National Park Service
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Yellowstone National Park

TRANSPORTATION AND VEHICLE MOBILITY STUDY

Phase 2

TRAFFIC AND PARKING ANALYSIS

FINAL
JULY 2018

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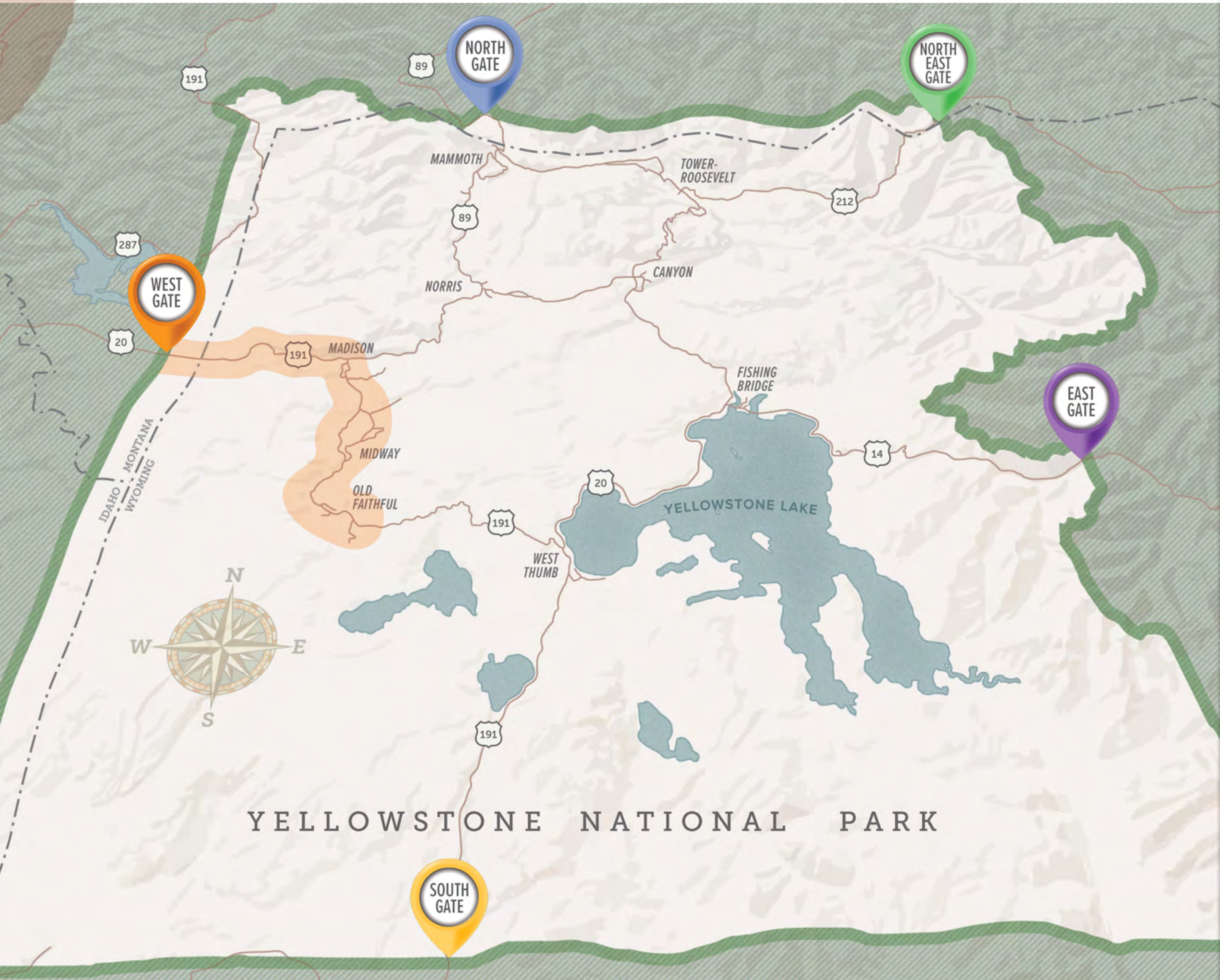
In June 2017, a study titled Transportation and Vehicle Mobility Study – Data Collection and Analysis was completed to better understand the parking and traffic conditions at Yellowstone National Park (YNP). That 2017 study serves as a foundation for this second phase of study. For further information on the purpose, background, approach, and analysis methodologies, please refer to the June 2017 study. The June 2017 study indicated that the roadway corridor, intersections, and key parking areas that experienced the most congestion in the YNP were those located between the West Entrance Gate and Old Faithful. For this reason, this Phase 2 study was completed to collect more robust data, create a model for parking utilization at key parking lots, and provide detailed analysis of the traffic flow and capacity along the study corridor to understand possible strategies to improve the traffic flow along the corridor and key parking areas between West Gate and Old Faithful.

