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# Traffic Simulation to Evaluate Road Capacity for Transportation Alternatives on the Denali National Park Road

**Interim Report 03/29/2011. rev.2.**

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# 1. Introduction

The previous task agreement with the Denali National Park evaluated the sensitivity of crowding indicators on the Denali Park Road by comparing the violation rates of three standards when traffic levels were increased incrementally starting from a low-use level to a very high-use level (Morris et. al, 2010). The study enabled park managers to assess road capacity limits and 'test' the degree of which the current system operates within these limits. The derivation of the three standards was done in tandem with our efforts to develop a traffic simulation model, and is explained in Manning & Hallo (2010). The results were then used to guide the park management team to hypothesize new transportation alternatives to meet future visitor demands while preserving visitor quality of experience and protecting other natural resources (wildlife) that are affected by traffic along the road.

This report summarizes the results and cooperative study efforts lead by the University of Minnesota research team to evaluate the transportation alternatives provided by the Denali NPS management team. Each alternative included new proposed routes and route behaviors that required modifications to the original traffic simulation model developed in the previous study task agreement. In addition to evaluating the alternatives, the University of Minnesota team designed and conducted a 'ground-truth' study to compare the biological and social road capacity indicators of the simulation with real data. The remaining report is organized into four sections. The first section provides the results of the 'ground-truth' study. The second section discusses modifications to the original traffic simulation model. Section 3 then summarizes the alternatives modeled and their results. The last section provides a synopsis of stand-alone, windows, executable tool that can be used to produce analysis reports for the alternatives.

# 2. Comparative Assessment of Simulation Model and Real Capacity Indicators

In the previous cooperative task agreement, the model was validated by comparing pair-wise travel times between 61 bus routes. The results indicated a discrepancy of about 20 minutes between actual trajectories and the simulated trajectories for the peak day being modeled in the simulation. Even though the result quantified an expected error between the simulated and actual travel behavior of the buses along the road, park managers needed a more concrete assessment of the accuracy to which the model could forecast resulting road capacity indicators - namely, the number of vehicles throughout the day present at rest areas, wildlife stops, and specific viewscapes, as well as traffic patterns and available acceptable gap times at several wildlife crossings locations (which correlates with the gap crossing opportunities for Dall's Sheep).

## 2.1 Experiment

The original peak day in July of 2007 utilized in the model was once again used for this assessment. Since the GPS traces for all the routes on that day were not available, the simulation model was used to create surrogates for this data. From the provided savage checkpoint log records at mile 15, twenty surrogate routes were created; six of them were Denali Natural History Tours (DNHT), while the remaining routes were Lodge, VTS, and Tundra Wilderness Tour (TWT) routes. The departure times for all real buses with the GPS traces where approximated from the time stamps near the start of the simulated road for the departure times for the matched routes in the simulation. Note that the traffic simulation road model start point is just west the park headquarters located at mile 3. For the surrogate routes, the departure times were estimated at the traffic model road beginning point using the average travel time for the same real known routes that were within 1 hour of the simulated surrogate route. The actual private vehicle traces where also not available and therefore represented as additional surrogate data in the simulation model (50 trips were registered at the savage check point). The simulation model was then executed for 30 repetitions to capture the random variability of the microsimulation model.

## 2.2 Results

The analysis consisted of comparing mean and standard deviations aggregated into hourly segments for the crowding indicators and sheep crossing standard and traffic volumes, each of which are briefly summarized below. Detailed tabulated results were delivered previously to the Denali park team in the summer of 2010.

### *2.2.1 Wildlife crowding indicator*

The results imply relatively good correspondence across all measures with exception to the wildlife crowding indicator. The analysis of the wildlife of the number of vehicles at a wildlife stop was divided spatially into four sub-zones: the WAC to Teklanika (the simulation starts at mile 3), Teklanika to Toklat, Toklat to Eielson, and Eielson to Kantishna. The entire length of the road was also utilized (figures 1 – 5).

There was a general tendency to overestimate the crowding level over many portions of the day, although the general trends were consistently captured. There are, and may be, several reasons for this. The analysis assumes buses bunch tightly together at any wildlife stop along the road. This assumption could not be validated in the real data because many of the wildlife stops were not identified, and even if they could have been, it was not possible to verify if buses stopped within a vicinity of another bus is related to the same, or a different wildlife stop. Second, the simulation model does not consider 'creeping' behavior that can be observed in some buses, and wildlife encounters remain at a fixed location along the road for the estimated duration of the event.

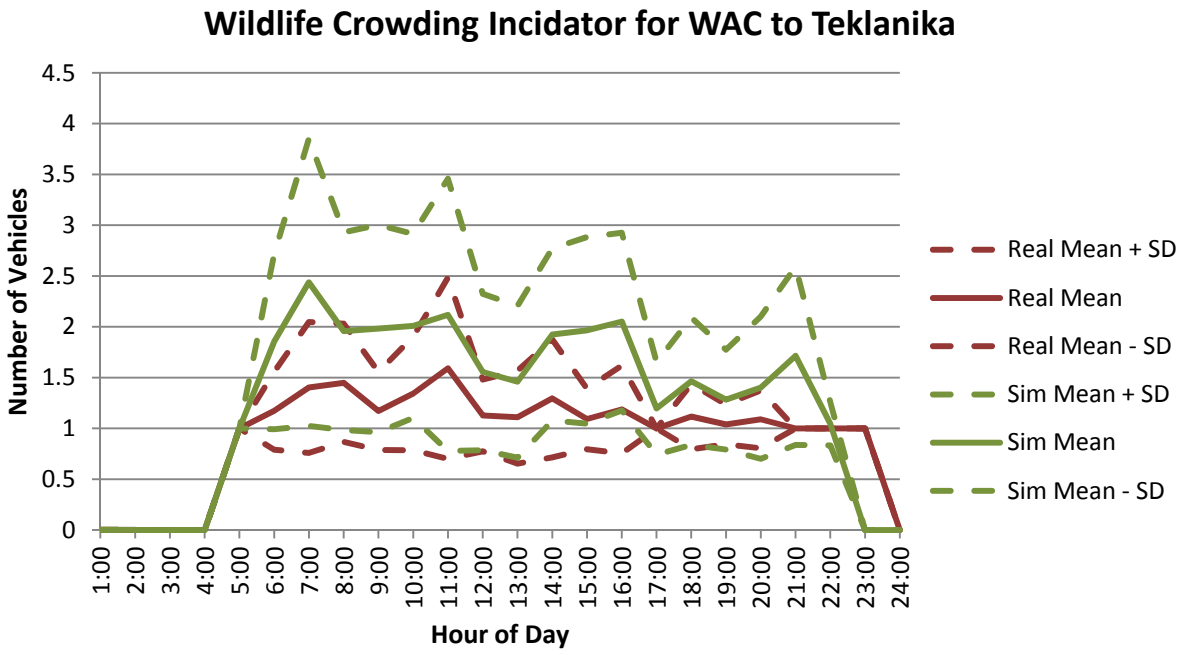


**Figure 1. Comparison of crowding indicator at wildlife stops between the actual and simulated data between WAC and Teklanika.**

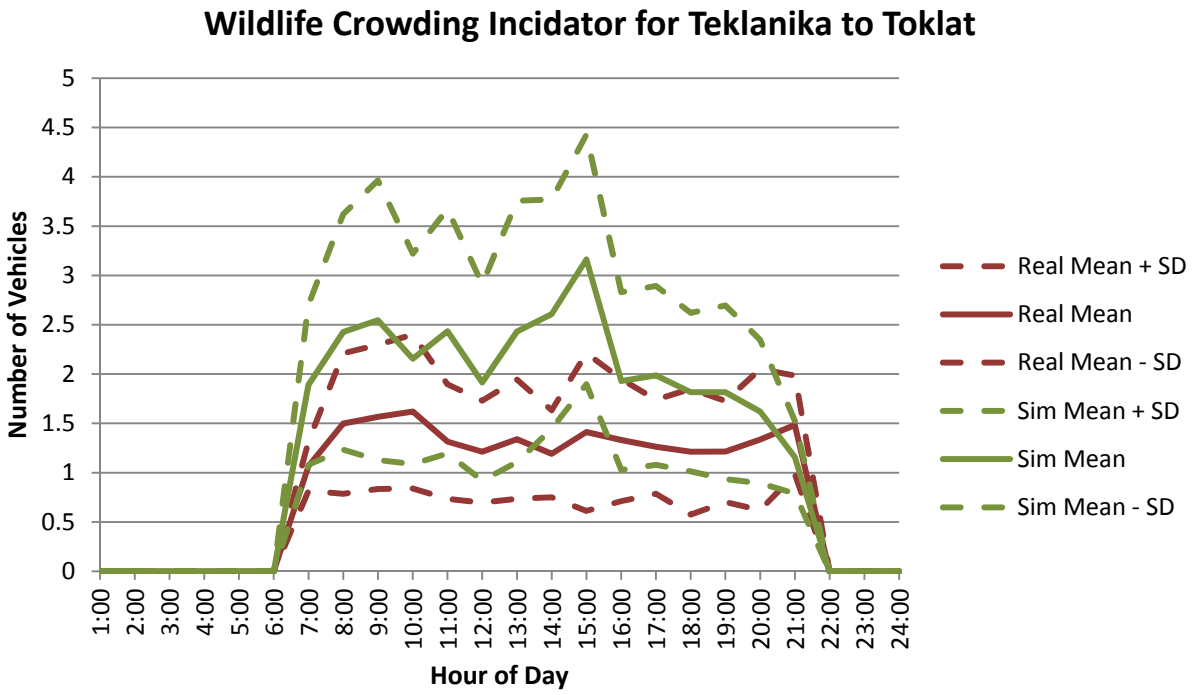


**Figure 2. Comparison of crowding indicator at wildlife stops between the actual and simulated data between Teklanika and Toklat.**

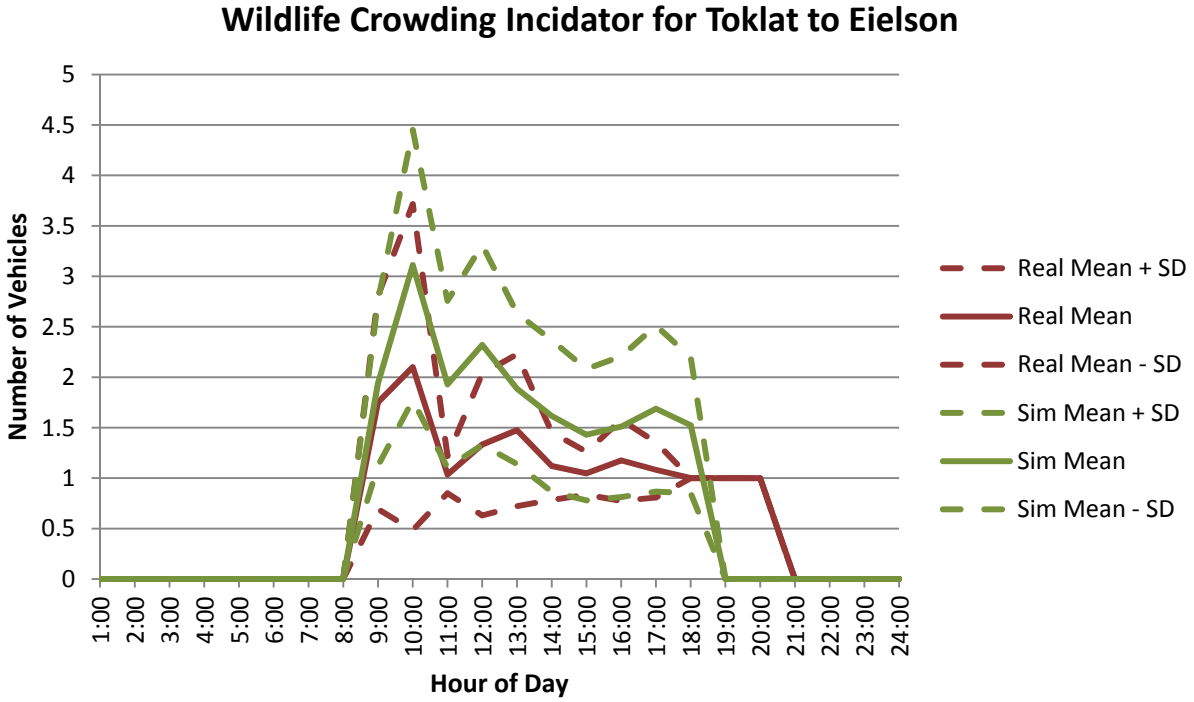


**Figure 3. Comparison of crowding indicator at wildlife stops between the actual and simulated data between Toklat and Eielson.**

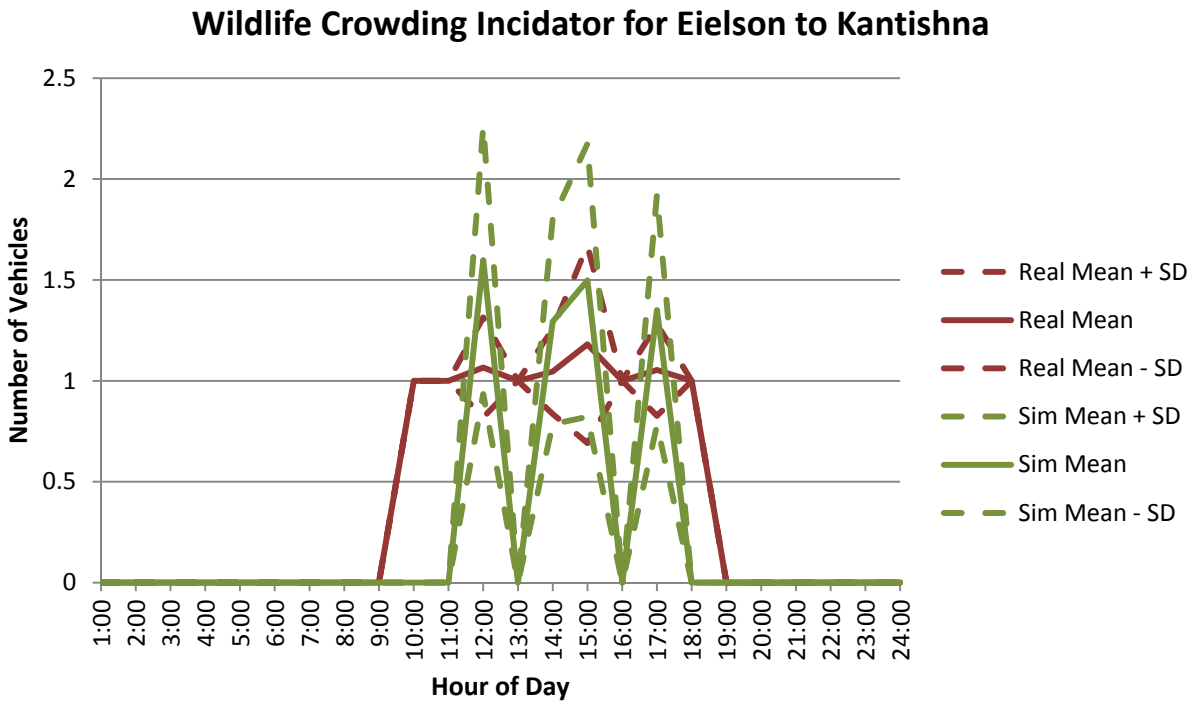


**Figure 4. Comparison of crowding indicator at wildlife stops between the actual and simulated data between Eielson and Kantishna.**

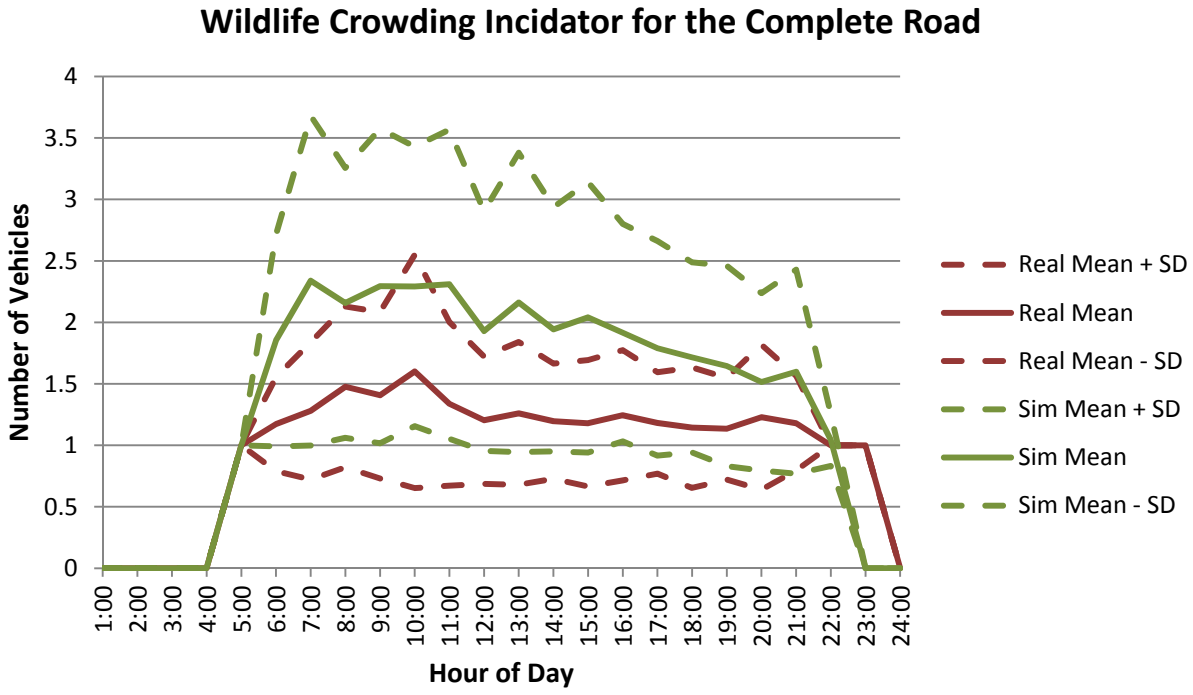


**Figure 5. Comparison of crowding indicator at wildlife stops between the actual and simulated data.**

### *2.2.2 Rest area crowding indicator*

The number of buses at one time at three rest areas were analyzed: Teklanika, Polychrome, and Toklat (figures 6 – 8), all of which showed good correspondence between simulated and real data. Eielson was not considered in the analysis since there were no route destinations or rest stops to Eielson during the 2007 year. Vehicles do not stop at rest areas in the simulation and were therefore not considered in the comparative analysis.

