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I-29 User Costs Analysis

Phase I - Using Simulation and Signal Analysis Tools

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BACKGROUND

The North Dakota Department of Transportation (NDDOT) has been undertaking major construction activities in the Fargo metropolitan area. The thrust of these activities is the reconstruction of Interstate 29 which is a major corridor through the Midwest. This interstate also serves as a major trunk line for NAFTA commodities and goods. The main components of this 6-year construction activity include the following:

- Adding capacity to northbound and southbound travel lanes.
- Widening and improving existing interchanges along I-29.
- Expanding grade separation to include additional arterials across I-29 such as 1st Ave N. overpass, 9th Ave. S. underpass, and 17th Ave. S. underpass.
- Rehabilitating existing and adding arterials to provide alternate routes for I-29 travel.

The I-29 corridor is a major thoroughfare that serves the Fargo-Moorhead metropolitan area commercial and passenger interstate traffic as well as local travel. The proportion of through traffic (traffic not originating or terminating in the local area) is less than 20 percent of the total AADT. The remaining traffic is generated locally. It should also be noted that truck traffic along the corridor is significant, approximately 10 percent. That is largely due to economic activity in the Fargo-Moorhead area and trade activity with Canada.

It is clear that I-29 is the preferred route for many Fargo motorists and for all practical purposes can not be separated from the metropolitan area local transportation system. The construction activity will greatly impact the whole system, not only the normal I-29 traffic.

In preparation for the I-29 lane closures, the NDDOT and the City of Fargo completed major improvements to routes that would serve as detours to I-29, such as 32nd Ave. S., 45th St. and 42nd St. These projects were essential to alleviate the problem that will be created as a result of reducing travel lanes on I-29 during upcoming construction. During the same period, the City of Fargo is conducting some major construction projects on the city system, including the re-construction of University Dr. and 10th St. N. arterials.

Regardless, this past summer was a hectic period for both transportation officials and Fargo-Moorhead motorists. Individual users were sensitive to the transportation construction activity and how it was impacting travel in the area. Trips that normally took 15 minutes were taking 30 and sometimes 45 minutes. Traffic conditions were unpredictable and changed quickly because of construction activity or incidents. Most of these problems took place when the main routes in the system reached and exceeded their capacities during rush hours.

The NDDOT is taking a pro-active role for the upcoming construction phase by better planning for and facilitating the expected shifts in traffic patterns during construction. One project by the Advanced Traffic Analysis Center (ATAC) collected data on construction zone traffic operations including merge areas, travel speeds, and queues. This project will analyze the impacts on users using dynamic routing assignment and static traffic analysis. The impacts are measured and converted to user costs, which account for opportunity costs and operating costs.

OBJECTIVES

The objective of this project is to assist the NDDOT in estimating traffic delays and user costs due to the I-29 reconstruction during 2001. Traffic delays will be gathered for both traffic using I-29 and local streets experiencing the inherent impacts of I-29 detours. The analysis will therefore include both travel time increases and control delay on key arterials.

The network developed in this phase of the analysis will make up the basis for supporting traffic management and operation during the actual construction period. That would include evaluating detour route arrangement, estimating traffic diversion (i.e., additional traffic) on designated routes, and accommodating the increased traffic through mainly improved traffic signal timing and providing information to motorists.

There are two main objectives of this project: analyze impacts to user cost contributed to I-29 construction and provide a sensitivity analysis for varying levels of traffic diversion. The next section will describe the analysis in more detail.

SCOPE of ANALYSIS

The planned 2001 construction activity on I-29 will involve closing northbound lanes from 32 Ave. S to Main Ave. Traffic which will stay on I-29 will use the two southbound lanes for head-to-head traffic operations. Further, motorists will be instructed to use alternate routes to bypass the construction area.

In addition to the I-29 reconstruction, a portion of 13th Ave. S. between 38th St. and Fiechtner Dr. will be reduced to one lane per direction. Since this area is currently experiencing congestion during peak hour periods, the reduction in capacity will also put a strain the transportation system.