FIGURE 1.



WEST GATE TO OLD FAITHFUL— EXISTING CONDITIONS

INTRODUCTION

The project study area spans along US-191 from the West Gate to Madison Junction and along Grand Loop Road from Madison Junction to the Old Faithful interchange as shown in Figure 1. Almost the entire corridor is a two-lane, 45 miles per hour rural road 35 mile per hour sections near intersections. The corridor has occasional pullouts to allow for vehicles to pull off to the side of the road for recreation, sight-seeing, and to allow others vehicles to pass.

PURPOSE

Existing and newly collected data was used to document existing transportation and visitor use conditions along the corridor between West Gate and Old Faithful. The additional data was gathered to build upon the data collected in summer 2017 to understand in more detail how this key corridor functions and more accurately assess the impacts due to entrance gate operations, pull-outs, wildlife viewing, geyser eruptions, and side friction from congested areas.

DATA COLLECTION

The project team collected vehicle travel times, intersection turning movement counts, parking lot occupancy counts, west entrance processing data, and vehicle classification data during July and September of 2017. Pneumatic tube data collected in August 2016 was also used to further classify vehicles in the park.

EXISTING VEHICLE CONDITIONS

Existing transportation conditions along the West Gate to Old Faithful corridor was documented and built upon data previously collected in summer 2017. The NPS provided all current traffic counter data for counters already deployed and in-use in YNP. The following data was collected:

- Travel times within the corridor
- Vehicle turning movement data
- Additional parking lot counts
- West Gate performance analysis
- Distributions of cars vs buses vs recreational vehicles.

TRAVEL TIMES WITHIN THE CORRIDOR

Travel time runs were performed from the West Gate to Old Faithful on July 23rd-25th and September 3rd-5th, 2017. In total, 12 runs were performed in the northbound direction (from Old Faithful to the West Gate) and 16 runs were performed in the southbound direction (from the West Gate to Old Faithful) in order to establish an average speed and travel time. Table 1 outlines the results of the travel time runs.

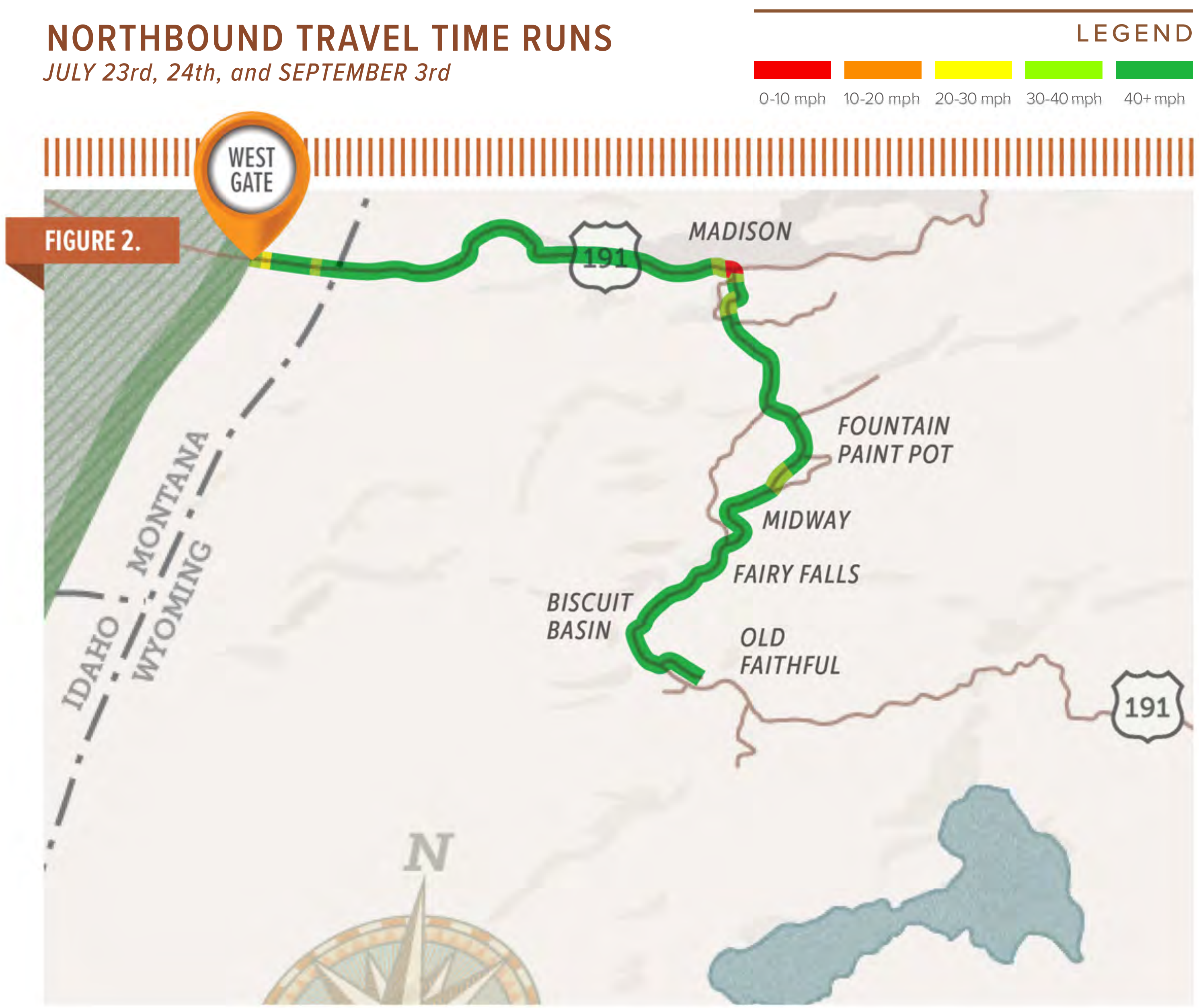
TABLE 1.
TRAVEL TIME RUN RESULTS (HOURS:MINUTES:SECONDS)