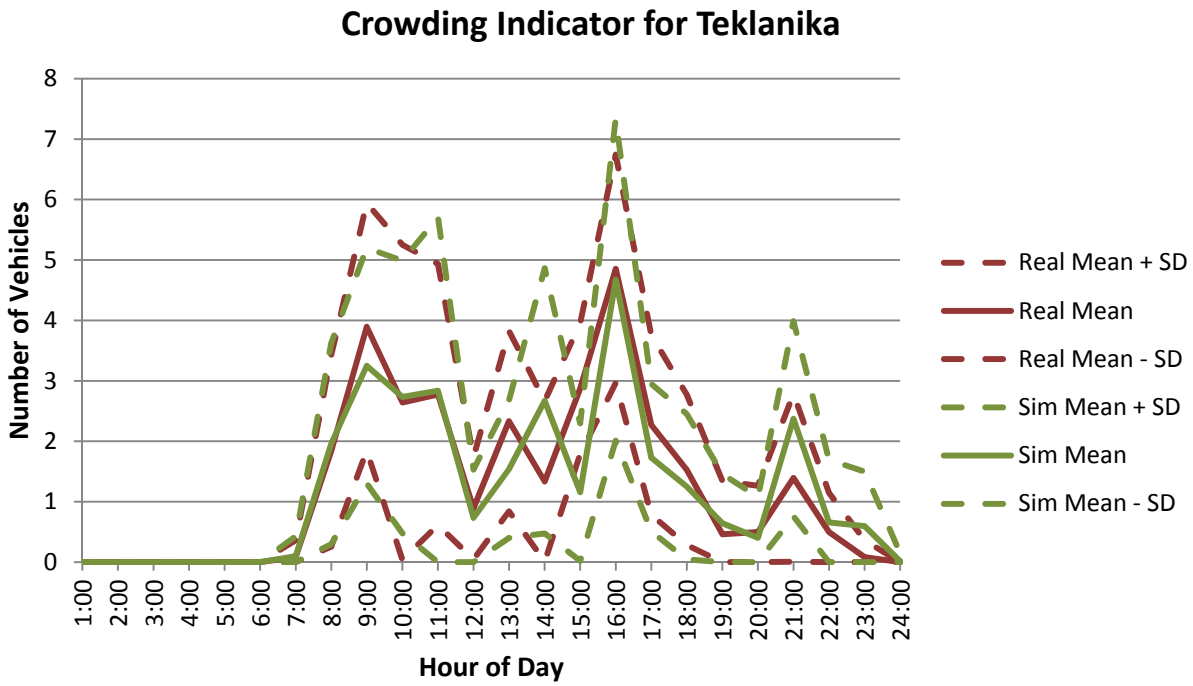


**Figure 6. Comparison of crowding indicator at Teklanika rest area between the actual and simulated data.**

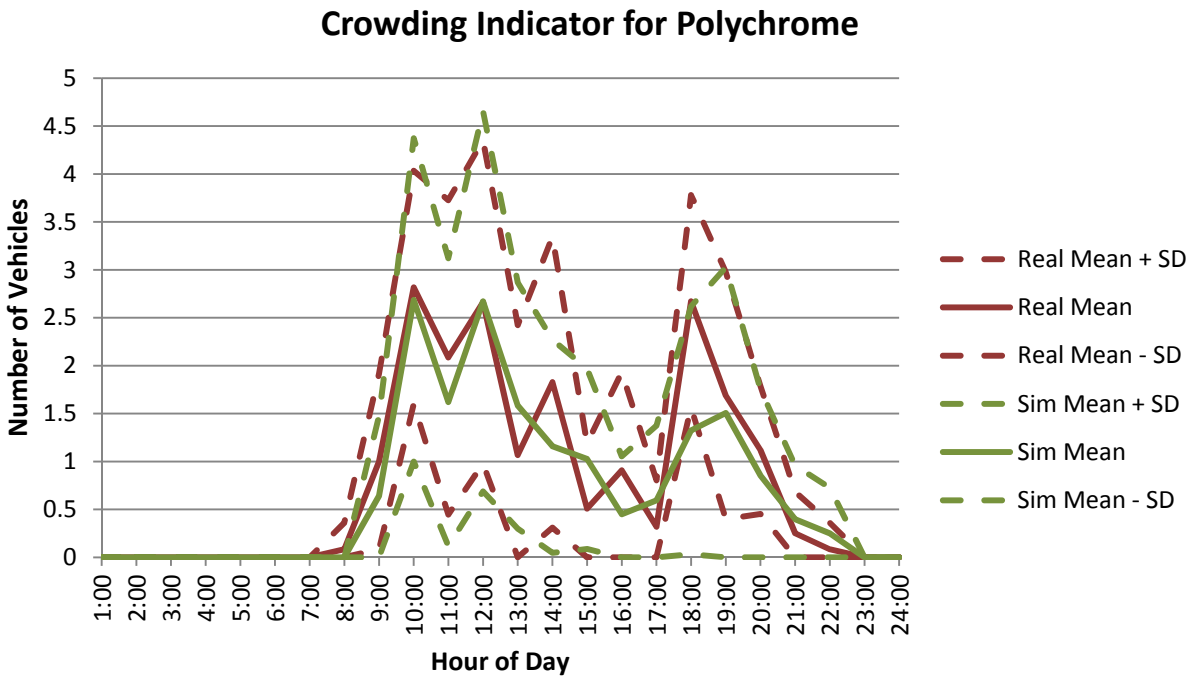


**Figure 7. Comparison of crowding indicator at polychrome rest area between the actual and simulated data.**

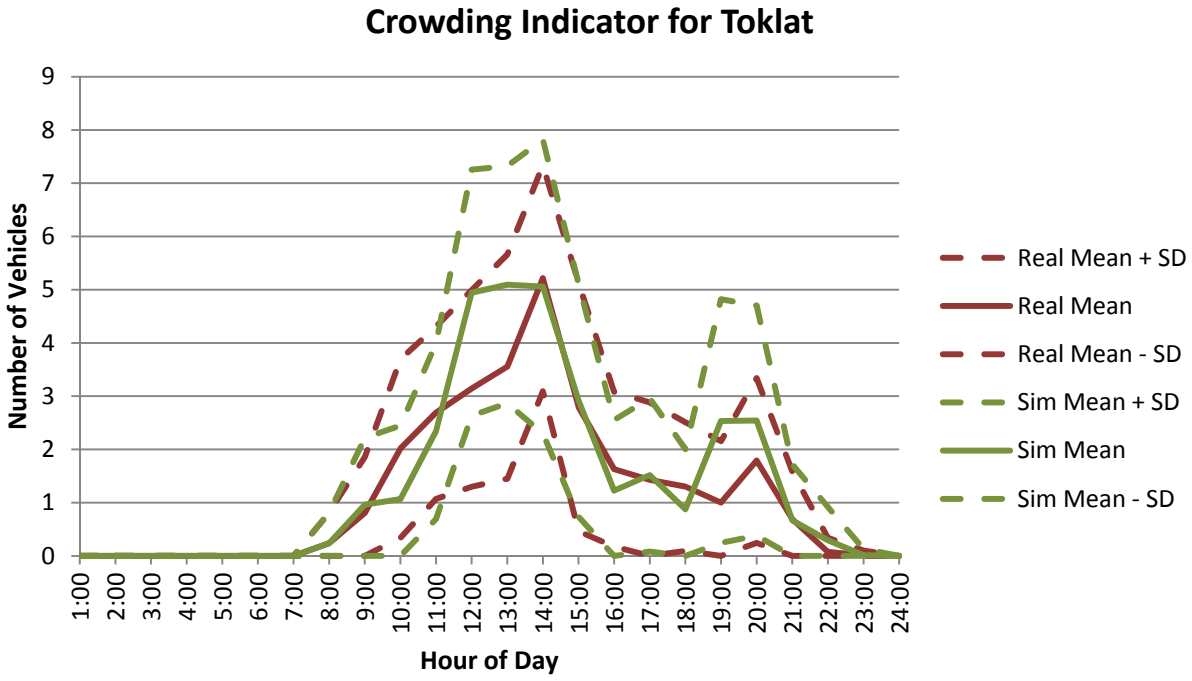


**Figure 8. Comparison of crowding indicator at Toklat rest area between the actual and simulated data.**

### *2.2.3 Viewscape crowding indicator*

The viewscape crowding indicator was calculated by collecting the maximum number of vehicles at one time within three defined road segments located at mile 26, mile 57, and mile 61 --an iconic viewscape at Stoney Dome (figures 9-11). The lengths of the road segments were approximately 1 mile, for mile 61 and 26, and about 0.85 miles at mile 57. The indicators for both the real and simulated data were calculated using the maximum vehicle density extracted within 1 minute intervals. The results indicated a good correspondence between the real and simulation data.

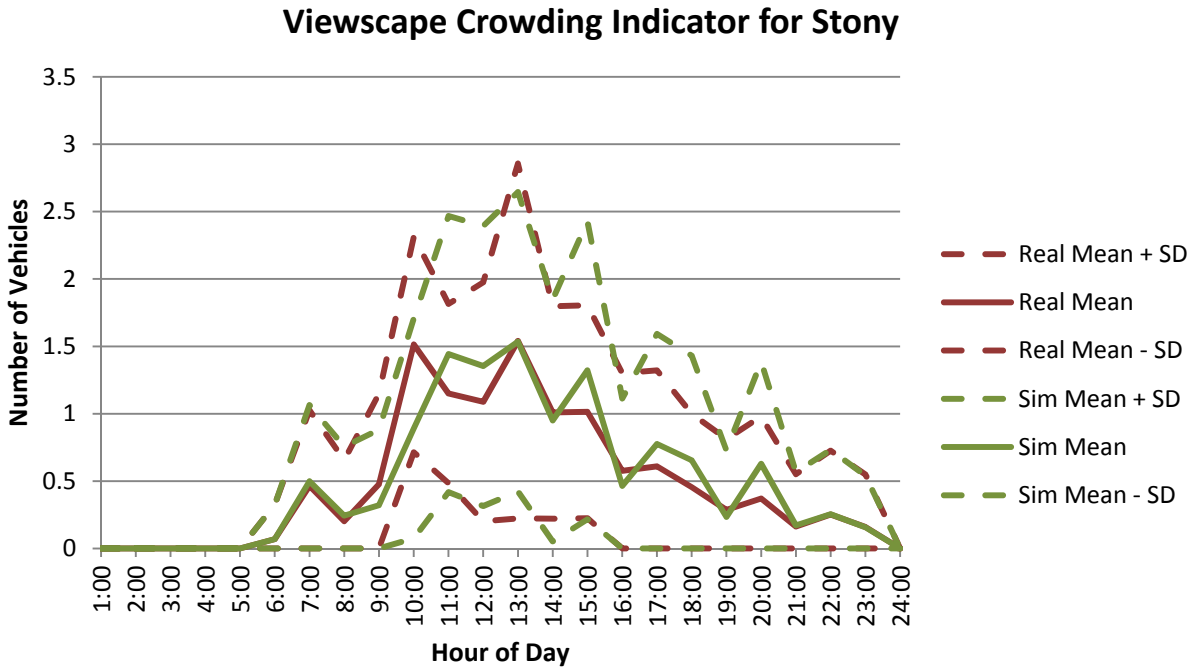


**Figure 9. Comparison of scenic viewscape crowding within each hour of the day at Stoney overlook.**

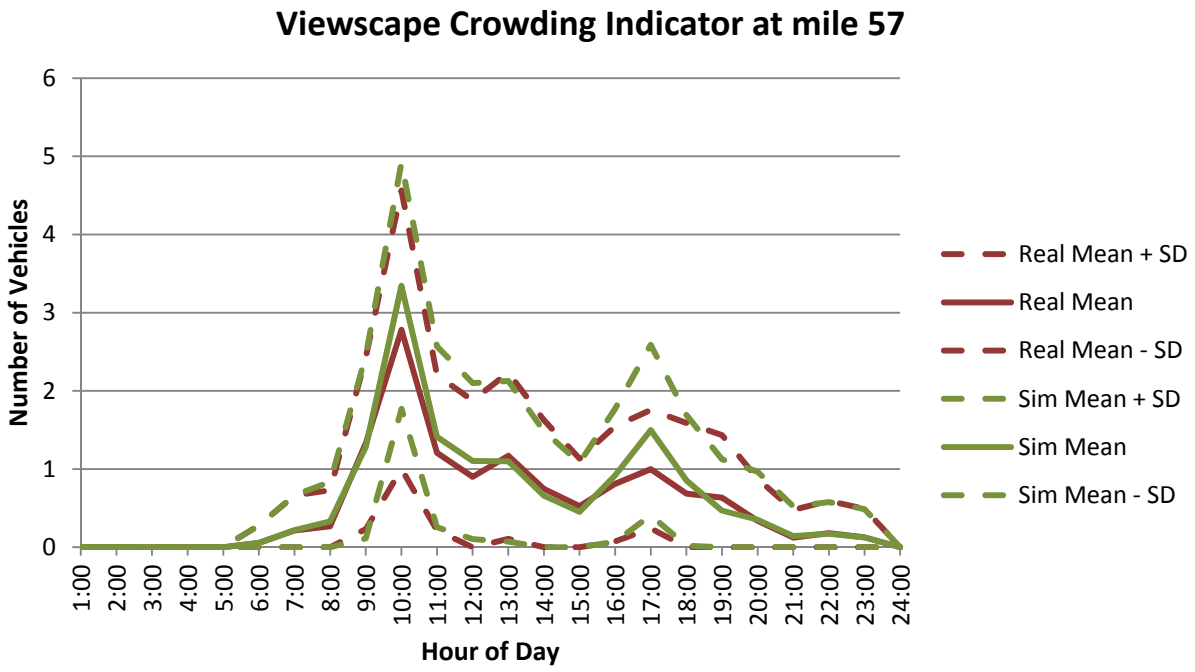


**Figure 10. Comparison of road viewscape crowding within each hour of the day at mile 57, west of Toklat.**

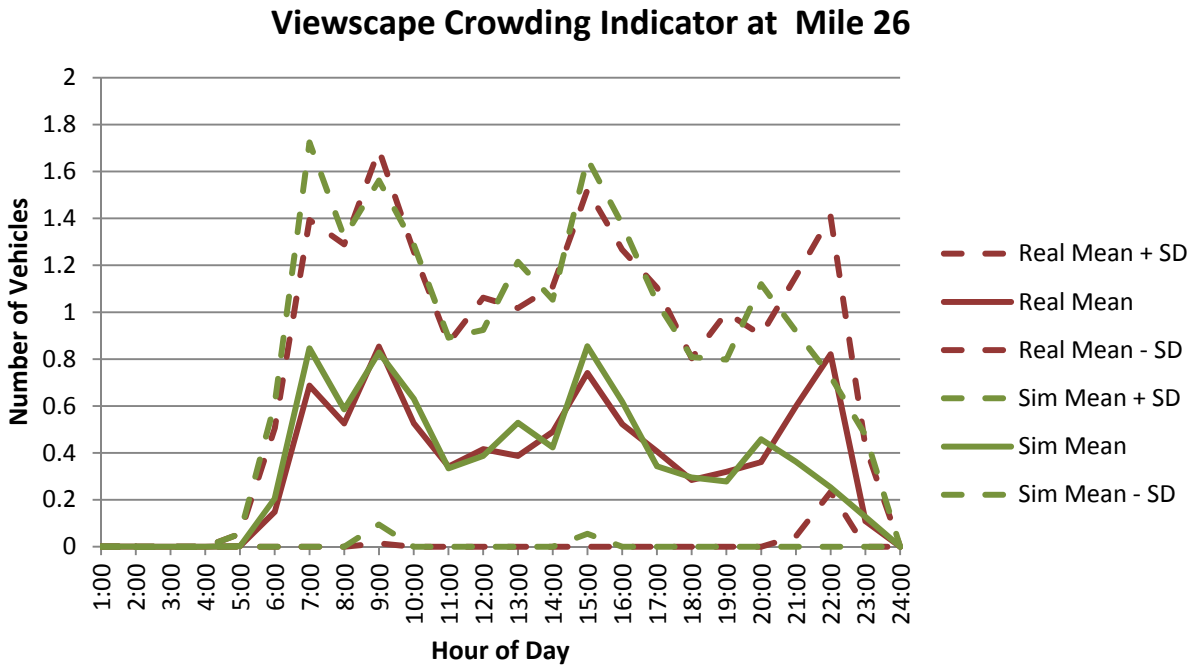


**Figure 11. Comparison of road viewscape crowding within each hour of the day near mile 26, east of the Teklanika rest area.**

### *2.2.4 Dall's Sheep Crossing Evaluation*

Hourly traffic levels and the resulting availability of 10 minute gaps within each hour were compared for this evaluation. Specifically, the total amount of gap time from gaps greater than 10 minutes within each hour were compared at miles 21.6, 37.6, and 52.8 (figures 12, 14,16). In addition hourly traffic volumes were compared, with the aforementioned crossings and for two additional crossings located at miles 60.6 (Near Stoney overlook) and 68.5 (just west of Eielson) (figures 13, 15, 17, 18, and 19).

