. Sometimes unplanned construction or other events may alter the preferred data collector locations or the truck flow patterns.

- While only one supervisor was originally planned for each data collection visit, it was determined that installing one supervisor on each side of the border was highly desired. One supervisor would be designated the overall site supervisor. This presented several benefits, the most important being added safety and security for the data collectors, particularly for a collector who needed to move to a remote location upstream from the border when the queue extended beyond their original location. Other benefits were increased awareness of current conditions and the origin of backups, the increased ability to relieve data collectors for breaks and lunch while maintaining continuous data collection, and assisting with data collection during exceptionally high-volume times or in difficult locations (such as remote spots along a highway when the vehicles were passing at free-flow speeds). Without the extra supervisor, a single supervisor would make repeated trips across the border to check on the collectors, relieve them, and provide them with food and drink if they were not conveniently located nearby. Border delays would often make this an extremely time-consuming process.

- For Mexican data collection, it is recommended that Mexican nationals be used, both as supervisors and as data collectors. This helps to enhance coordination with national, state, and local officials and to minimize the likelihood of immigration or other problems with federal, state, or local agencies.

- As mentioned above, the supervisors should be used to maintain nearly constant data collection during breaks. This improves data quality by ensuring the supervisors repeatedly observe each collector and can identify and correct any problems they might be having. Further, this improves the number of trucks matched at both the #1 and #2 locations, improving the sample size for analysis.

- Communication between the data collectors and their supervisors is crucial to an efficient and successful effort, particularly when one of the data collectors must move upstream past the end of a growing queue. Communication with the supervisor is also important when a data collector is having a problem with an official questioning their authority to do their work or when some other unexpected event occurs. For example, occasionally, there may be an anomaly with the data collection equipment and the collector can receive immediate instructions on how to proceed rather than having to wait until the supervisor next visits their location. Two-way radios (FRS-type with up to a two-mile range) and cell phones work adequately in most situations, but interference and range can limit their effectiveness. Cell phone service can be spotty near border areas. Additional longer-range communication options that do not require FCC approval should be considered for future collections. Obviously, when using cell phones, ensure that long-distance charges and roaming fees will not be significant costs.

- It is important to ensure that the data collectors are safe and comfortable during their long periods of collection. If their data collection locations cannot provide adequate cover from severe rains or heat, additional vehicles should be considered. Comfortable sport chairs with attachable beach umbrellas served to protect the collectors well during light rain and moderate sun. Ensure that the collectors have an adequate supply of water and that facilities are conveniently accessible. This becomes more difficult for the remote locations upstream from the border crossing.

## REFERENCES

Turner, S.M., W.L. Eisele, R.J. Benz, and D.J. Holdener. *Travel Time Data Collection Handbook.Report.* No. FHWA-PL-98-035. Federal Highway Administration, Texas Transportation Institute, March 1998