	WEST ENTRANCE – MADISON JCT.		MADISON JCT. – OLD FAITHFUL		WEST ENTRANCE – OLD FAITHFUL	
	NORTHBOUND	SOUTHBOUND	NORTHBOUND	SOUTHBOUND	NORTHBOUND	SOUTHBOUND
AVERAGE	0:17:50	0:23:05	0:23:29	0:26:48	0:41:19	0:49:53
MEDIAN	0:17:35	0:19:54	0:23:34	0:26:20	0:40:36	0:45:16
MINIMUM	0:16:43	0:18:08	0:21:26	0:24:18	0:39:01	0:42:28
MAXIMUM	0:19:27	0:39:50	0:26:55	0:32:23	0:45:46	1:09:35
STANDARD DEVIATION	0:00:51	0:06:53	0:01:35	0:02:47	0:02:07	0:08:19
WILDLIFE JAM	0:19:27	0:39:50	0:23:34	0:29:46	0:43:03	1:09:35

The table shows that during the study, the northbound travel time in the study peak period from Old Faithful to the West Gate was much quicker and more consistent than the southbound travel time from the West Gate to Old Faithful. Much of the delay during the travel time runs was due to traffic slowdowns near major parking lots and pullouts. Figure 2 and Figure 4 show the average northbound and southbound travel speed during each of the travel time runs on July 23rd, July 24th, and September 3rd. It should be noted that the July 25th runs were excluded from these averages, because wildlife viewing near the road created a significant traffic jam along the West Entrance road. The travel speed in both the northbound and southbound directions for the wildlife jam during those runs are shown in Figure 3 and Figure 5, respectively.

NORTHBOUND TRAVEL TIME RUNS

JULY 23rd, 24th, and SEPTEMBER 3rd



NORTHBOUND TRAVEL TIME RUNS

JULY 25th (Wildlife Jam)

The wildlife jam figures are based on a single run each. Because of this, any stops along the run become more apparent. The delay at Fairy Falls was caused by a wildlife jam in this area. The delay in the Midway area was caused by congestion associated with general traffic congestion due to on-street parking maneuvers, pedestrians activity along the roadside.