It was expected that the level of traffic would influence gap distribution to some degree. A general observation with the sheep crossings results is that a precipitous decrease in available sheep crossing opportunities represented by available gaps > 10 minutes occurs when traffic volumes exceed about 14 vehicles per hour (vph). This is corroborated by relatively good correspondence between simulated and real traffic characteristics at the crossings at least for the current system. This also was observed for the hypothetical, proposed alternatives discussed in the subsequent sections of the report.

To conclude, the comparative study provided the park service an indication of ability of the simulation model to 'ground-truth' baseline conditions for the actual transportation system that was operation in 2007. The assessment of the baseline was then used to judge results for the hypothesized, alternative transportation systems 'operating' on the same day. The alternative transportation systems consider new bus operator behaviors and routes that are not present in the current transportation system or the traffic simulation model. The modifications to the traffic model for the alternative transportation systems are described next.

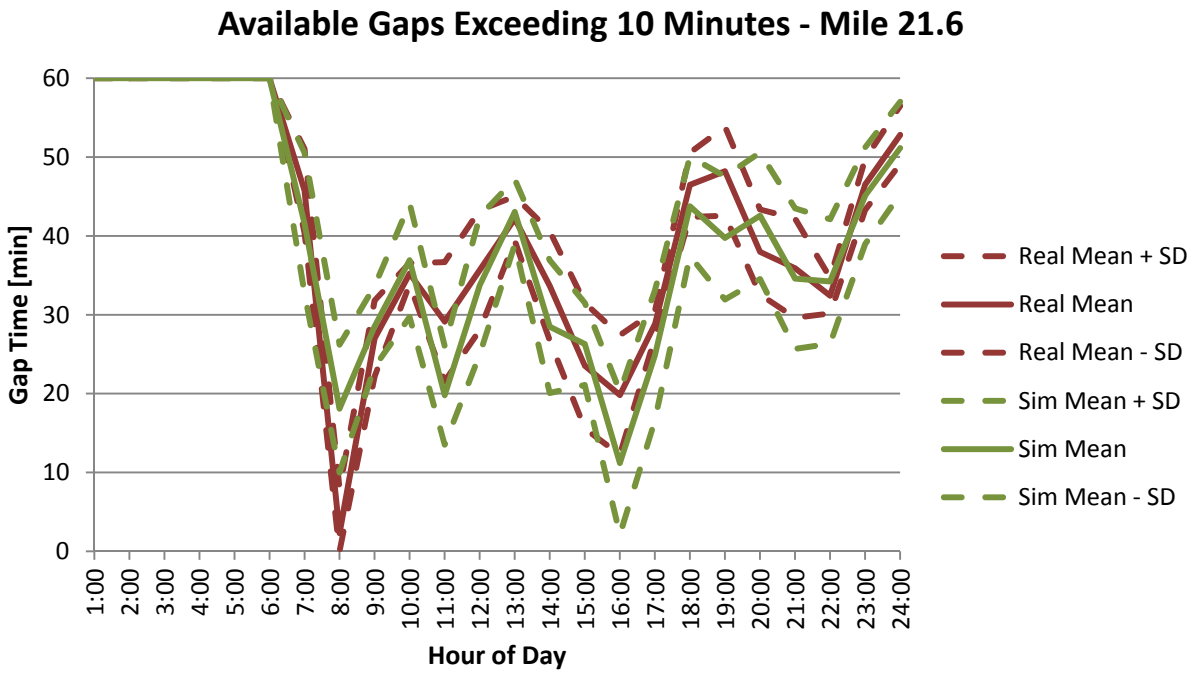


**Figure 12. Comparison of available total gap time > 10 minutes within each hour of the day at mile 21.6.**

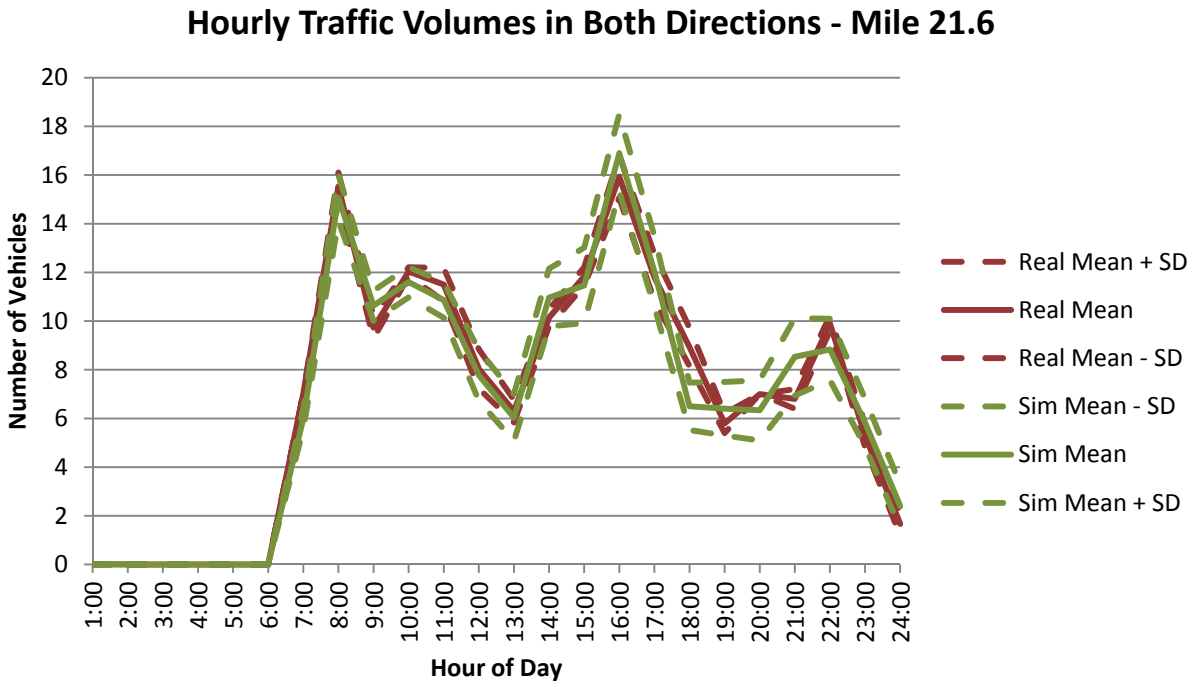


**Figure 13: comparison of hourly traffic volumes at mile 21.6.**

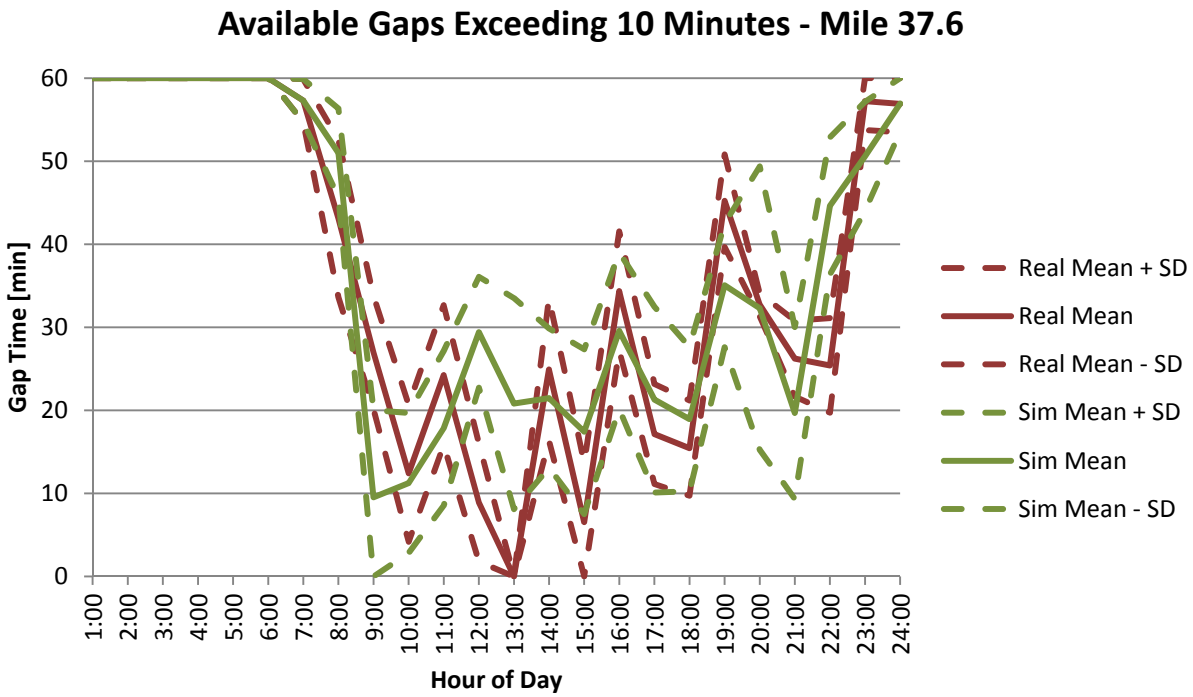


**Figure 14. Comparison of available total gap time > 10 minutes within each hour at mile 37.6.**

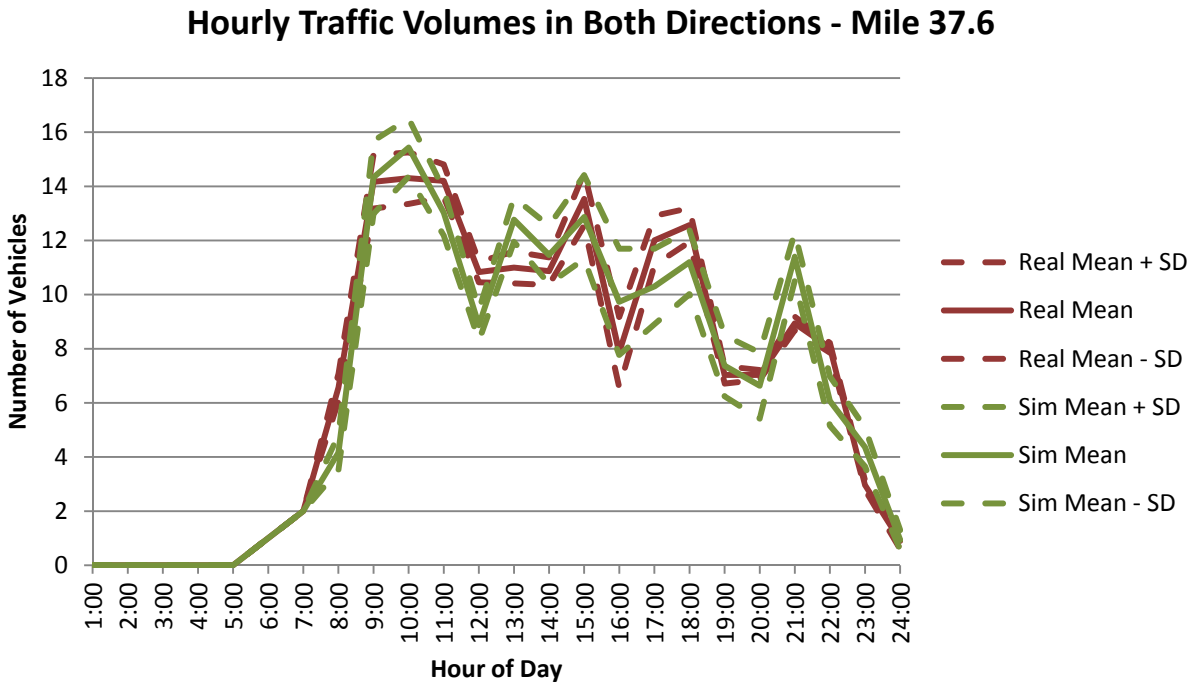


**Figure 15: comparison of hourly traffic volumes at mile 37.6.**

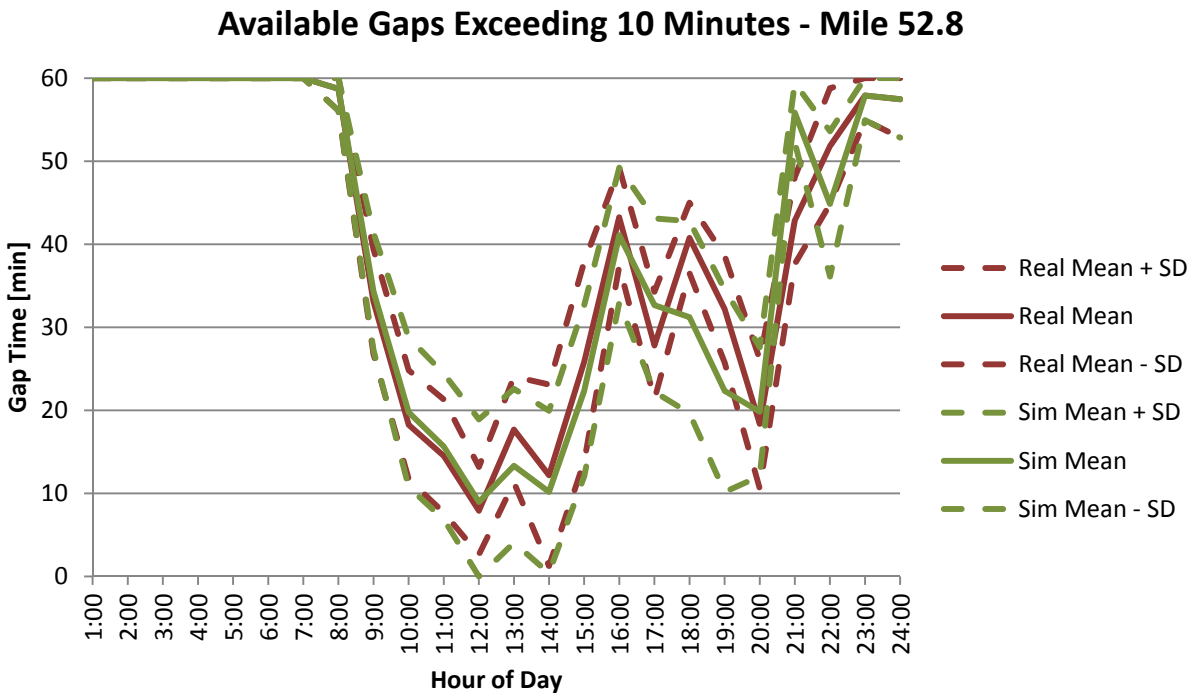


**Figure 16. Comparison of available total gap time > 10 minutes within each hour of the day at mile 52.8.**

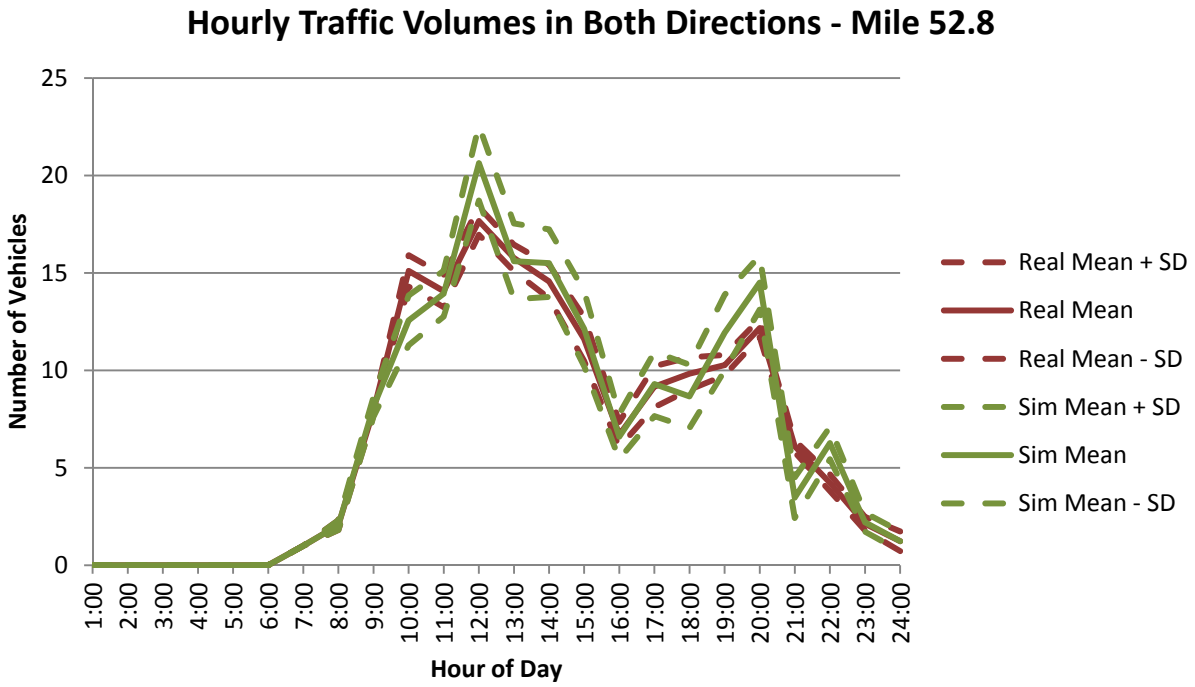


**Figure 17. Comparison of of hourly traffic volumes at mile 52.8.**

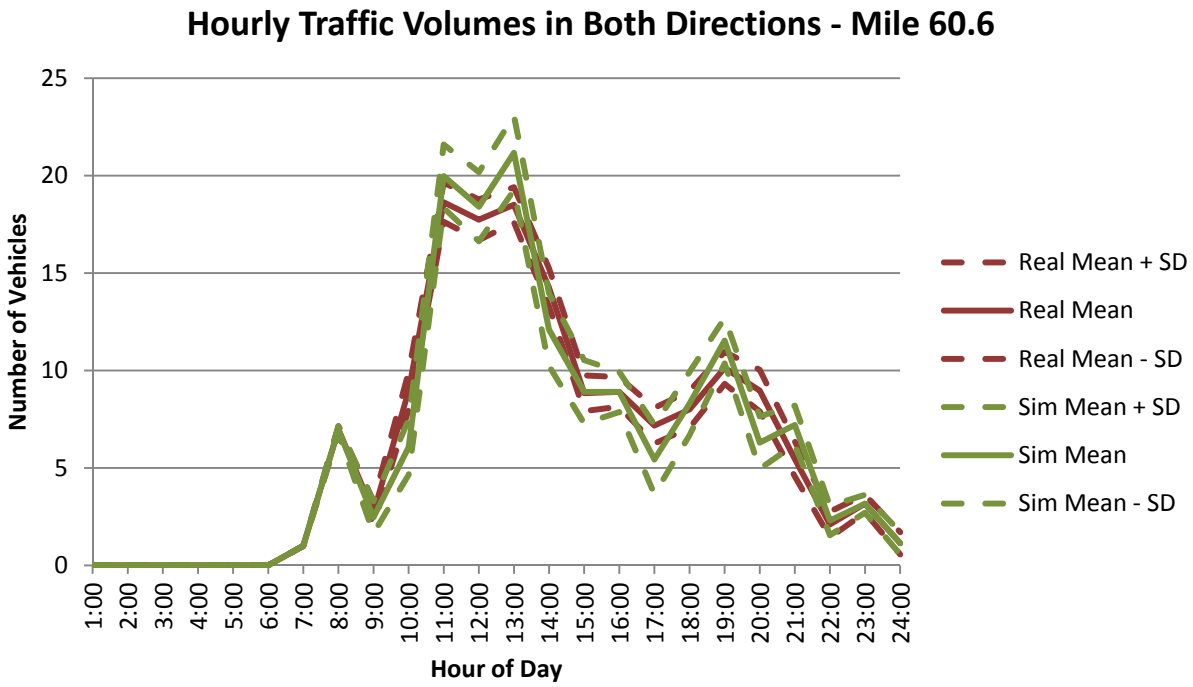


**Figure 18. Comparison of of hourly traffic volumes at mile 52.8.**

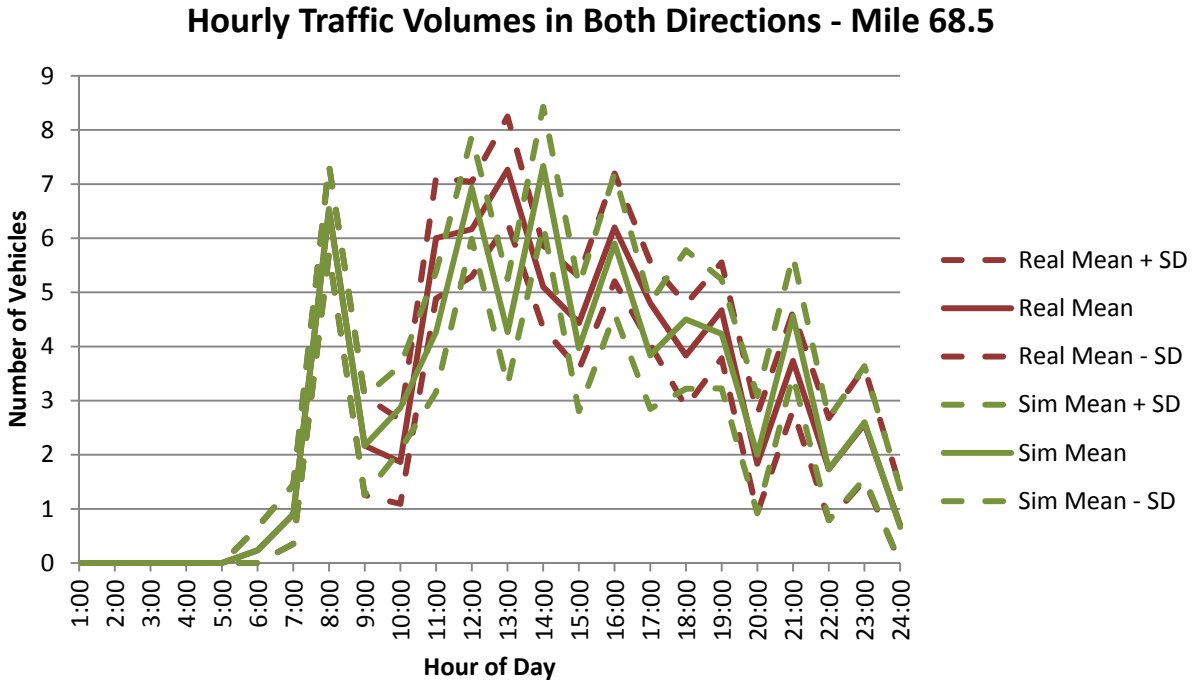


**Figure 19. comparison of of hourly traffic volumes at mile 52.8.**

# 3. Traffic Simulation Model and Data Output Modifications

Several modifications of the traffic simulation model were required to evaluate the alternatives. This section briefly describes the modifications to wildlife encounters, routes, and corresponding changes to the simulation model output.

## 3.1 Wildlife Encounters

The wildlife encounter schedule was modified by integrating wildlife stops that were indicated in the LCD panel data. A summary of the data provided by the NPS team revealed three days during the peak season in 2008 where the number of panels out in operation, and the number of these that were used for recording stops were fairly evenly dispersed: 7/29, 8/3, and 8/9. Of the three days, 8/3, was contained the largest number of recorded entries; 216 stop entries from 11 different panels out of 18 operating out on the road. The stop data were extracted over the missing section from the aforementioned day, and spliced into the 2007 encounter schedule data. An examination of the simulated EVC routes indicated an increase in total travel time on the park road of about 12 to 20 minutes from the original Fish Creek VTS routes, which, when compared to a sampling of actual EVC routes, is a reasonable representation.

## 3.2 Route Modifications

Several new routes that were added in the 2008 and 2009 season were incorporated into the model. This required determining and updating rest stop dwell time behaviors for the new routes. Specifically rest stop dwell time mean and standard deviations for VTS Camper, Kantishna, Eielson, Wonder Lake routes, lodge bus routes, and the new Kantishna Experience (KE) tour were calculated for both travel directions from datasets provided by the Denali park managers. The dwell time datasets were derived from the GPS probes on the buses. Mean and standard deviations for lodge bus dwell times at Teklanika and Toklat were also updated for the model in a similar manner.

## 3.3 Output Modifications

The output from a microscopic traffic simulation model is predicted vehicle trajectories at desired time steps. The traffic simulation software was programmed and configured to output trajectory and other traffic measurement data used to compute the crowding and wildlife impact indicators. The number of vehicles within the road viewscapes is derived by recording the maximum number of vehicles that entered each of the sections within a 60 second time interval. This time interval is roughly half the estimated minimum travel time of the buses passing through any of the viewscape section locations from the GPS data (approximately two minutes). Second, four more vehicle ‘detectors’ were placed in the simulation model to monitor east and west bound traffic at two additional Sheep crossings located at 60.6, and 68.5. A timestamp is

generated and stored along with the type of vehicle when the vehicle crosses a detector. The crowding of vehicles at scenic rest stops and at wild life encounters along the road is computed from the locations of stopped vehicles. Therefore, only the trajectory states during the period where a vehicle stops in the simulation are stored. The current traffic simulation studies summarized herein required that private vehicles be included in the wildlife crowding indicator in addition to the buses (bunch size). Private vehicles stop for wildlife but in general for a shorter period of time than the buses. For example, if the private vehicle stopped behind buses that have stopped for a wildlife encounter along the road, it will attempt to overtake the buses after a short period of time if prevailing, oncoming traffic conditions allow the maneuver (about 1 minute). Note the described private vehicle behavior was part of the previous traffic simulation model but their contributions to the wildlife crowding indicators were not considered. The output processing and storage for the traffic simulation model was modified accordingly as part of this cooperative study to allow this calculation.