Although the impacts of the I-29 and 13th Ave. S. construction will affect the entire Fargo-Moorhead system in some way, a portion of that system will be largely affected. This portion of the system will mainly consist of the I-29 corridor in Fargo and other arterials in the area. The resulting network is delineated by 45th St. in the west, 25th St. in the east, 12th Ave. N. in the north, and 52nd Ave. S in the south as shown in Figure 1.

The NDDOT has developed a diversion route plan to facilitate the movement of I-29 traffic during construction. Information about the detours or alternate routes will be displayed at key locations to encourage motorists to avoid the I-29 construction area. The main alternate routes include Main Ave. in West Fargo (from I-94) located about 4 miles west of the I-29 construction, 45th St., 52nd Ave. S., and 12th Ave. N.

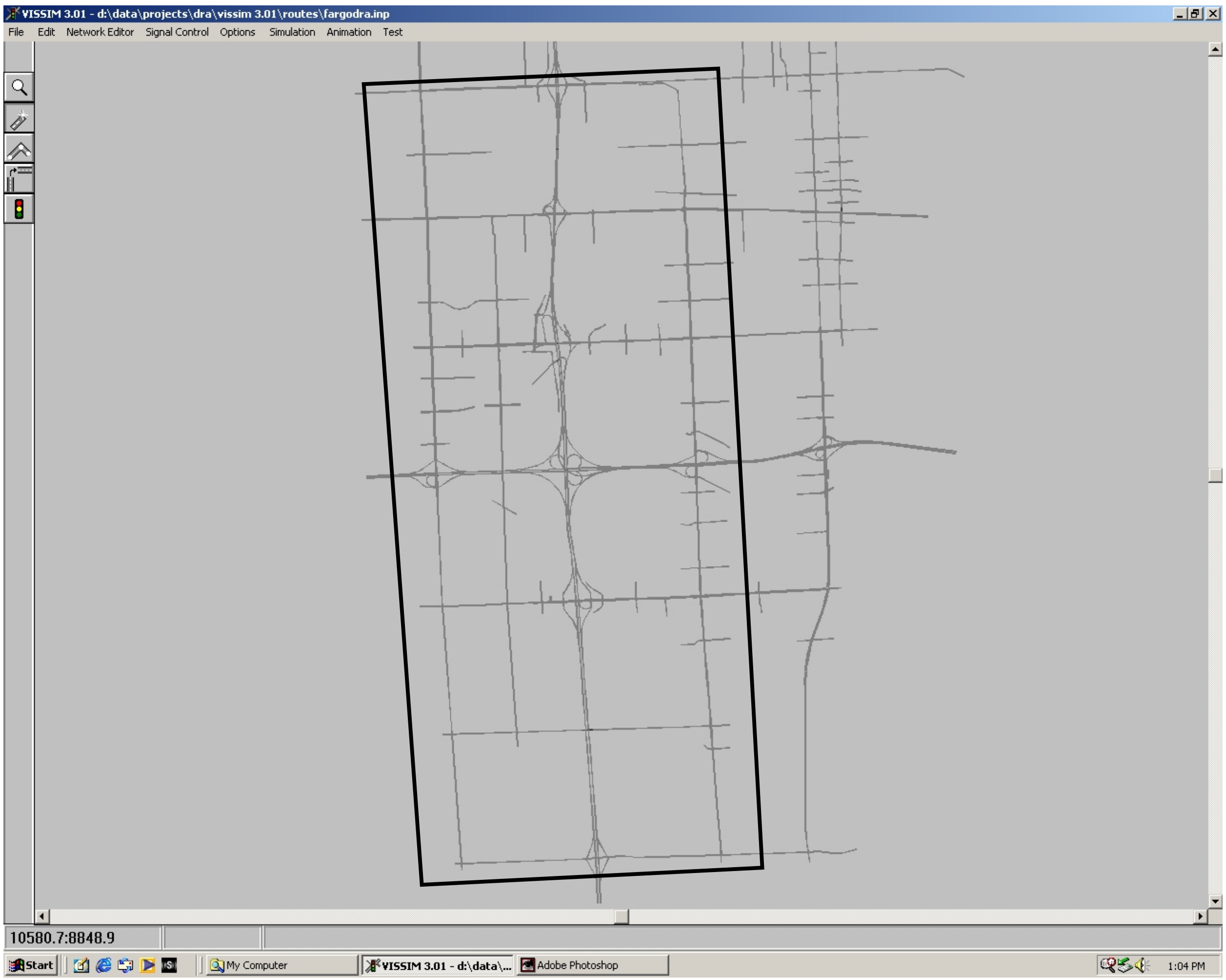

Figure 1. Case Study Network as shown in VISSIM.

Several models were applied during the analysis, namely a static traffic analysis tool, Synchro, and a microscopic simulation program, VISSIM. The analysis will determine the traffic delays and user costs during normal traffic conditions (without construction) and during the construction season, including the effects to the I-29 corridor and city arterials.

METHOD of ANALYSIS

The approach to estimating traffic delays and user costs due to the I-29 2001 construction generally relates to the types of delays expected. There are three main components of potential delay increases in construction-related traffic delays and user costs:

1. Decreased travel speed due to congestion, traffic control, etc.,
2. Increased control delay (due to high congestion and high v/c ratio for the detour) and,
3. Increased delay due to incidents and special events.

Data collected during the summer 2000 construction season in Fargo indicated that not only I-29 through traffic (that is less than 20% of total AADT) would be affected, but that routes in the general vicinity of the construction zone would suffer greatly. It is also important to point out the dynamic nature of traffic operations and the volatility of operating at or exceeding capacity.

Driver Behavior

Motorists generally react to the performance of the network by making decisions about the timing of their trips, routes they use, and to a lesser extent their mode of travel and choice of their destination. In the Fargo area, the main two changes in motorist behavior will be the timing and routing factor. Therefore, it is assumed that motorists will learn from their driving experience during the beginning of the construction period.