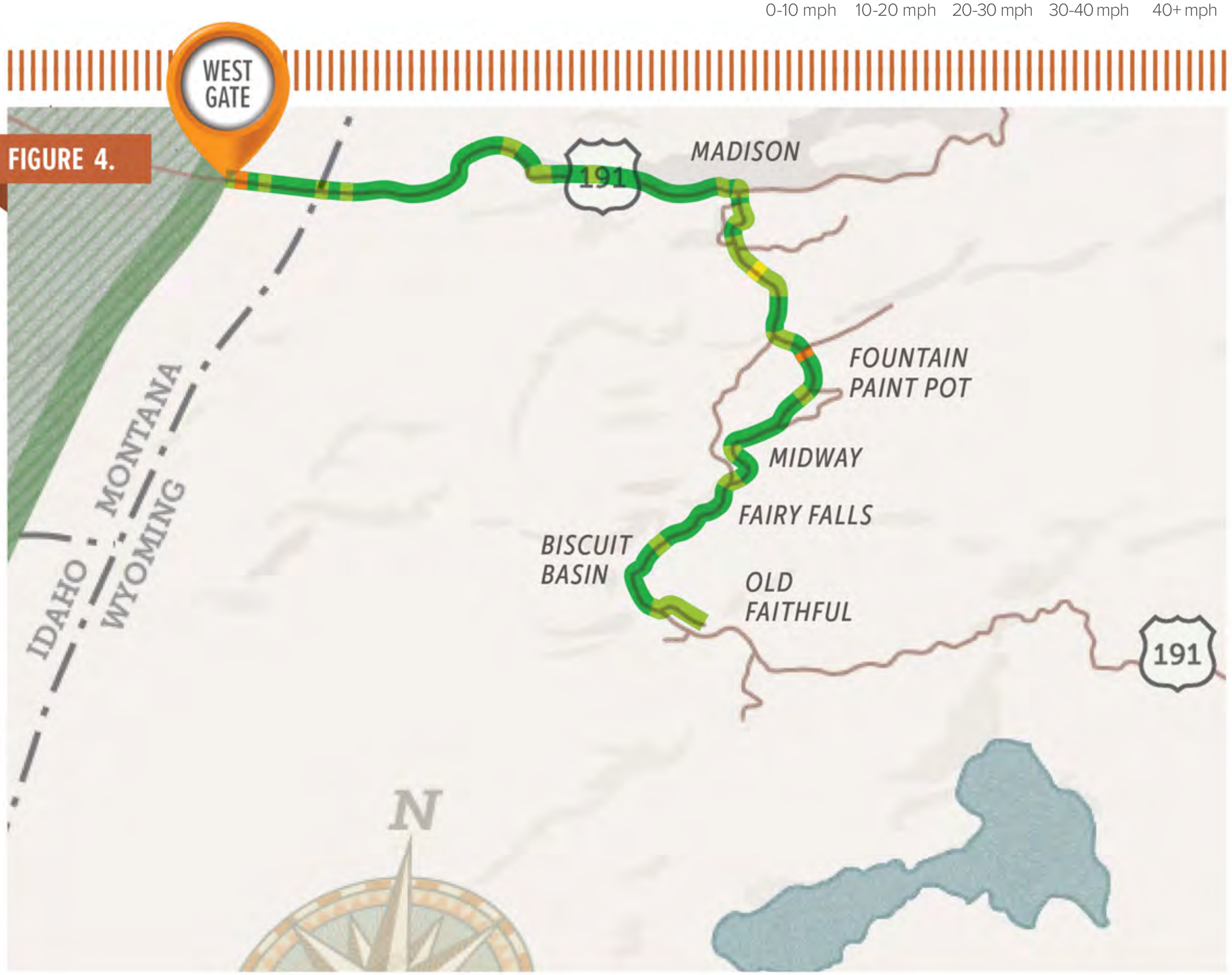
SOUTHBOUND TRAVEL TIME RUNS

JULY 23rd, 24th, and SEPTEMBER 3rd

LEGEND

0-10 mph | 10-20 mph | 20-30 mph | 30-40 mph | 40+ mph

FIGURE 4.