Other changes to the model specific to each of the alternatives will be summarized within subsequent sections of the report.

# 4. Traffic Microsimulation of Denali Park Road Alternative Transportation Systems

Originally, the task agreement, with guidance from Denali park managers, proposed modeling and testing four alternative transportation systems. Park managers later decided to evaluate three systems, each of which combined operational elements from the original four systems. A common element in all systems was the elimination of the shortest route, the Denali Natural History Tours (DNHT). All three proposed alternatives retained some of the routes from the original, current system. The remainder of this section summarizes the modeling and development effort on the three alternatives, with more focused attention on two of these systems which the NPS desired to scrutinize and test in much greater detail.

## 4.1 Alternative A: The One-Bus Alternative

### *4.1.1 Description of the alternative*

The concept of this system is to provide a single, unified service for all types of visitor groups to the park. All buses stopped at the campsites along the park road and there are no dedicated tour-only routes. The alternative proposes to illuminate the DNHT routes and replace these trips with service to Teklanika. There were three Teklanika routes, with varied rest stops at the Savage Cabin at roughly mile 13, 2 miles East the Savage check station, or Primrose at mile 17. The routes drop off and pick up campers. The intent was to compensate the increased bus traffic by eliminating the private vehicle camper trips to the Teklanika campgrounds. Campers would instead travel to the campsites at Teklanika using the bus service.

### *4.1.2 Modeling and output considerations*

As previously mentioned, park managers where interested in understanding the contribution between the private vehicles, lodge buses and the concessioner bus service to the three crowding indicators and traffic volumes at each of the wildlife crossing locations. Each of three Teklanika routes provided different rest area opportunities at the Savage Cabin at mile 12.5 and Primrose at mile 17. The dwell times at the rest areas were commensurate with the previous DNHT route, while the Teklanika rest area dwell times were characterized as being identical to the previous Toklat TWT route estimated from the previous 2007 model data in Morris et. al (2010). An additional significant departure from the current system is the near elimination of the Polychrome rest area at mile 46 as a primary rest area or destination for any route; only the Toklat (mile 54) and Eielson Concessioner (mile 66) buses contained a designated westbound stop, for 10 +/-3 minutes.

The weighted crowding norm violation standards (Morris et. al, 2010) as derived from Halo and Manning (2010) were used for evaluating the resulting social capacity of the alternative. The

wildlife crossing standard of 10 minute gaps used in previous studies was again used to evaluate potential impact on Dall's sheep.

### *4.1.3 Schedule set scenarios*

A single schedule scenario 105 buses was provided by the park managers to accommodate future visitor demands. This represents an 20% increase from the allocated 88 maximum daily bus trip limit specified under the current General Management Plan (30 Tundra Wilderness Tours, 36 VTS trips, and 22 Denali Natural History Tours). The schedule distribution congregates most of the departures in the morning hours before 11 AM (71%), with a secondary afternoon surge in departures between 1 PM and 3:30 PM (figure 20).

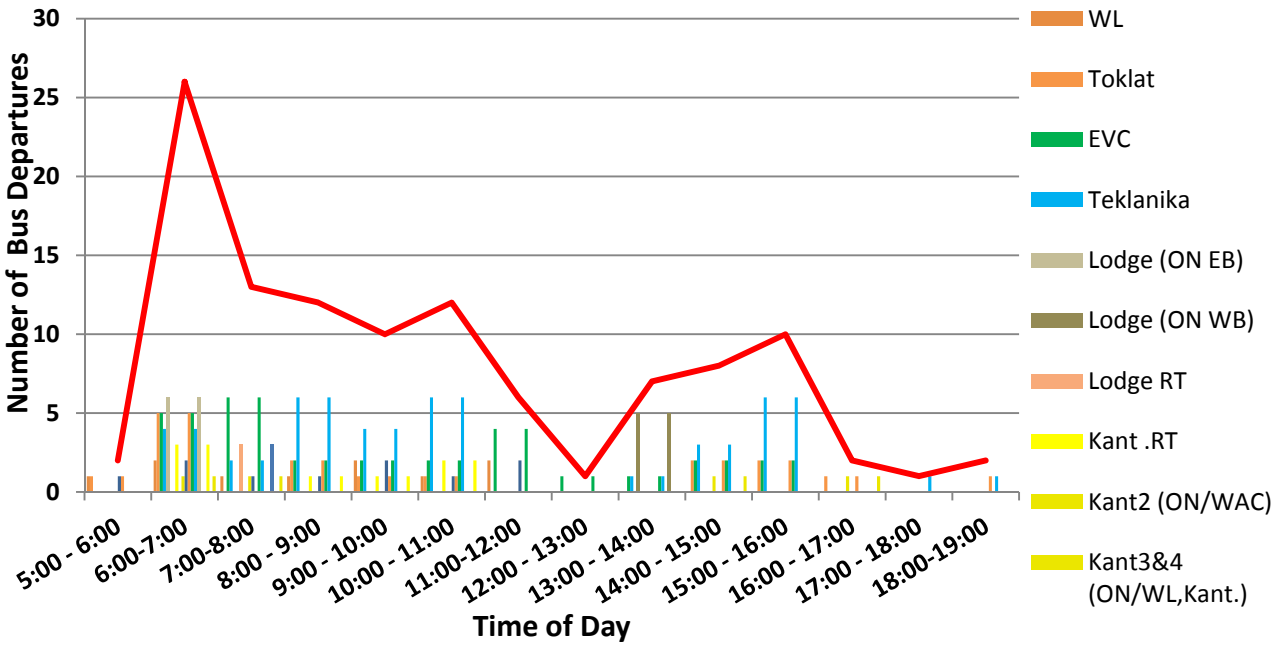


**Figure 20. Proposed 'one-bus' alternative departure schedule**

### *4.1.4 Results*

The results indicated a significant decrease in available sheep crossing opportunities at mile 21.6 (figure 21), particularly during the mid and late morning hours of the day, while crossing opportunities at the other two locations appear to provide more consistent crossing opportunities than the 50% to 60% increase presented in Morris et. al (2010). As one would expect, the level of hourly traffic negatively impacts sheep crossing opportunities. As was mentioned previously in section 2, sheep crossing opportunities represented by available gaps > 10 minutes fell off significantly (drops near or below 10 minutes within a given hour) when traffic volumes increased beyond about 14 vehicles per hour (vph) (figure 22).

**Figure 21. Available total gap time > 10 minutes within each hour for the three Dall's sheep crossings for the 'One Bus' Alternative.**

**Figure 22. 'One Bus' Alternative hourly traffic volumes for the three sheep crossings.**

Wildlife crowding results exhibited similar trends and violation levels for the same road sections, while schedule differences of fewer vehicles traveling further into the park, and replacing the Fish Creek routes with the further-in Eielson service, resulted in reduced viewscape crowding (figures 23 and 24). Only more salient results are presented in this report. Complete detailed results of these and other indicators, in the form of Excel compatible spreadsheets, where delivered to the NPS Denali park managers.