After the first week or so, motorists start to develop preferred routes (minimum travel time) for certain trips and times of the day. At that time, the network is said to have reached equilibrium. What that means is that no driver believes that he or she can find a route which could improve their travel time. Of course, this processing is mostly based on driver's perception of delay and may be inaccurate. System operators (NDDOT) can influence driver choices through a number of mechanisms, such providing information about alternate routes, discouraging the use of the construction zone by providing delay information, working with media, etc.

Only when the network has reached equilibrium is it possible to collect statistics on traffic delays and user costs. Given this dynamic nature of traffic equilibrium, the most appropriate tool to evaluate traffic operations for larger system wide impacts is traffic simulation. Traffic simulation allows the analyst to evaluate dynamic traffic characteristics and interaction as they occur on a time-step basis, rather than averaging the network performance over a certain time period.

Diversion Scenarios

According to TRB Special Report #212 (1986), the most extensive travel demand management strategies yielded a maximum 50% mainline demand reduction. However, given the relatively small size of the metro area (and hence most motorists are familiar with and comfortable with alternative routes) more ambitious diversion ratios will be analyzed as well. Therefore, the analysis included the base case (normal conditions) and five construction scenarios with closed I-29 lanes and diversion percentages of 0%, 25%, 50%, 75%, and 100%. This provides a wide range of traffic delay impacts for through and local traffic.

Analysis Tools

In selecting effective analysis tools for estimating traffic delays and user costs due to the I-29 construction work, the following factors were considered:

- Available time when the information was required-limited, approximately 3 weeks including data collection.
- Readily available data with no additional field data collection.
- Account for the interaction of diverted traffic over the analysis network, including traffic signal delay and effect of congestion (to the extent possible given 1 and 2 above).