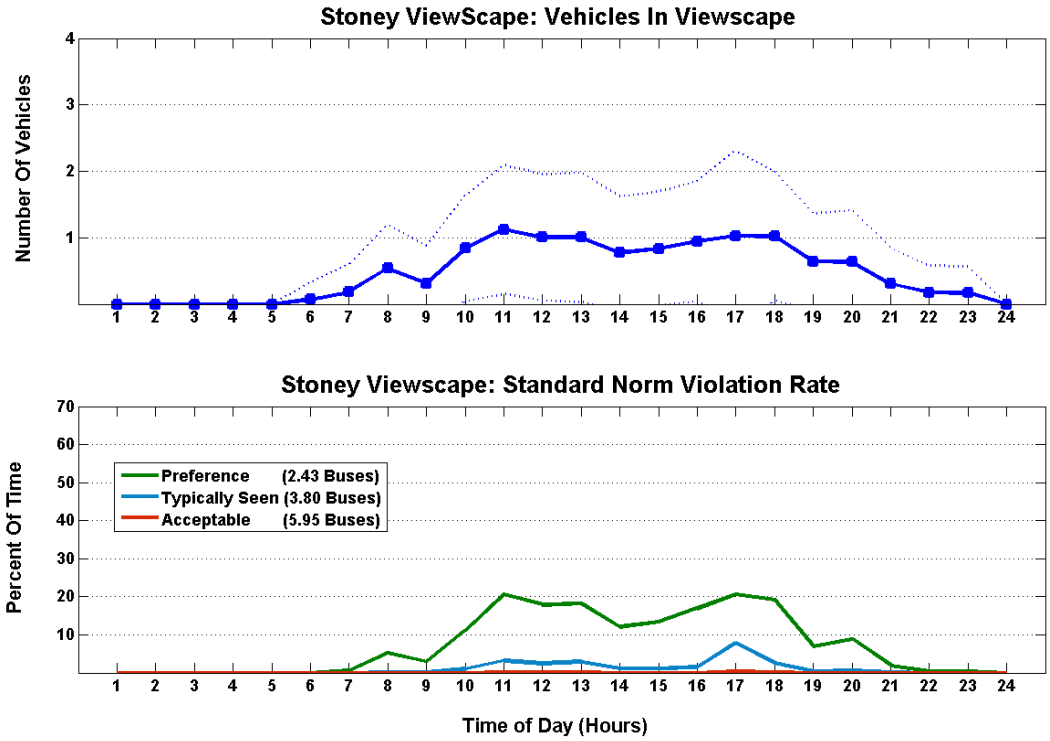


**Figure 23. 'One Bus' viewscape indicator and crowding standards for iconic viewscape at mile 61.**

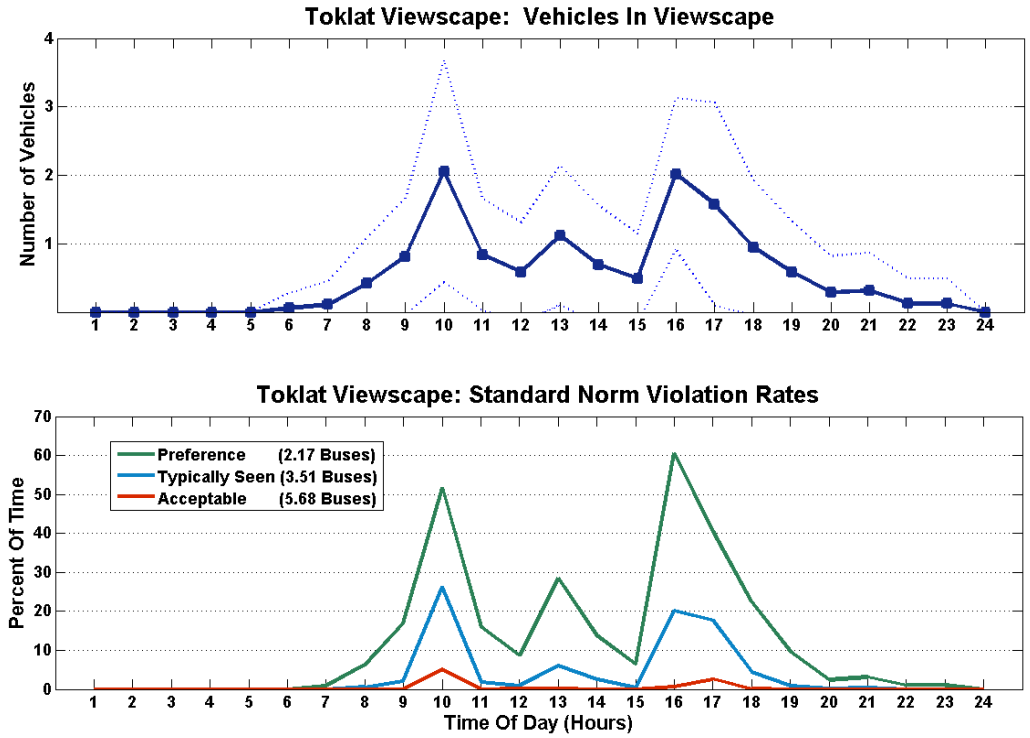


**Figure 24. One Bus' viewscape indicator and crowding standards for generic viewscape at mile 57.**

The Denali park management team determined that no further investigation of this alternative was warranted. The study of this alternative did however provide further insight to understand how changes in routes and operators affected road capacity. The remaining two alternatives were studied in much greater detail, using a set of evaluative standards criteria developed for the record of decision (ROD) necessary for framing an Environmental Impact Statement (EIS) for new park road daily and seasonal traffic limits.

## 4.2 Alternative B: Shuttle Service & Tours

### *4.2.1 Description of the alternative*

This alternative retains separate park concessioner sponsored tours and visitor transportation shuttles for hikers and campers. Three tour routes, one with the Turn-around point at Stoney Overlook (mile 62), the Eielson Visitor Center (EVC) and Kantisha (i.e., "Kantishna Experience") were incorporated into the traffic simulation model. The tour route with the turn-around at Stony had a designated rest stop at Toklat. Several one way, and round-trip service routes are offered to the wonder lake camp ground facilities throughout the day were also added to the model. As in the one bus alternative there are no routes terminating at the Polychrome rest area, although the rest area is used for several extended west-bound stops by VTS routes with destinations west of Polychrome pass. The new Teklanika routes replaces the current, DNHT service.

### *4.2.2 Modeling considerations*

Dwell times for all proposed routes were specified by the Denali park managers and integrated into the model. All prescribed wait times for buses and private vehicles at wildlife encounters remained identical to the previously developed models. There are no prescribed stops at rest areas for the private vehicles. An additional viewscape section at Grassy located at mile 69 in the model was added to accommodate the Grassy Pass viewscape.

### *4.2.3 EIS standards*

Initially, the simulation output from this alternative was expressed using a range of crowding standard norm values, and then delivered to the park managers to help them formulate standards specific to the EIS for the two remaining alternative transportation systems described herein. For Table 1 summarizes the provided standards for both wildlife (Dall's sheep) and crowding. Alternative B, the crowding standards were divided between two subzone sections along the road. The first subzone, was defined between the savage check station at mile 15 to mile 31, near the Teklanika bridge. A second subzone covers the remainder of the road from mile 31 to Kantishna. The standards for crowding levels decrease from one subzone to the next, as visitors travel further into the park.

**Table 1. EIS standards and acceptable violation levels for Alternative B**

| Indicator | Desired Conditions for Alternative B |
|---|---|
| **Wildlife Stops** | |
| Number of vehicles at a wildlife stop – Wildlife viewing subzone 1 | 75% of wildlife stops over the GMP season will have **3** or fewer vehicles |
| | 90% of wildlife stops over the GMP season will have **4** or fewer vehicles |
| | 95% of stops over the GMP season will have **5** or fewer vehicles |
| Number of vehicles at a wildlife stop – Wildlife viewing subzone 2 | 75% of wildlife stops over the GMP season will have **2** or fewer vehicles |
| | 90% of wildlife stops over the GMP season will have **3** or fewer vehicles |
| | 95% of stops over the GMP season will have **4** or fewer vehicles |
| **Viewscapes** | |
| Number of vehicles in a viewscape – Wildlife viewing subzone 1 | 85% of the time between 7 am and 10 pm, there will be **3** or fewer vehicles visible in the Mile 26 viewshed |
| | 95% of the time between 7 am and 10 pm, there will be **4** or fewer vehicles visible in the Mile 26 viewshed |
| Number of vehicles in a viewscape – Wildlife viewing subzone 2 | 85% of the time between 7 am and 10 pm, there will be **2** or fewer vehicles visible in the Miles 55, 62 and 69 viewsheds |
| | 95% of the time between 7 am and 10 pm, there will be **3** or fewer vehicles visible in the Miles 55, 62 and 69 viewsheds |
| **Rest Stops and the Eielson Visitor Center** | |
| Number of vehicles parked at one time at Teklanika rest stop | No more than **12** buses at one time for a total of no more than **10** vehicles at any one time exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 4 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| Number of vehicles parked at one time at Toklat rest stop | No more than **11** buses at one time for a total of no more than **11** vehicles exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 5 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| Number of vehicles parked at one time at the Eielson Visitor Center | No more than **10** buses at one time with a total of no more than **13** vehicles exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 7 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| **Sheep Gaps** | |
| Sheep Gap Spacing | Milepoints 21.6, 37.6, 52.8, 60.6 and 68.5 will have a **10** minute gap in traffic every hour with a 95% success rate (23 of 24 hours with gaps). |

### *4.2.4 Schedule set scenarios*

The scheduled increase scenarios provided by the NPS Denali park management team are summarized in table 2, with the baseline conditions of 101 buses, increasing to 146 buses, with 146 departures from the beginning of the park road (Table 2). Schedule increases generally follow a similar pattern to the 'One Bus' scenario, with a majority (64%) of buses departing before 11:00 AM (figure 25). Schedule increases are done with the park concessioner shuttle and tour bus service while the number of lodge buses remained essentially unchanged.

**Table 2. Proposed baseline schedule and incremental increases for Alternative B.**

| Route | % Increase | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Baseline** | **+5%** | **+10%** | **+15%** | **+20%** | **+25%** | **+30%** | **+40%** | **+50%** |
| **TekTour1** | 6 | 8 | 8 | 9 | 9 | 9 | 10 | 12 | 13 |
| **TekTour2** | 13 | 13 | 14 | 15 | 16 | 16 | 16 | 18 | 18 |
| **TekTour3** | 13 | 13 | 13 | 13 | 13 | 14 | 15 | 15 | 16 |
| **TWT EVC** | 13 | 14 | 14 | 15 | 17 | 17 | 17 | 19 | 20 |
| **TWT Tok** | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 9 | 10 |
| **KE** | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| **Camp Tek** | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 |
| **Camp Tok** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| ***CampWL** | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 11 |
| **VTS EVC** | 15 | 16 | 16 | 17 | 17 | 17 | 20 | 21 | 22 |
| **VTS WL** | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 10 | 11 |
| **VTS KAN** | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **VTS TOK** | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| **Lodges** | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| **Totals** | **101** | **104** | **109** | **113** | **117** | **121** | **127** | **136** | **146** |

*Wonder Lake Camper route (WL) includes one or more EB routes originating from Wonder Lake.

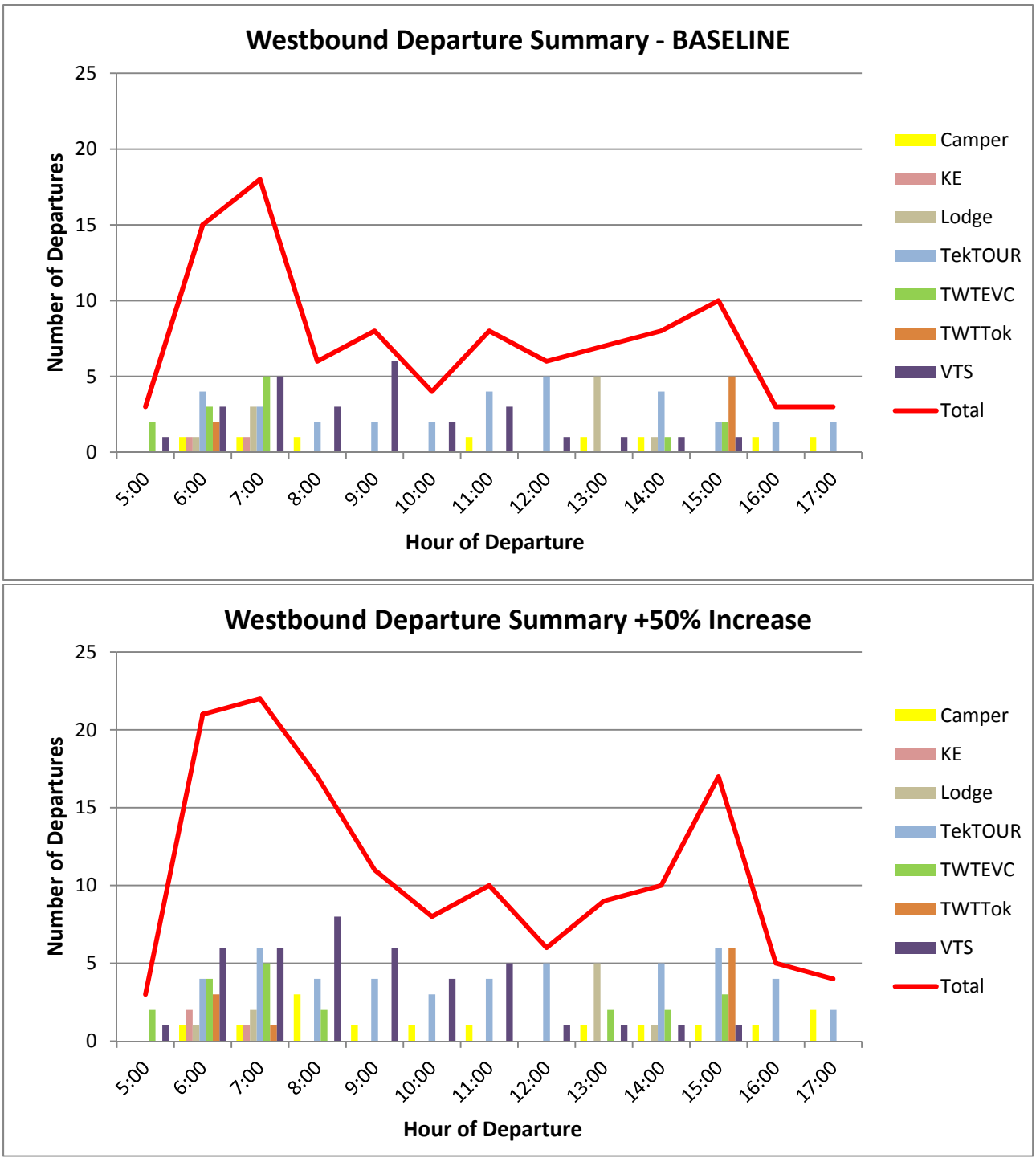


**Figure 25. (top) baseline westbound departure, and highest increase (bottom) for Alternative B schedule increase scenarios.**

### *4.2.5 Schedule Increase Results*

Tables 3 through 6 summarize violations of the aforementioned EIS standards. For each standard, a one sided T-test was done to test for exceeding each standard at the p=0.05 level of significance, and are highlighted in each of the tables below. The Dall's Sheep gap standard tables list the average 10-minute gap spacing for each hour across a 24 hour period, and their standard deviations calculated from 30 experiments. The model forecasted significant wildlife viewing crowding violations in the second subzone, until the scheduled 50% increase scenario, where all standards within both subzones were violated beyond the acceptable standard violation levels. Two crowding peaks in the second subzone (averaging between 3 to 4 vehicles) that occurred in mid-morning and afternoon contributed significantly to the violations beyond acceptable levels.

The other crowding standards were violated less frequently than the wildlife crowding standards. There was small to modest violations for the Toklat viewscape. Interestingly, the model forecasts no violations for any of the scenarios for the viewscape before Teklanika indicating that vehicles remained dispersed far enough apart to reduce the number of vehicles observed at one time, within one minute, small. Only the Eielson Visitor Center rest stop area resulted in small but statistically significant violations of the set crowding standard.

Violations at all of the sheep crossing locations, with exception of the furthest crossing at mile 69, started from the +15% increase scenario and beyond. In particular, the Sheep crossing standard associated with the closest crossing near mile 21 – not far from the Toklat viewscape located at mile 26, was significantly violated for all scenarios. One reason for the violations was an observed 'echo' effect from returning eastbound bus trips throughout the day, that added to west bound trips, and in particular in the afternoon.

**Table 3: Alt-B Schedule Increase Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Subzone 1, > 3.0 vehicles | 14.87 | 15.61 | 17.33 | 18.19 | 20.00 | 21.43 | 22.26 | 25.62 | ***29.59** | 25.00 |
| Subzone 1, > 4.0 vehicles | 5.20 | 6.11 | 7.05 | 7.32 | 7.74 | 9.10 | 9.43 | ***11.60** | ***14.97** | 10.00 |
| Subzone 1, > 5.0 vehicles | 1.55 | 1.84 | 2.66 | 2.60 | 2.92 | 3.45 | 3.59 | 4.54 | ***6.94** | 5.00 |
| Subzone 2, > 2.0 vehicles | ***30.25** | ***28.33** | ***30.34** | ***31.42** | ***32.34** | ***35.27** | ***36.71** | ***39.63** | ***42.74** | 25.00 |
| Subzone 2, > 3.0 vehicles | ***11.82** | ***10.76** | ***12.54** | ***13.98** | ***14.96** | ***16.95** | ***17.82** | ***19.67** | ***22.36** | 10.00 |
| Subzone 2, > 4.0 vehicles | 4.30 | 4.15 | 4.77 | ***5.92** | ***6.73** | ***7.75** | ***8.09** | ***9.45** | ***11.21** | 5.00 |

**Table 4: Alt-B Schedule Increase Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| **Subzone 1, Teklan > 3 vehicles** | 0.36 | 0.40 | 0.68 | 0.67 | 0.77 | 0.89 | 0.96 | 1.39 | 10.00 | 15.00 |
| **Subzone 1, Teklan > 4 vehicles** | 0.06 | 0.04 | 0.10 | 0.10 | 0.14 | 0.11 | 0.16 | 0.20 | 3.33 | 5.00 |
| **Subzone 2, Toklat > 2 vehicles** | 8.86 | 11.05 | 11.69 | 12.08 | 12.49 | 13.20 | 14.68 | ***15.66** | ***17.37** | 15.00 |
| **Subzone 2, Toklat > 3 vehicles** | 3.50 | 4.07 | 4.81 | ***5.46** | ***6.03** | ***6.31** | ***6.84** | ***7.19** | ***5.00** | 5.00 |
| **Subzone 2, Stoney > 2 vehicles** | 4.77 | 6.23 | 6.35 | 6.74 | 7.27 | 7.61 | 8.24 | 9.29 | 13.33 | 15.00 |
| **Subzone 2, Stoney > 3 vehicles** | 1.06 | 1.56 | 1.66 | 1.81 | 2.11 | 1.98 | 2.32 | 2.62 | 8.33 | 5.00 |
| **Subzone 2, Grassy > 2 vehicles** | 0.45 | 0.58 | 0.65 | 0.61 | 0.65 | 0.64 | 0.66 | 0.64 | 0.00 | 15.00 |
| **Subzone 2, Grassy > 3 vehicles** | 0.08 | 0.09 | 0.11 | 0.10 | 0.09 | 0.10 | 0.13 | 0.08 | 0.00 | 5.00 |

**Table 5: Alt-B Schedule Increase Rest Stop Crowding Standard Violations**

| Reststop Area Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| **Teklanika > 12 buses** | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.03 | 0.00 |
| **Toklat > 11 buses** | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | ***0.26** | ***1.16** | 0.00 |
| **Eielson > 10 buses** | ***1.64** | ***1.45** | ***1.89** | ***2.07** | ***2.73** | ***3.51** | ***3.67** | ***5.42** | ***7.68** | 0.00 |

**Table 6. Alt-B Schedule Increase Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mile 21.6** | ***0.88** | ***0.86** | ***0.84** | ***0.80** | ***0.80** | ***0.79** | ***0.77** | ***0.73** | ***0.70** | 0.95 |
| **SD Mile 21.6** | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | |
| **Mile 37.6** | 0.95 | ***0.94** | 0.95 | ***0.94** | ***0.94** | ***0.91** | ***0.91** | ***0.89** | ***0.89** | 0.95 |
| **SD Mile 37.6** | 0.04 | 0.05 | 0.04 | 0.04 | 0.03 | 0.05 | 0.04 | 0.05 | 0.06 | |
| **Mile 52.8** | 0.97 | 0.97 | 0.96 | ***0.93** | 0.95 | ***0.94** | ***0.92** | ***0.88** | ***0.88** | 0.95 |
| **SD Mile 52.8** | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.03 | 0.05 | 0.05 | 0.06 | |
| **Mile 60.6** | ***0.94** | 0.95 | ***0.94** | ***0.93** | ***0.93** | ***0.91** | ***0.91** | ***0.89** | ***0.87** | 0.95 |
| **SD Mile 60.6** | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.06 | 0.05 | |
| **Mile 68.5** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.95 |
| **SD Mile 68.5** | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | |

### *4.2.6 EIS mitigation scheduling*

The UMN team then investigated schedule changes to reduce or eliminate EIS standards violations for the base conditions. The first strategy was to shift morning departures of routes that turn-around at Eielson, Wonder Lake campgrounds, and Kantishna to progressively later times – especially the routes that were one-way trips, while ensuring they complete their trips before the end of the (simulated) operational period (before midnight). The general scheduled AM/PM departure patterns in the original scenarios were preserved (morning departures were not shifted later than 10:00AM. Forty combinatorial test cases were executed that gradually shifted the aforementioned departures later in the day. Although some patterns for reducing standards violations were emerging, none of them reduced the violations to the levels needed dictated by the aforementioned EIS standards. Sheep crossing standard violations were largely unaffected.

A second strategy, provided in schedules contrived Denali park managers, attempted to spread departure headways in a uniform pattern, constraining departures to after 5:00AM. In addition, adherence to current Lodge buses departure times —particularly those that are needed to transport visitors eastbound out of the park to ensure ample boarding time for afternoon train departures, needed to be preserved; schedules could not be adjusted by more than ½ an hour. The simulation model predicted that such small shifts did not markedly improve results (the "NPS-Lodge bus Shift" scenario case in tables 7- 10). Note that their schedules removed two Teklanika Tours from the original base condition. The Denali park managers indicated that three more of these routes (5 total) could be removed if necessary to improve compliance with the EIS standards.

A reduction in the number of times an alternative schedule is executed in the simulation was required so that more exploratory iterations could be tested within the timeframe of the project.

An examination of the mean values for any of the EIS standards revealed that they do not change more than 5 to 10 percent between about 10 to 30 iterations. Therefore 10 repetitions were selected to provide a reasonable compromise to capture the stochastic nature of the simulation for each iterative test.

### *4.2.7 EIS mitigation results*

Both aforementioned scenarios (figure 26) resulted in modest improvements in most of the wildlife crowding standards (Table 7). There was no improvement in reducing the EIS standard violations for two of the three set wildlife crowding standards observed in the second subzone for both the provided schedule scenarios. The Toklat viewscape was negatively affected although the crowding standards were still acceptable-- well below the three violation levels (Table 8). Rest area crowding showed slight improvements in reducing the violation level closer to the desired set standards (Table 9). Of particular significance is the improvement of the sheep crossing standard at mile 21, increasing from 88% to 94% crossing gap availability for each hour of the day -- still statistically below, but much closer to the desired acceptable standard of 23 out of 24 hours (95%) with at least one > 10 minute gap (Table 10).

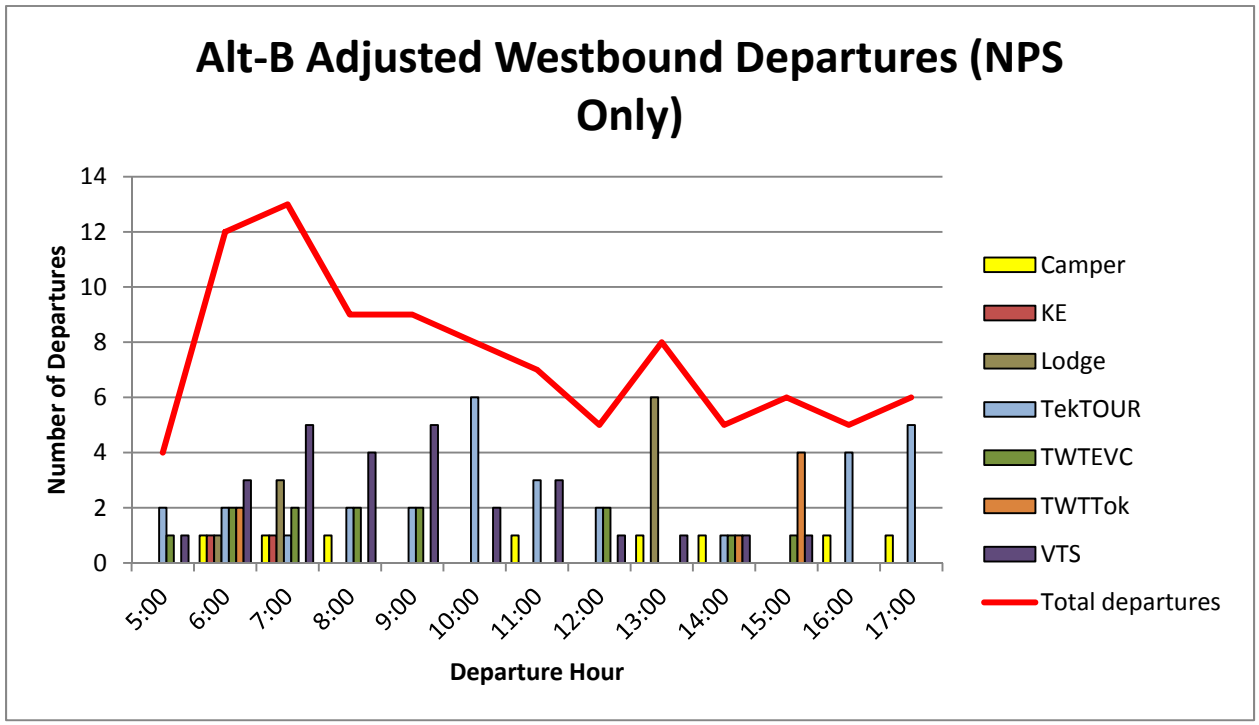


**Figure 26. An initial adjusted schedule provided by the Denali park managers, which yielded better results than the original base schedule with similar total departures.**

The UMN team then proceeded to experiment with several schedule adjustments to the "NPS" scenario to further reduce the standards violations. One observation at the sheep crossings where violations occurred was a concomitant 'echo' effect from returning, east-bound traffic (figure 27). The return 'echo' adds to the west bound traffic, thereby reducing the frequency of large

headway gaps (> 10 minutes). We then examined this phenomenon in order to deduce which bus route departures to shift, or remove, to lessen large peaks in the hourly traffic volumes that were associated with violations.

**Figure 27. Alt-B East bound vs. West bound hourly traffic volumes at mile 60.6 sheep crossing for "NPS" schedule. (private vehicle hourly volumes not shown)**

The tables 7 – 10 summarize three tests which provided the best improvements relative to the provided cases. The strategies used in each either shifting routes (MTO 2, MTO 1), or further

removal of three more Teklanika bus routes (MTO 3). An effective strategy appeared to be shifting Teklanika routes and longer distance routes (Wonder Lake and to EVC) to very early in the morning. MTO 3 attempted to reduce afternoon traffic build-ups by removing three afternoon Teklanika tours. An experiment, not presented herein, that removed morning tours did not improve the result.

To conclude, the schedule mitigation study did not provide any scenarios in which not all violations of set standards were within the acceptable levels defined by the EIS for this alternative. However, most standards were reduced significantly and in particular the Sheep crossing standard could be satisfied for all crossing locations. Eliminating the Teklanika bus trips alone did not significantly reduce the standards violations – even within the road section where the routes would operate. Rather, the study suggests that judicious temporal schedule departure shifts of routes may provide equal, if not better improvements than by eliminating trips alone.

**Table 7. Alt-B Schedule Alteration Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | NPS, Lodge bus Shift | NPS | MTO 1 | MTO 2 | MTO 3 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Subzone 1, > 3.0 vehicles** | 14.87 | 11.86 | 12.40 | 11.61 | 12.02 | 11.38 | 25.00 |
| **Subzone 1, > 4.0 vehicles** | 5.20 | 2.99 | 3.30 | 3.54 | 3.71 | 3.48 | 10.00 |
| **Subzone 1, > 5.0 vehicles** | 1.55 | 0.86 | 0.78 | 0.83 | 0.93 | 0.74 | 5.00 |
| **Subzone 2, > 2.0 vehicles** | ***30.25** | ***30.12** | ***30.16** | ***29.45** | ***29.64** | ***29.99** | 25.00 |
| **Subzone 2, > 3.0 vehicles** | ***11.82** | ***11.13** | ***11.98** | ***11.42** | ***11.24** | ***11.41** | 10.00 |
| **Subzone 2, > 4.0 vehicles** | 4.30 | 3.68 | 4.30 | 4.39 | 4.40 | 3.97 | 5.00 |

**Table 8. Alt-B Schedule Alteration Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | NPS, Lodge bus Shift | NPS | MTO 1 | MTO 2 | MTO 3 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Subzone 1, Teklan > 3 vehicles** | 0.36 | 0.31 | 0.32 | 0.46 | 0.40 | 0.31 | 15.00 |
| **Subzone 1, Teklan > 4 vehicles** | 0.06 | 0.04 | 0.03 | 0.07 | 0.06 | 0.04 | 5.00 |
| **Subzone 2, Toklat > 2 vehicles** | 8.86 | 11.56 | 12.03 | 11.54 | 11.64 | 11.54 | 15.00 |
| **Subzone 2, Toklat > 3 vehicles** | 3.50 | 4.90 | 4.94 | 4.91 | 4.95 | 4.98 | 5.00 |
| **Subzone 2, Stoney > 2 vehicles** | 4.77 | 6.65 | 6.86 | 6.61 | 6.66 | 6.73 | 15.00 |
| **Subzone 2, Stoney > 3 vehicles** | 1.06 | 1.56 | 2.07 | 2.04 | 2.13 | 1.90 | 5.00 |
| **Subzone 2, Grassy > 2 vehicles** | 0.45 | 0.21 | 0.63 | 0.71 | 0.61 | 0.61 | 15.00 |
| **Subzone 2, Grassy > 3 vehicles** | 0.08 | 0.01 | 0.09 | 0.14 | 0.14 | 0.16 | 5.00 |

**Table 9. Alt-B Schedule Alteration Rest Stop Crowding Standard Violations**

| Reststop Area Crowding Standards | BASE | NPS, Lodge bus Shift | NPS | MTO 1 | MTO 2 | MTO 3 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Teklanika > 12 buses** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Toklat > 11 buses** | 0.00 | ***0.15** | 0.15 | 0.13 | 0.13 | 0.18 | 0.00 |
| **Eielson > 10 buses** | ***1.64** | ***1.12** | ***1.37** | ***0.97** | ***0.93** | ***0.93** | 0.00 |

**Table 10. Alt-B Schedule Alteration Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | NPS, Lodge bus Shift | NPS | MTO 1 | MTO 2 | MTO 3 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Mile 21.6** | ***0.88** | ***0.94** | 0.94 | 0.97 | 0.96 | 0.95 | 0.95 |
| **SD Mile 21.6** | 0.06 | 0.04 | 0.05 | 0.03 | 0.04 | 0.04 | |
| **Mile 37.6** | 0.95 | ***0.94** | ***0.94** | 0.95 | 0.95 | 0.96 | 0.95 |
| **SD Mile 37.6** | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | |
| **Mile 52.8** | 0.97 | 0.96 | 0.96 | 0.95 | 0.95 | 0.97 | 0.95 |
| **SD Mile 52.8** | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | |
| **Mile 60.6** | ***0.94** | ***0.92** | ***0.93** | 0.95 | 0.95 | 0.93 | 0.95 |
| **SD Mile 60.6** | 0.04 | 0.05 | 0.04 | 0.02 | 0.04 | 0.05 | |
| **Mile 68.5** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.95 |
| **SD Mile 68.5** | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | |

## 4.3 Alternative C: Loop Service & Specialty Tours

### *4.3.1 Description of alternative*

Economy tour routes (lower cost, self-guided tours) as well as tour routes traveling to the end of the park road were studied for different scheduling loads. In addition, 5 specialty tours were modeled to accommodate bird watching, family, and evening tours. A proposed shuttle loop service between Kantishna and the EVC, originating and terminating from the park entrance or the Wilderness Access Center (WAC), provides service to campers and hikers at the far west end of the park ("VTS Loop" in the schedule increase summary table 12). This then replaces some of the service to the wonder lake shuttle routes utilized in Alternative B, as well as separate shuttle service to Kantishna. Lastly, an additional shuttle route provides service up to the Igloo campground at mile 34 ("Camp IG" in table 12).

### *4.3.2 Modeling considerations*

For the bird "Bird watching" specialty tours the park management team specified longer stop time behaviors at wildlife sightings (twice as long as the prescribed wait times for all wildlife stops in the model). Additional rest stops were added to the simulation model for these routes at Tattler (mile 37.5), Sable pass (mile 39.1), and one mile east of the Polychrome rest stop (mile

45). Dwell times for these areas were prescribed by the Denali park managers (about 12 minutes). The specialty tours went as far as Toklat, with the exception of the aforementioned Bird Watching tour route which travels to the EVC at mile 66. The intent of VTS Loop service was to have more tightly controlled departures. This was achieved in part using features of the AIMSUN traffic simulation modeling software to control the departures from Eielson.

### *4.3.3 EIS standards*

The EIS standards considered three sub-zones along the park road instead of the two defined for Alternative B. The first subzone is located between the Savage check point and Teklanika (subzone 1), the second between Teklanika and the EVC (subzone 2), and the third between EVC and Wonderlake (subzone 3). The standards for crowding levels decrease from one subzone to the next, as visitors travel further into the park. The standards applied to this alternative are summarized in table 11.

**Table 11. Specified EIS standards for transportation alternative system C delivered by Denali NPS park management**

| Indicator | Desired Conditions for Alternative C |
|---|---|
| **Wildlife Stops** | |
| Number of vehicles at a wildlife stop – Wildlife viewing subzone 1 | 75% of wildlife stops over the GMP season will have **3** or fewer vehicles |
| | 90% of wildlife stops over the GMP season will have **4** or fewer vehicles |
| | 95% of stops over the GMP season will have **5** or fewer vehicles |
| Number of vehicles at a wildlife stop – Wildlife viewing subzone 2 | 75% of wildlife stops over the GMP season will have **2** or fewer vehicles |
| | 90% of wildlife stops over the GMP season will have **3** or fewer vehicles |
| | 95% of stops over the GMP season will have **4** or fewer vehicles |
| Number of vehicles at a wildlife stop – Wildlife viewing subzone 3 | 75% of wildlife stops over the GMP season will have **1** or fewer vehicles |
| | 90% of wildlife stops over the GMP season will have **2** or fewer vehicles |
| | 95% of stops over the GMP season will have **3** or fewer vehicles |
| **Viewscapes** | |
| Number of vehicles in a viewscape – Wildlife viewing subzone 1 | 85% of the time between 7 am and 10 pm, there will be **3** or fewer vehicles visible in the Mile 26 viewshed |
| | 95% of the time between 7 am and 10 pm, there will be **4** or fewer vehicles visible in the Mile 26 viewshed |
| Number of vehicles in a viewscape – Wildlife viewing subzone 2 | 85% of the time between 7 am and 10 pm, there will be **2** or fewer vehicles visible in the Miles 55 and 62 viewsheds |
| | 95% of the time between 7 am and 10 pm, there will be **3** or fewer vehicles visible in the Miles 55 and 62 viewsheds |
| Number of vehicles in a viewscape – Wildlife viewing subzone 3 | 85% of the time between 7 am and 10 pm, there will be **1** or fewer vehicles visible in the Mile 69 viewshed |
| | 95% of the time between 7am and 10 pm, there will be **2** or fewer vehicles visible in the Mile 69 viewshed |
| **Rest Stops and the Eielson Visitor Center** | |
| Number of vehicles parked at one time at Teklanika rest stop | No more than **12** buses at one time for a total of no more than **10** vehicles at any one time exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 4 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| Number of vehicles parked at one time at Toklat rest stop | No more than **11** buses at one time for a total of no more than **11** vehicles exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 5 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| Number of vehicles parked at one time at the Eielson Visitor Center | No more than **10** buses at one time with a total of no more than **13** vehicles exclusive of NPS operational support vehicles (i.e. to meet the desired condition, if there are 6 buses present there can be up to 7 non-bus vehicles present; NPS operational support vehicles will not count against this total) |
| **Sheep Gaps** | |
| Sheep Gap Spacing | Milepoints 21.6, 37.6, 52.8, 60.6 and 68.5 will have a **10** minute gap in traffic every hour with a 95% success rate (23 of 24 hours with gaps). |

### *4.3.4 Schedule set scenarios*

Eight schedule increases were tested above a baseline condition for this alternative. As before the increases are relative to tour and shuttle operators and are independent of the lodge buses. The departure time distribution for this alternative is distributed somewhat differently than the previous alternatives, although the majority of trips still depart before 11:00 A.M. (60%) (figure 28).