The VISSIM traffic simulation model was selected to be the main analysis tool. VISSIM has a Dynamic Traffic Assignment (DTA) feature which enables user behavior response to network performance. The DTA uses very simple input consisting of an origin-destination (O-D) matrix for the analysis area indicating trip distribution between zone pairs by time of day. VISSIM then uses that information to assign trips within the network, first starting with a shortest-path solution from origin to destination. Each subsequent simulation attempts to improve the previous route choice, until no improvement is possible. This process represents how motorists learn and develop experiences before they decide which routes they will use for their trips in order to minimize their travel time.

This feature however had not been tested before on an extensive network such as the one used for this analysis. The 63 signalized intersection included in the network, together with several interchange created numerous routing choices. As a result, in order for the network to reach equilibrium, the simulation model requires approximately 100 iterations for each analysis scenario. Data tabulations were placing tremendous demands on the computers used for the simulations. Thus, the larger DTA network is currently being analyzed.

As a result, a smaller VISSIM network was used for the analysis. VISSIM simulated I-29 from 52^{nd} Ave. S. to 12^{th} Ave. N. This analysis was validated with data collected this summer along I-29 to account for speed reductions, merge operations, and queue length as a result of peak hour traffic congestion. The results from the analysis are travel times increases from normal conditions due to the construction activity on I-29. The analysis included the base case (normal operations) and five diversions scenarios of 0%, 25%, 50%, 75%, and 100%.

In order to account for impacts on other arterial routes within the analysis network, signalized intersection analysis was performed using Synchro 4.2. The analysis included routes designated as alternative routes to I-29 by the NDDOT (45^{th} St. and 12^{th} Ave. N.). In addition, delays on 25^{th} St. were analyzed since it provides north south access for the city and was adversely affected during the 2000 I-29 construction.

DATA COLLECTION

Several types of data were obtained to construct the simulation network, including roadway geometry, traffic control, and origin-destination (O-D) demands. Roadway geometry and traffic control data were obtained from the NDDOT and the City of Fargo. A total of 63 signalized intersections were included in the DTA network. Additionally, traffic speeds, traffic composition, and traffic volume data collected by the ATAC during I-29 summer 2000 construction were used, including traffic counts on 45^{th} St., 25^{th} St. and 12^{th} Ave. N. The data revealed extensive delays during peak periods, especially in the afternoon with speeds reduced to under 10 MPH along the construction zone and queues building greater than two miles in some cases. Also, merge operations at key locations revealed stop and go traffic for mainline I-29 traffic, creating additional delays.

Average Annual Daily Traffic (AADT) and O-D trip distribution data were obtained from the Fargo-Moorhead Council of Government's (F-M COG) TRANPLAN model. Unfortunately, the O-D data were the hardest to obtain. As indicated in the Analysis Method section, a complete zone to zone O-D matrix would be required to cover the whole network. However, due to difficulties getting access to the TRANPLAN model, a partial trip O-D matrix for 68 zones was constructed by hand from the model's trip assignment maps. TRANPLAN's traffic assignment is based on macro-level network performance, unlike the detailed network performance captured through the simulation model VISSIM. It should also be noted that the F-M COG did not spare any effort to assist the ATAC in obtaining the data, including working with their consultant in Minneapolis.

ANALYSIS CASES

The original analysis, which focused a complete evaluation of vehicle interaction, vehicle diversion, and signal delay on all existing arterials and interstate highways using traffic simulation, was not completed due to time constraints. This analysis is on-going and will be completed in the near future. However, the ATAC has completed a partial estimation of the user costs using a smaller analysis network consisting of the specified diversion route and I-29, as described below.

Given the uncertainty of driver behavior in response to the I-29 construction activity, it would be inappropriate to use a single diversion scenario. Therefore, the analysis included several scenarios or cases, which correspond to a range of driver behavior, specifically related to percentage of traffic that would use alternate routes. The following scenarios were used:

1. Base Case: normal operations, including current geometry and traffic on I-29, and the current network flows on the arterial system. Used to calculate baseline travel time and delay for the network.
2. Construction Cases: reflect summer 2001 construction work on I-29 closing NB lanes, and operating head-to-head traffic on the SB lanes and a wide range of driver behavior. Five construction cases were analyzed with 0%, 25%, 50%, 75%, and 100% diversion percentage of I-29 through traffic to the 45^{th} St. detour.