**Table 12: Proposed baseline schedule and incremental increases for Alternative for C.**

| **Route** | **% Increase** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Baseline** | **+5%** | **+10%** | **+15%** | **+20%** | **+25%** | **+30%** | **+40%** | **+50%** |
| **TekTour1** | 6 | 7 | 9 | 9 | 10 | 10 | 11 | 12 | 13 |
| **TekTour2** | 11 | 11 | 11 | 12 | 13 | 13 | 13 | 14 | 14 |
| **TekTour3** | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 14 | 15 |
| **TWT EVC** | 12 | 13 | 13 | 14 | 14 | 15 | 16 | 17 | 18 |
| **TWT Tok** | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 8 |
| **Econ EVC** | 10 | 11 | 12 | 12 | 12 | 12 | 13 | 14 | 15 |
| **Econ Tek** | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 9 |
| **Specialty** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **KE** | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| **Camp IG** | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| ***Camp WL** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 |
| **VTS EVC** | 10 | 11 | 11 | 12 | 13 | 13 | 13 | 15 | 16 |
| **VTS TOK** | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 6 | 6 |
| **VTS Loop** | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 |
| **Lodges** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **Totals** | **100** | **104** | **109** | **113** | **118** | **121** | **127** | **136** | **145** |

*Wonder Lake Camper route (WL) includes an EB route originating from Wonder Lake.

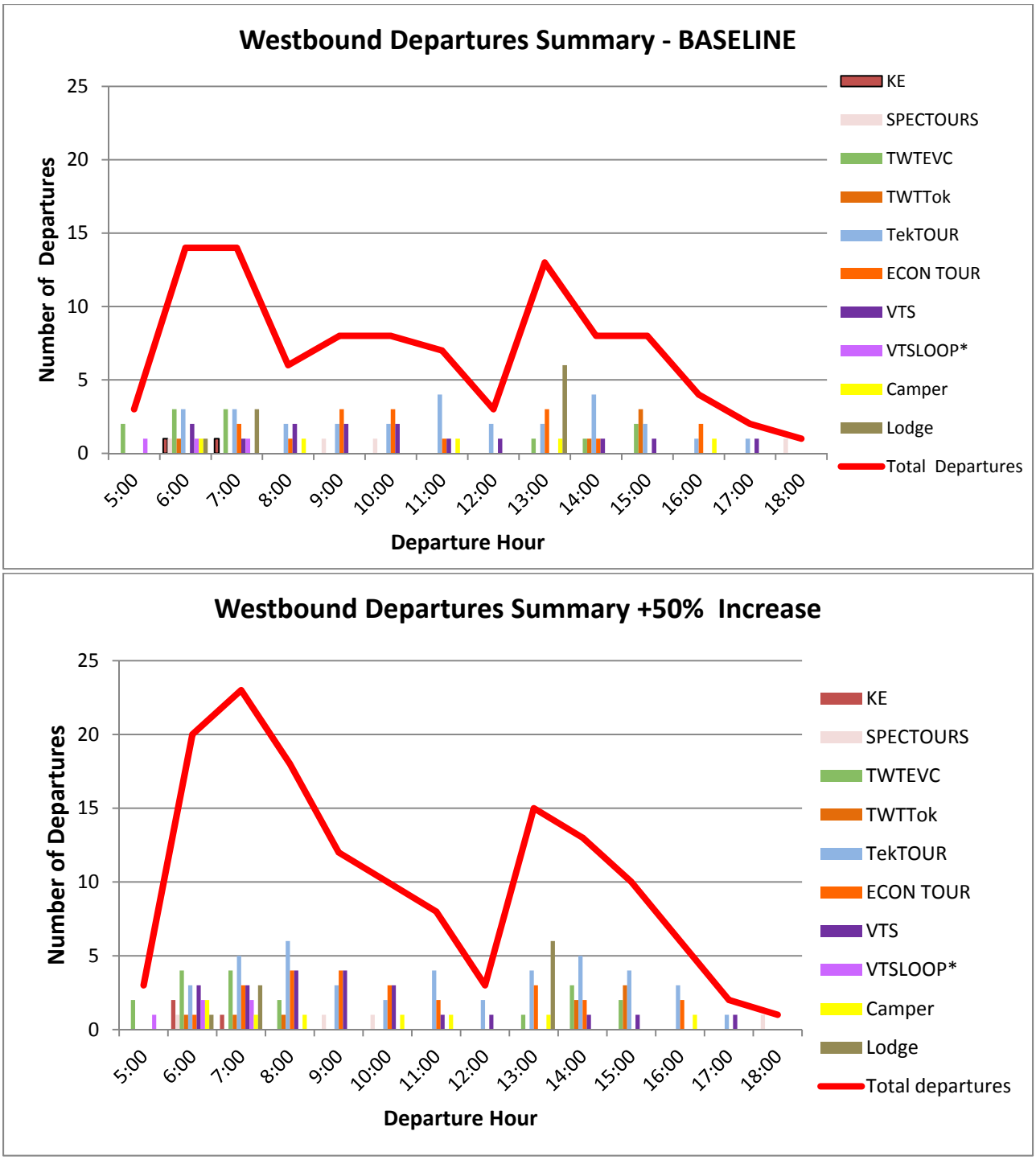


**Figure 28. (top) baseline westbound departure, and highest increase (bottom) for Alternative C schedule increase scenarios.**

### *4.3.5 Schedule Increase Results*

Tables 13 through 16 summarize violations of the Alternative C standards. Similar to the results for the Alternative B scheduled increases, there were significant violations above the acceptable

standard levels for the subzone 2 standards. Note, however, that subzone 2 is substantially shorter than subzone 2 for Alternative B. This implies that the crowding is affected to a large degree between the EVC and Toklat since the scheduled wildlife encounters within this section are greater than beyond the EVC.

Viewscape crowding violations were not prevalent until the 20% increase scenario, and similar to Alternative B, only within the viewscape west of Toklat. Reststop crowding standards violations were statistically significant although the violation levels never more than about 3% above the acceptable levels set forth in the EIS.

All the sheep crossing locations, except the furthest location near mile 69, violated the standard starting at the 20% increase scenario. Similar to alternative B, the traffic volume data revealed an 'echo' effect of returning buses adding to the traffic of the outbound (Westbound) buses. The sheep crossing standard associated with mile 21.6 was significantly violated for all scenarios.

**Table 13. Alt-C Schedule Increase Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| **Subzone 1, > 3.0 vehicles** | 17.32 | 19.89 | 20.70 | 21.54 | 25.54 | ***27.60** | ***28.80** | ***32.34** | ***35.34** | 25.00 |
| **Subzone 1, > 4.0 vehicles** | 7.41 | 7.96 | 9.26 | 9.35 | ***11.83** | ***13.25** | ***14.51** | ***17.36** | ***20.08** | 10.00 |
| **Subzone 1, > 5.0 vehicles** | 3.00 | 3.28 | 3.77 | 4.01 | 5.08 | ***5.72** | ***6.66** | ***8.18** | ***10.44** | 5.00 |
| **Subzone 2, > 2.0 vehicles** | ***26.62** | ***27.49** | ***28.94** | ***31.04** | ***32.83** | ***34.50** | ***35.42** | ***39.50** | ***43.19** | 25.00 |
| **Subzone 2, > 3.0 vehicles** | ***10.86** | ***11.61** | ***12.49** | ***13.06** | ***14.37** | ***16.04** | ***15.78** | ***18.91** | ***21.23** | 10.00 |
| **Subzone 2, > 4.0 vehicles** | 4.31 | 4.88 | 5.02 | 5.26 | ***6.15** | ***6.94** | ***6.98** | ***8.66** | ***9.40** | 5.00 |
| **Subzone 3, > 1.0 vehicles** | 27.01 | 24.04 | ***28.56** | ***28.79** | 25.86 | ***29.32** | 23.92 | 26.90 | 24.25 | 25.00 |
| **Subzone 3, > 2.0 vehicles** | 5.25 | 4.18 | 6.51 | 4.95 | 4.71 | 6.67 | 3.72 | 4.72 | 7.90 | 10.00 |
| **Subzone 3, > 3.0 vehicles** | 0.20 | 0.30 | 0.26 | 1.08 | 0.60 | 0.39 | 0.22 | 0.49 | 1.67 | 5.00 |

**Table 14. Alt-C Schedule Increase Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Subzone 1, Teklan > 3 vehicles | 0.63 | 0.86 | 0.80 | 0.79 | 1.03 | 1.07 | 1.24 | 1.70 | 2.15 | 15.00 |
| Subzone 1, Teklan > 4 vehicles | 0.05 | 0.12 | 0.10 | 0.09 | 0.16 | 0.16 | 0.24 | 0.34 | 0.43 | 5.00 |
| Subzone 2, Toklat > 2 vehicles | 10.16 | 10.26 | 10.73 | 10.63 | 11.81 | 13.20 | 13.24 | 14.34 | ***15.48** | 15.00 |
| Subzone 2, Toklat > 3 vehicles | 4.65 | 4.58 | 4.99 | 4.81 | ***5.73** | ***6.34** | ***6.38** | ***6.98** | ***7.71** | 5.00 |
| Subzone 2, Stoney > 2 vehicles | 4.83 | 5.40 | 5.66 | 5.96 | 6.61 | 7.61 | 7.06 | 8.40 | 9.66 | 15.00 |
| Subzone 2, Stoney > 3 vehicles | 1.21 | 1.47 | 1.54 | 1.74 | 1.92 | 2.36 | 2.22 | 2.67 | 3.42 | 5.00 |
| Subzone 3, Grassy > 1 vehicles | 2.50 | 2.64 | 2.75 | 2.63 | 2.99 | 2.95 | 2.85 | 2.87 | 3.41 | 15.00 |
| Subzone 3, Grassy > 2 vehicles | 0.43 | 0.43 | 0.52 | 0.49 | 0.51 | 0.44 | 0.47 | 0.44 | 0.58 | 5.00 |

**Table 15. Alt-C Schedule Increase Reststop Crowding Standard Violations**

| Reststop Area Crowding Standards | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Teklanika Rest Stop, > 12 buses | ***0.09** | ***0.10** | ***0.06** | ***0.12** | ***0.16** | ***0.29** | ***0.37** | ***0.38** | ***0.48** | 0.00 |
| Toklat Reststop, > 11 buses | 0.00 | 0.00 | 0.00 | 0.01 | ***0.10** | ***0.12** | ***0.10** | ***0.23** | ***0.38** | 0.00 |
| Eielson Reststop, > 10 buses | ***0.06** | ***0.04** | ***0.15** | ***0.21** | ***0.85** | ***1.25** | ***1.20** | ***1.95** | ***2.75** | 0.00 |

**Table 16. Alt-C Schedule Increase Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | +5% | +10% | +15% | +20% | +25% | +30% | +40% | +50% | Std Viol Level |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mile 21.6** | ***0.89** | ***0.87** | ***0.85** | ***0.83** | ***0.81** | ***0.83** | ***0.81** | ***0.77** | ***0.73** | 0.95 |
| **SD Mile 21.6** | 0.04 | 0.05 | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 | 0.07 | |
| **Mile 37.6** | 0.96 | 0.96 | 0.95 | ***0.93** | ***0.93** | ***0.93** | ***0.92** | ***0.89** | ***0.87** | 0.95 |
| **SD Mile 37.6** | 0.03 | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | |
| **Mile 52.8** | 0.97 | 0.95 | ***0.94** | 0.94 | ***0.94** | ***0.94** | ***0.91** | ***0.90** | ***0.88** | 0.95 |
| **SD Mile 52.8** | 0.03 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.07 | |
| **Mile 60.6** | 0.97 | 0.95 | 0.95 | ***0.93** | ***0.93** | ***0.93** | ***0.92** | ***0.89** | ***0.88** | 0.95 |
| **SD Mile 60.6** | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | |
| **Mile 68.5** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.95 |
| **SD Mile 68.5** | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | |

### *4.3.6 EIS mitigation scheduling*

The MTO created a schedule maintaining the same scheduling constraints discussed in the previous alternatives. Rather than first eliminating any routes from the base condition, MTO 1, attempted to almost 'platoon' some of the routes together, while leaving at least one very large headway (greater than 10 minutes – preferably 15 minutes) within an hour interval with the reasoning that the probability of increasing sheep crossing opportunities would be improved. Many simulation experiments then shifted departures while examining hourly viewscape density and traffic characteristics at sheep crossings as described previously.

### *4.3.7 EIS mitigation results*

The first mitigation schedule, MTO 1, reduced or at least preserved almost all of the standards violation levels to below acceptable limits (Tables 17 – 20). The Dall's Sheep crossing standard at mile 21 still violated the EIS set standard limit.

The result did not improve the sheep crossing standard at mile 21 while most of the standards did not change that much.

One approach to reduce the violation level for the particular sheep crossing was to selectively remove Teklanika tour routes to further increase the bus departure headways with the objective to systematically reduce traffic volumes and thereby increase the frequency of large crossing gaps > 10 minutes. As in the previous transportation systems, a general observation of about 14 vph is associated with curtailing available greater than 10 minute gap times within each hour. Simulation experiments were conducted by sequentially removing either, or both, AM and PM routes and then processing the results. MTO 10 represents the removal of four Teklanika Tour routes, which produced the most favorable results for this strategy (two in the morning, and two in the later afternoon hours).

Experiments that combined schedule shifts with varying amount of the Teklanika route removals were also done; MTO 5 cut 3 of the four routes and instead shifted 2 other bus routes placed near the noon hour earlier in the morning. MTO 8 consists of only schedule shifts thereby retaining the same number of bus departures as the base condition. MTO 9 combines both, the removal of the four Teklanika routes in MTO 10 and the schedule shifts in MTO 8. MTO 9 (figure 29) represented the best compromise toward satisfying acceptable violations of the set standards defined in the EIS. Although the average violation levels exceeded the acceptable levels for a few of the standards, they were not statistically significant; the other standards were well below the set standard violation limits.

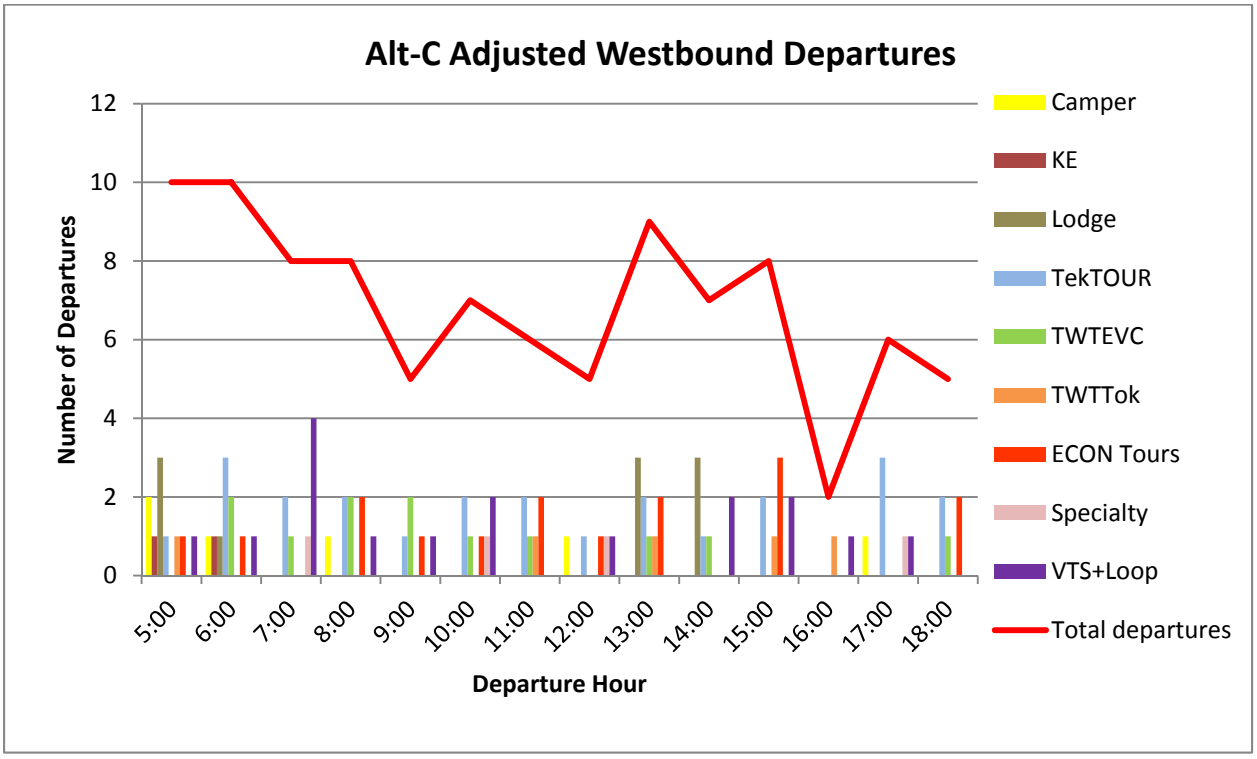


**Figure 29. An adjusted schedule, "MTO 9", which yielded better results than the original base schedule with similar total departures.**

In conclusion, the EIS mitigation study for this alternative indicates that it was possible to devise a schedule that would result in violations that were nearly within acceptable levels defined within the EIS specifications. Once again, the schedule mitigation study for this alternative confirms that eliminating available trips to Teklanika alone did not substantially improve the outcomes, and that temporal shifts in departure schedules of other buses must also be considered.

**Table 17. Alt-C Schedule Alteration Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | MTO 1 | MTO 5 | MTO 8 | MTO 9 | MTO 10 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Subzone 1, > 3.0 vehicles** | 17.32 | 10.10 | 9.17 | 11.11 | 10.83 | 9.97 | 25.00 |
| **Subzone 1, > 4.0 vehicles** | 7.41 | 3.05 | 3.26 | 4.11 | 3.47 | 3.32 | 10.00 |
| **Subzone 1, > 5.0 vehicles** | 3.00 | 1.37 | 1.35 | 1.52 | 1.25 | 1.14 | 5.00 |
| **Subzone 2, > 2.0 vehicles** | ***26.62** | 23.45 | 23.76 | 24.70 | 25.18 | 24.99 | 25.00 |
| **Subzone 2, > 3.0 vehicles** | ***10.86** | 7.74 | 7.53 | 7.61 | 8.35 | 8.96 | 10.00 |
| **Subzone 2, > 4.0 vehicles** | 4.31 | 2.35 | 2.28 | 2.35 | 2.42 | 2.44 | 5.00 |
| **Subzone 3, > 1.0 vehicles** | 27.01 | 22.33 | 23.05 | 24.71 | 24.27 | 27.63 | 25.00 |
| **Subzone 3, > 2.0 vehicles** | 5.25 | 3.31 | 3.27 | 3.15 | 3.01 | 3.31 | 10.00 |
| **Subzone 3, > 3.0 vehicles** | 0.20 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 |

**Table 18. Alt-C Schedule Alteration Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | MTO 1 | MTO 5 | MTO 8 | MTO 9 | MTO 10 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Subzone 1, Teklan > 3 vehicles** | 0.63 | 0.53 | 0.40 | 0.37 | 0.24 | 0.37 | 15.00 |
| **Subzone 1, Teklan > 4 vehicles** | 0.05 | 0.04 | 0.06 | 0.02 | 0.03 | 0.02 | 5.00 |
| **Subzone 2, Toklat > 2 vehicles** | 10.16 | 9.26 | 8.72 | 8.50 | 8.57 | 9.32 | 15.00 |
| **Subzone 2, Toklat > 3 vehicles** | 4.65 | 3.14 | 3.24 | 3.16 | 3.44 | 3.67 | 5.00 |
| **Subzone 2, Stoney > 2 vehicles** | 4.83 | 4.35 | 4.23 | 4.58 | 4.53 | 4.24 | 15.00 |
| **Subzone 2, Stoney > 3 vehicles** | 1.21 | 1.24 | 0.82 | 1.20 | 1.18 | 1.07 | 5.00 |
| **Subzone 3, Grassy > 1 vehicles** | 2.50 | 2.54 | 2.63 | 2.32 | 2.32 | 2.38 | 15.00 |
| **Subzone 3, Grassy > 2 vehicles** | 0.43 | 0.40 | 0.44 | 0.46 | 0.51 | 0.42 | 5.00 |

**Table 19: Alt-C Schedule Alteration Rest Stop Crowding Standard Violations**

| Reststop Area Crowding Standards | BASE | MTO 1 | MTO 5 | MTO 8 | MTO 9 | MTO 10 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Teklanika > 12 buses** | ***0.09** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Toklat > 11 buses** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Eielson > 10 buses** | ***0.06** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 20: Alt-C Schedule Alteration Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | MTO 1 | MTO 5 | MTO 8 | MTO 9 | MTO 10 | Std Viol Level |
|---|---|---|---|---|---|---|---|
| **Mile 21.6** | ***0.89** | ***0.88** | ***0.89** | ***0.89** | 0.93 | ***0.91** | 0.95 |
| **SD Mile 21.6** | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | |
| **Mile 37.6** | 0.96 | 0.95 | 0.98 | 0.97 | 0.98 | 0.98 | 0.95 |
| **SD Mile 37.6** | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | |
| **Mile 52.8** | 0.97 | 0.96 | 0.98 | 0.98 | 0.97 | 0.96 | 0.95 |
| **SD Mile 52.8** | 0.03 | 0.04 | 0.04 | 0.02 | 0.03 | 0.04 | |
| **Mile 60.6** | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.95 |
| **SD Mile 60.6** | 0.04 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | |
| **Mile 68.5** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.95 |
| **SD Mile 68.5** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |

## 4.4 Private Vehicle Access Reduction

An important aspect of the alternative transportation systems is to improve public access to the Teklanika campgrounds with bus service in place of issuing private vehicle permits for campers destined for the Teklanika campgrounds as currently done with the current system. The shuttle service routes turn-around at the Teklanika rest area. Park managers wished to gain an understanding of how the potential elimination of the private vehicle trips to this destination might affect the set standards. Experiments with the traffic simulation model to test this affect are described next.

### *4.4.1 Description of modeled private vehicle trip reductions*

In order to test the impact on reduction of private trips to the Teklanika campgrounds, private vehicle round trips were reduced from the simulation model. The present model does not actually contain private trip destinations to Teklanika. Instead, private vehicle trips originate or pass at destinations beyond Teklanika (East fork, Eielson, the lodges, and Wonderlake/Kanishna). The savage check station logs on the particular day that was simulated indicated that 14 private camper vehicles were destined for Teklanika. It was then assumed that the campground was at capacity and therefore 14 private vehicles would exit the park during the same day to make room for the new campers. The effect of this reduction within the first subzone was then approximated by reducing an average of 14 vehicle round trips (out of the original total of 57 private vehicle trips in the simulation) to the west end of the park. Specifically, 9 private vehicle round trips to Eielson plus another 5 round trips to the Camp Denali Lodges and Kantishna were removed from the model.

Comparative simulation runs were done with both alternative base schedules, as well as one of the mitigation schedules that showed significant improvements of standards violation levels. As with the other simulation studies, 10 replication experiments were executed to account for stochastic effects of the traffic model. Tables 21 through 26 summarize the results for the experiments. Note that the results for the other subzones are not presented because the private vehicle trip reduction directly affected these

subsections, which would not be the case if the private vehicle trips terminated instead at Teklanika – a destination within the first subzone boundary.

### *4.4.1 Results of modeled private vehicle trip reductions*

Due to the reduction in the round-trip vehicles, there were slightly fewer stops for wildlife within subzone 1. Most of the reduction occurred for wildlife bunch sizes less than 3 vehicles. The frequency of wildlife stops with bunch sizes of 3 or more vehicles did not change very much. Therefore, the standards violation rate increases slightly. An interesting effect of fewer vehicles stopping for wildlife is that the bus route impendence is reduced; the original departure headway spacing between buses will therefore tend to be preserved in particular at the beginning of their trips. The effect increased the traffic volume slightly at certain hours during the operational period, but more importantly reduced the frequency of large gap times at the mile 21.6 sheep crossing.

**Table 21. Alt-B Private Vehicle Trip Reduction Effect On Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | BASE – 14 car trips | NPS | NPS – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Subzone 1, > 3.0 vehicles** | 14.87 | 14.14 | 12.40 | 14.97 | 25.00 |
| **Subzone 1, > 4.0 vehicles** | 5.20 | 4.98 | 3.30 | 4.49 | 10.00 |
| **Subzone 1, > 5.0 vehicles** | 1.55 | 1.72 | 0.78 | 1.14 | 5.00 |

**Table 22. Alt-B Private Vehicle Trip Reduction Effect On Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | BASE – 14 car trips | NPS | NPS – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Subzone 1, Teklan > 3 vehicles** | 0.36 | 0.36 | 0.32 | 0.42 | 15.00 |
| **Subzone 1, Teklan > 4 vehicles** | 0.06 | 0.03 | 0.03 | 0.03 | 5.00 |

**Table 23. Alt-B Private Vehicle Trip Reduction Effect On Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | BASE – 14 car trips | NPS | NPS – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Mile 21.6** | ***0.88** | ***0.89** | 0.94 | ***0.92** | 0.95 |
| **SD Mile 21.6** | 0.06 | 0.06 | 0.05 | 0.03 | |

The base condition and a schedule EIS mitigation condition were compared by removing the same aforementioned private vehicle trips as Alterantive-B. The reduction of the vehicle trips

through subzone 1 for Alternative-C had little or no effect on the set standards. Similar to alternative B, There was no noticeable improvement to the sheep crossing gap time standards for either of these cases.

**Table 24. Alt-C Private Vehicle Trip Reduction Effect On Wildlife Encounter Crowding Standard Violations**

| Wildlife Stop Crowding Standards | BASE | Base – 14 car trips | MTO 9 | MTO 9 – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Subzone 1, > 3.0 vehicles** | 17.32 | 16.87 | 10.83 | 10.37 | 25.00 |
| **Subzone 1, > 4.0 vehicles** | 7.41 | 7.28 | 3.47 | 4.07 | 10.00 |
| **Subzone 1, > 5.0 vehicles** | 3.00 | 3.24 | 1.25 | 1.07 | 5.00 |

**Table 25. Alt-C Private Vehicle Trip Reduction Effect On Viewscape Crowding Standard Violations**

| Viewscape Crowding Standards | BASE | Base – 14 car trips | MTO 9 | MTO 9 – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Subzone 1, Teklan > 3 vehicles** | 0.63 | 0.61 | 0.24 | 0.26 | 15.00 |
| **Subzone 1, Teklan > 4 vehicles** | 0.05 | 0.07 | 0.03 | 0.00 | 5.00 |

**Table 26: Alt-C Private Vehicle Trip Reduction Effect On Sheep Crossing Standard Violations**

| Sheep Standard prob. Hourly > 10 min. gap | BASE | Base – 14 car trips | MTO 9 | MTO 9 – 14 car trips | Std Viol Level |
|---|---|---|---|---|---|
| **Mile 21.6** | ***0.89** | ***0.89** | 0.93 | **0.93** | 0.95 |
| **SD Mile 21.6** | 0.04 | 0.05 | 0.04 | 0.03 | |

To conclude, the reduction in round trips of private vehicles through the first subzone had little impact on reduction of standards violations. In particular, the improvement of the sheep crossing standard within the first subzone by eliminating a modest number of vehicles traveling through that section of roadway could not be substantiated by the model predictions. There are several observations of the current simulation model that likely contributed to results. The behavior of private vehicles dictated that they travel the road at slightly higher speeds than the buses. In addition, as mentioned previously, private vehicles have very short waiting times at wildlife stops, and none stop at the rest stop areas. Vehicles therefore can ‘catch up’ to buses and then follow relatively closely behind them (within about 300 meters). This ‘platooning’ effect continues until the buses either pull over for a designated stop or for wildlife, where the vehicles can then pass around the bus. The effect of these behaviors is that the > 10 minute gap times are not diminished very much since the headway gap times will be small (on the order of ½ minute).

# 4. Data Processing Tool

The purpose of building the stand-alone data processing tool, *RoadCap*, is to encapsulate the extensive post-processing of the traffic simulation output data into one singular package that can then be used by park managers to generate and manipulate the simulation output. As the proposed workplan for the task agreement articulated, the development and output refinement of the tool was done in conjunction with the evaluation process of the alternative transportation systems. A summary of the current data processing workflow to utilize the tool is provided below. The end of the section will summarize current limitations of the tool that could be addressed in future work to further improve the tool.

## 4.1 Workflow Description

The *RoadCap* Denali park road capacity evaluation program is a stand-alone windows XP/7 executable generated through the MATLAB compiler. The software requires the installation of several DLLs that comprise the MATLAB run-time environment, which is referenced by the executable. No software licensing is required to run tool.

### *4.1.1 RoadCap Inputs*

There are four ASCII text formatted input files that are needed by the tool to process all road capacity indicators and standards:

1. <Scenario Name>-output.txt – contains each vehicle trajectory (vehicle stops), an encoded reason for stopping, its operator type and route designation, the Alaska NAD83 Zone 5 State Plane x,y coordinates, the time stamp in HH:MM:SS, vehicle speed, and the calculated distance along the road. Both rest stops and stops at wildlife encounter behavior is extracted from this data.
2. <Scenario Name>-ViDens.txt – contains the maximum number of vehicles at one time for the given viewscapes, separated by defined vehicle types (for example, “car”, “VTS”, “Tour”, “Lodge” ).
3. <Scenario Name>-ShpCros.txt – contains sheep crossing detector trip times, and the vehicle type that tripped the detector.
4. <Scneario Name>-VEHICLE_TYPE_LUT.txt – contains a look-up table to match the vehicle type attribute generated by the traffic simulation software with pre-defined vehicle type attributes in the processing software.

In addition, five pre-formatted spreadsheet files are utilized. The first four are MicroSoft Excel formatted report generation template files that cannot be modified or removed:

1. output-.xlsx – spreadsheet template for wildlife stop crowding indicators and norms.

2. Reststops-.xlsx – spreadsheet template for rest stop crowding indicators and norms.

3. ShpCros-.xlsx – spreadsheet template for sheep crossing impact indicators and standards.

4. ViDens.xlsx – spreadsheet template for viewscape crowding indicators and norms.

5. NormsAndViolations.xlsx – an Microsoft Excel spreadsheet that defines standards for each indicator. The user can modify the table values in order to explore different standards.

The reports generated by *RoadCap* require template excel spreadsheets within a subdirectory, <Root Installation>/Denali_RoadTools/Templates/<Transportation System>. The templates should not be modified or deleted. Currently there are two transportation systems, "Alt-B", and "Alt-C". The user editable spreadsheet, NormsAndViolations.xlsx must reside in the same directory as *RoadCap* – e.g., <Root Installation>/Denali_RoadTools.

### *4.1.2 RoadCap Outputs*

The output of the software contain up to four separate Excel spreadsheet reports that summarize results for each of the three crowding indicators and standards and the sheep crossing indicators and standard. The final spreadsheet reports are stored in the current working directory. The contents of the reports are extensive but self-explanatory, and have been developed over several iterations and discussions with the Denali park staff.

### *4.1.3 Using RoadCap*

The installation consists of first running the MATLAB executable environment installer for windows, *MCRInstaller.exe*, which walks the user through a simple installation process. Then copy the folder, Denali_RoadTools and all of its contents to a desired root location. The executable *RoadCap*.exe is within this folder.

The tool is very straight forward to use, and 'walks' the user through a few steps to set up and complete the analysis. First, the user selects which transportation system is to be analyzed. Although the menu selection lists several transportation systems, only Alterative B and Alternative C have been tested at this time. Then, the user is prompted through the GUI to search and select the appropriate text file to optionally process (they are filtered according to the indicator). Canceling out of the selection of the file will force *RoadCap* to skip processing the associated indicator. This is useful when only specific indicators wished to be examined from the traffic simulation output.

The tool takes several minutes to run the calculations and generate the spreadsheet reports, depending on the number of repeated experiments executed for the given scenario, and number of reports generated. A DOS command shell console window opens and typically prints out

occasional messages and diagnostics during the processing the data that can be ignored. Future versions will have options to remove these messages altogether. The DOS command shell window closes when *RoadCap* terminates.

Standards and acceptable violation levels can be changed by editing the tables in the aforementioned spreadsheet, NormsAndViolations.xlsx. The location and size of the formatted tables in the spreadsheet, and the worksheet names must not be modified.

#### *4.1.3.1 generating vehicle LUT tables*

The vehicle type attribute information is referenced differently for each constructed traffic microsimulation scenario. In order to 're-map' the reference to a consistent convention that is used for output processing, a utility program, *VehicleLUT.exe*, needs to be executed once for each simulation scenario. The output of the program generates the small text stub file, with the form: <Scenario Name>-VEHICLE_TYPE_LUT.txt. Future versions will automate this step within *RoadCap*. to further simplify and streamline the processing of the traffic microsimulation output.

## 4.2 Limitations

A worksheet within each of the generated reports, "Comparison Data" , is 'hard-coded' to reflect the current EIS standards for the two alternatives, Alt-B and Alt-C.

The tool has only been tested and designed to reflect current EIS standards for the two transportation alternatives, Alt-B and Alt-C. The number of road sections and their respective lengths cannot be variably defined by the user. The last named worksheet, "Comparison Data", in the reports is 'hardcoded' to the current EIS set standards for either alternative. Lastly, only one scenario can be selected and then processed at a time. It is not possible to 'batch' process for example a full directory containing sequential scenario results. Furthermore, the user must ensure that the selected simulation output files to be processed correspond to the same given scenario. A more generalized approach to address these limitations to further improve the use and flexibility of the tool could be developed as part of future work for later phases of the task agreement, with appropriate guidance by Denali park management staff.

# 5. Conclusions

The traffic simulation model that was developed in a previous task agreement was modified in order to forecast impacts on crowding and sensitive wildlife – Dall's sheep – for three hypothesized transportation alternatives. Extensive simulation tests for two of the three alternatives were done to determine if either of them would exceed or be within set standards that define road capacity. Most of the logistics and trip behaviors for vehicles were retained for the current model, with specific modifications formulated with guidance from the park staff. None of the simulations definitely produced outcomes that were clearly below all the acceptable standards defined by the EIS, although the level of violations for those indicators that exceeded the standards was not, in this author's opinion, substantial.

Interestingly, the model predicted that the relationship between the critical gap crossing time ( > 10 minutes ) and traffic volumes for the known sheep crossing locations was similar to the previous transportation system analyzed (about 13 to 14 VPH). However, a possible correspondence between less crowding at wildlife stops and improved sheep crossing opportunities (as defined by the > 10 minute standard) that was observed in the previous transportation system was not clearly observed for the proposed alternative transportation systems (Morris et. al, 2010). Such a relationship would have been useful criteria to modify the departure schedules for any of the alterative systems. One possible reason for this is that the subdivisions of the park road set forth in the EIS specifications are too course to observe such a relationship between the two standards.

There are several limitations of the alternative transportation systems simulation models. An important consideration is the fact that essentially the same day derived from a previous existing system and 'peak day', was assumed to be the 'typical day' for these systems. In fact, the wildlife encounters may have interdependence on the transportation system being operated; the drivers themselves might change their behaviors to adapt to the proposed alternatives, thereby the modeled wait times (and even driving speeds) may not be appropriate for these alternatives. Private vehicles do not stop at any of the rest stop areas in the simulation and are therefore not considered in the standards violations predicted by the model. Lastly, the modified schedules summarized are likely not the 'optimal' ones; there is no reason to conclude that 'better' schedules do not exist that would further reduce the level of violations for the EIS standards. To address more robust searches, requires the development of an iterative automated search method, which is beyond the scope of the present cooperative task agreement.

# References

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