RESULTS of ANALYSIS

This section provides a detailed description of the traffic delay and user costs calculated for the various analysis scenarios. The results will be discussed for each impact group (i.e., routes and traffic composition). For a summary of these results refer to the next section.

In general, the arterial analysis using Synchro estimated average daily delays based three peak hours each accounting for 10% of AADT and twenty-one off-peak hours each accounting for approximately 3.3% of AADT. Due to the longer peak periods on I-29, a different traffic time table was implemented which included three peak periods each consisting of two hours with 10% AADT and ten off-peak hours with 3.5% AADT.

45^{th} Street User Costs

This portion of the analysis includes only traffic that would normally use I-29 and would therefore be directly affected by the construction. This information was obtained from the 1996 metropolitan O-D trip distribution data. Diverted traffic volumes were calculated as a percentage of the 1996 AADT. Figure 2 illustrates the detour routes along 45^{th} Street, which are summarized as follows:

NB I-29:	west on 52^{nd} Ave. S., north on 45^{th} St,.east on 12^{th} Ave. N., north on I-29
SB I-29:	west on 12^{th} Ave. N., south on 45^{th} St., east on 52^{nd} Ave. S., south on I-29
EB I-94:	50% north on 45^{th} St. from I-94 , east on 12^{th} Ave. N., north on I-29
	50% north on 45^{th} St. from Main Ave., east on 12^{th} Ave. N., north on I-29

(Note: WB I-94 traffic that intends to use I-29 is not included in this analysis since it is difficult to determine which route these motorists would take.)

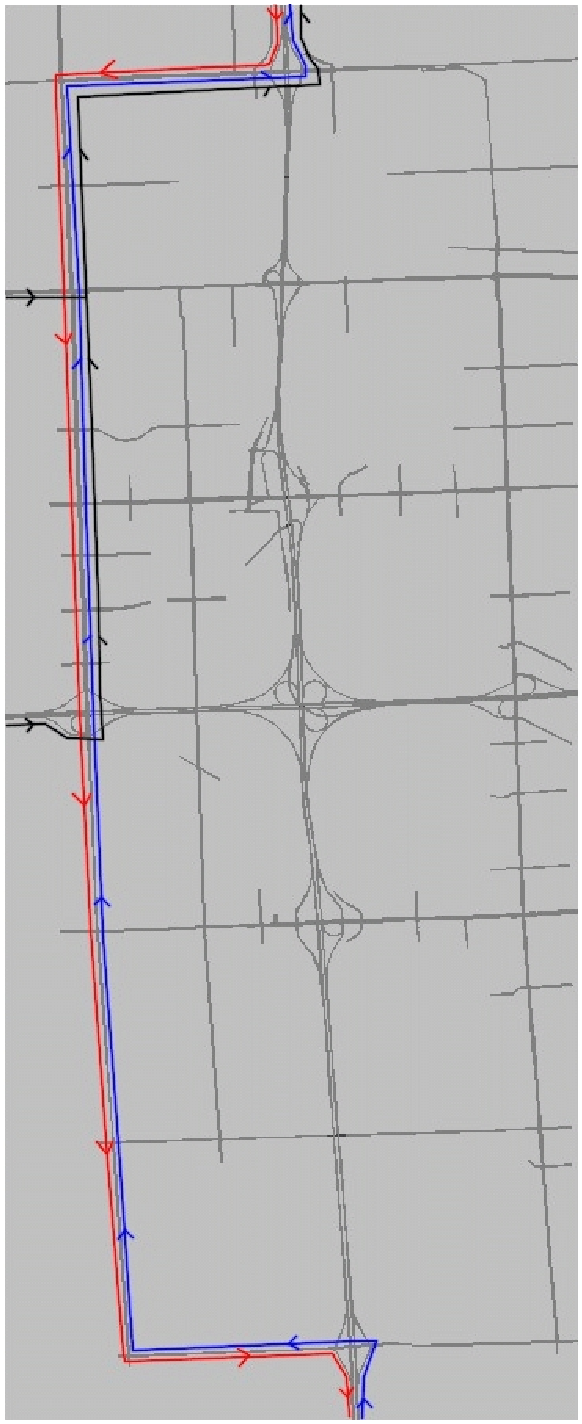

Figure 2- I-29 Detour Routes

The 45th Street detour included 18 signalized intersections. A traffic signal installation was assumed at 45th St. and 32nd Ave. S., while two signal installations were implemented at the 52nd Ave. S. and I-29 interchange.

Total travel time, which includes control delay and link travel time, was obtained from Synchro for each scenario (see Tables 2 through 5). For each case, the base-case travel time was subtracted from the construction travel time to estimate the increase in traffic delay. Using a hourly cost estimates in the NDDOT analysis, the increased delay (vehicle-hour) was converted to dollars. These hourly cost estimates were $11.50/hour for passenger vehicles and $25.00/hour for heavy vehicles. The impacts on the 45th Street detour ranged from $5,551 to $35,659 per day. These values are conservative since they only account for I-29 through traffic and do not include additional local traffic that will also use the diversion route to avoid the I-29 construction area.

25th Street User Costs

Although 25th Street was not designated as a diversion route for the I-29 construction, it will be adversely affected by the construction. Based on data collected before and during the summer 2000 construction, northbound volumes in the morning peak increased 80% while southbound volumes in the afternoon peak increased 96%. The 25th Street analysis area included 11 signalized intersections. The estimated delay experienced on 25th St. during the 2000 construction season was approximately $13,200 per day (see Table 6). It should be noted that 32nd Ave. S. was also under construction last summer so it is difficult to know exactly how much delay 25th St. will experience until the results from VISSIM Dynamic Traffic Assignment are available.

I-29 User Costs

This section discusses impacts of the construction activity on traffic that would still use I-29 (both through traffic that did not divert onto detours and local traffic that would continue to use I-29 during construction). The analysis corridor modeled in VISSIM included a section of I-29 from 52nd Ave. S. to 12th Ave. N. in Fargo. Local traffic was factored in or out at appropriate entry point along I-29 at each interchange (entry and exit ramps). Local traffic was assumed to remain on I-29 for these estimations.

Motorists would use other routes, however, given the relatively few options for north-south movement in the Fargo metropolitan area. Additional traffic would use the 45th St. detour route and the 25th St. This situation would create even more congestion and result in significant traffic delays which may offset or exceed any reduction in delays on I-29.

The potential increase in traffic delay ranged from about 138% (if 100% of I-29 through traffic takes the detour) to about 314% (if all the traffic remains on I-29). Generally, diversion percentages around the 25%-50% are more acceptable, although the 50% could be too high. Corresponding increases in user costs ranged from $58,390 (full diversion) to $129,785 (no diversion), as shown in Table 7. It should be noted that these values will be added to the traffic delay and user costs calculated for the detour routes.

SUMMARY of RESULTS

Table 1 shows a summary of the results of the user cost analysis. The table lists potential total cost ranging from $106,000 to $143,000. Once again, studies indicate that even with the most aggressive and comprehensive travel demand management, it is hard to influence more than 50% to take a detour or alternative route. However, the relatively small size of the metropolitan area where more drivers are familiar and comfortable with detour routes there could be different diversion ratios. It will all depend on the driver perception of network performance after the start of the construction. The numbers in Table 1 are very conservative since they only include impacts on detour routes and exclude impacts on other arterial which will be affected by construction (i.e., University Dr., Main Ave., 13th Ave. S., etc.).

Table 1. User Cost Summary.

I-29 Through Traffic Diversion %	Cost of Additional Travel Time			Total Cost
	Interstate 29	45th St. & 12th Ave. N.	25th St.	
0%	$129,798	$0	$13,151	$142,949
25%	$107,362	$5,551	$13,151	$126,064
50%	$88,023	$14,109	$13,151	$115,283
75%	$69,968	$23,207	$13,151	$106,326
100%	$58,390	$35,659	$13,151	$107,200

Table 2. Daily Impact on the 45th St. Detour based on a 25% Diversion of I-29 Through Traffic.

Type of Traffic	Detour Travel Time (veh-hr)	Base Case Travel Time (veh-hr)	Travel Time Increase (veh-hr)	% of Autos	Operating Cost/hr (Auto)	% of Trucks	Operatin g Cost/hr (Truck)	Number of Hours	Total Cost
Peak	595	521	74	90	11.50	10	25.00	3	$2,853
Off-peak	165	155	10	90	11.50	10	25.00	21	$2,699
									$5,551

Table 3. Daily Impact on the 45th St. Detour based on a 50% Diversion of I-29 Through Traffic.

Type of Traffic	Detour Travel Time (veh-hr)	Base Case Travel Time (veh-hr)	Travel Time Increase (veh-hr)	% of Autos	Operating Cost/hr (Auto)	% of Trucks	Operatin g Cost/hr (Truck)	Number of Hours	Total Cost
Peak	705	521	184	90	11.50	10	25.00	3	$7,093
Off-peak	181	155	26	90	11.50	10	25.00	21	$7,016
									$14,109

Table 4. Daily Impact on the 45th St. Detour based on a 75% Diversion of I-29 Through Traffic.

Type of Traffic	Detour Travel Time (veh-hr)	Base Case Travel Time (veh-hr)	Travel Time Increase (veh-hr)	% of Autos	Operating Cost/hr (Auto)	% of Trucks	Operatin g Cost/hr (Truck)	Number of Hours	Total Cost
Peak	829	521	308	90	11.50	10	25.00	3	$11,873
Off-peak	197	155	42	90	11.50	10	25.00	21	$11,334
									$23,207

Table 5. Daily Impact on the 45th St. Detour based on a 100% Diversion of I-29 Through Traffic.

Type of Traffic	Detour Travel Time (veh-hr)	Base Case Travel Time (veh-hr)	Travel Time Increase (veh-hr)	% of Autos	Operating Cost/hr (Auto)	% of Trucks	Operatin g Cost/hr (Truck)	Number of Hours	Total Cost
Peak	1033	521	512	90	11.50	10	25.00	3	$19,738
Off-peak	214	155	59	90	11.50	10	25.00	21	$15,921
									$35,659

Note: Tables 2-5 assumed 10% of the AADT for the diverted traffic in addition to the peak hour volume currently on 45th St. and 12th Ave. N.

Table 6. Daily Impact on 25th St. Based on 2000 Construction.

Type of Traffic	Detour Travel Time (veh-hr)	Base Case Travel Time (veh-hr)	Travel Time Increase (veh-hr)	% of Autos	Operating Cost/hr (Auto)	% of Trucks	Operatin g Cost/hr (Truck)	Number of Hours	Total Cost
Peak	500	305	195	99	11.50	1	25.00	3	$6,806
Off-peak	110	84	26	99	11.50	1	25.00	21	$6,353
									$13,159

Note: Peak-hour travel time is an average of the morning and afternoon values. The off-peak travel time was calculated using a third of the peak hour flow.

Table 7. Daily Impact on I-29.

I-29 Through Traffic Diversion %	Travel Time Increase (veh-hr)	Total Cost
0	10101	$129,798
25	8355	$107,362
50	6850	$88,023
75	5445	$69,968
100	4544	$58,390

Note: Travel time costs were obtained using 90% autos and 10% trucks with operating costs of $11.50 and $25.00, respectively.