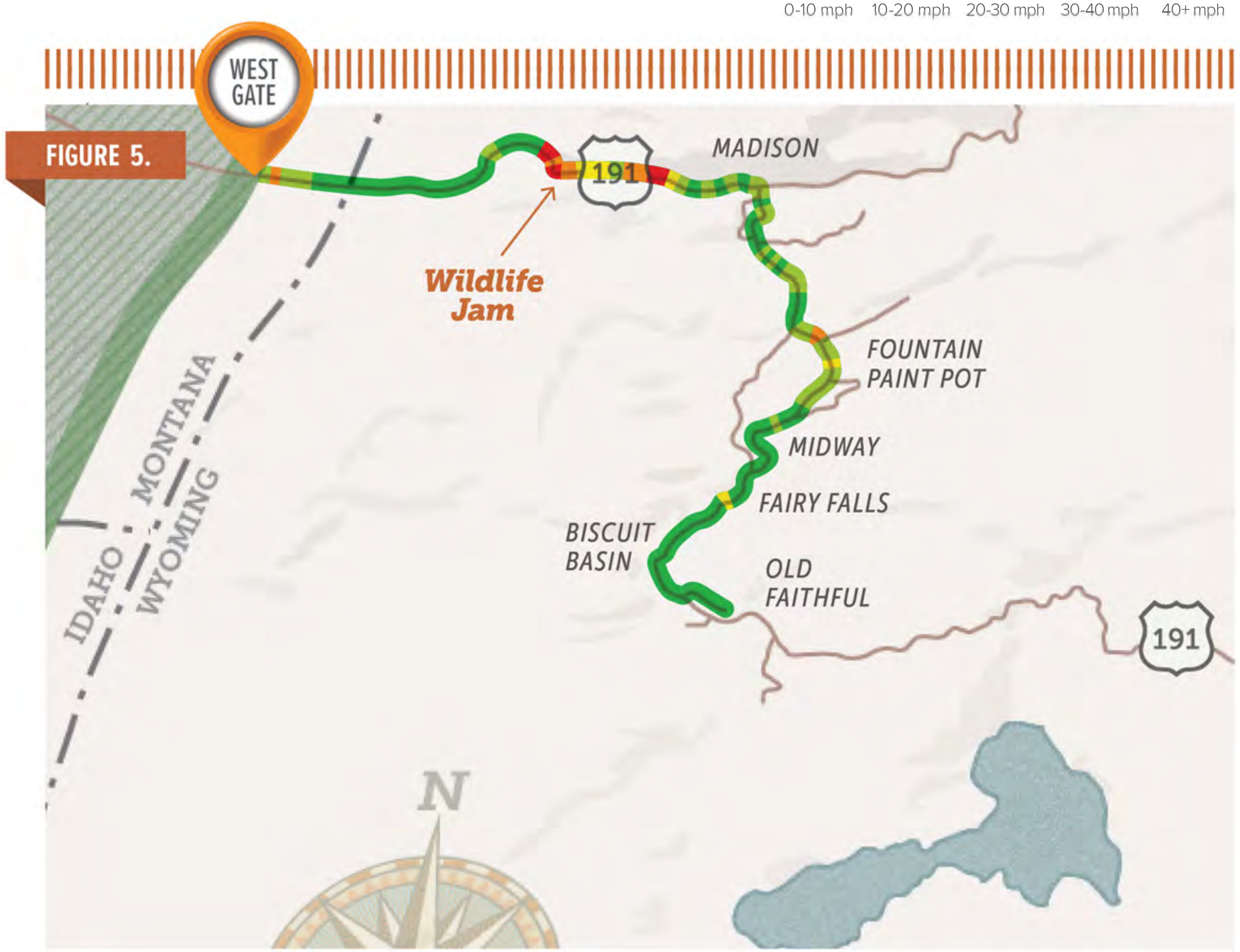
SOUTHBOUND TRAVEL TIME RUNS

JULY 25th (Wildlife Jam)

LEGEND

0-10 mph | 10-20 mph | 20-30 mph | 30-40 mph | 40+ mph

FIGURE 5.



The wildlife jam figures are based on a single run each. Because of this, any stops along the run become more apparent. The delay along West Entrance Road was caused by several animal crossings.

VEHICLE TURNING MOVEMENT DATA

Intersection turning movement counts were collected on July 23rd-25th and September 3rd-5th, 2017 using both manual and video counting methods. The counts were performed along the study corridor at the following intersections:

- Madison Junction
- The Madison Info Center parking lot,
- Both entrances to the Fountain Paint Pot parking lot,
- The Midway Geyser parking lot,
- Both entrances to the Fairy Falls parking lot,
- The Biscuit Basin parking lot.

Figure 6 shows the traffic volumes that were counted at each intersection during the study. Madison Junction was counted as part of the 2016 Phase 1 study as well. Overall, about 15% fewer traffic volumes were counted during this study. However, the major eastbound movements were only 6% less than counted during the previous study. For reference, it is common for traffic volumes to fluctuate about 10% up or down on any given day during the same peak hour.

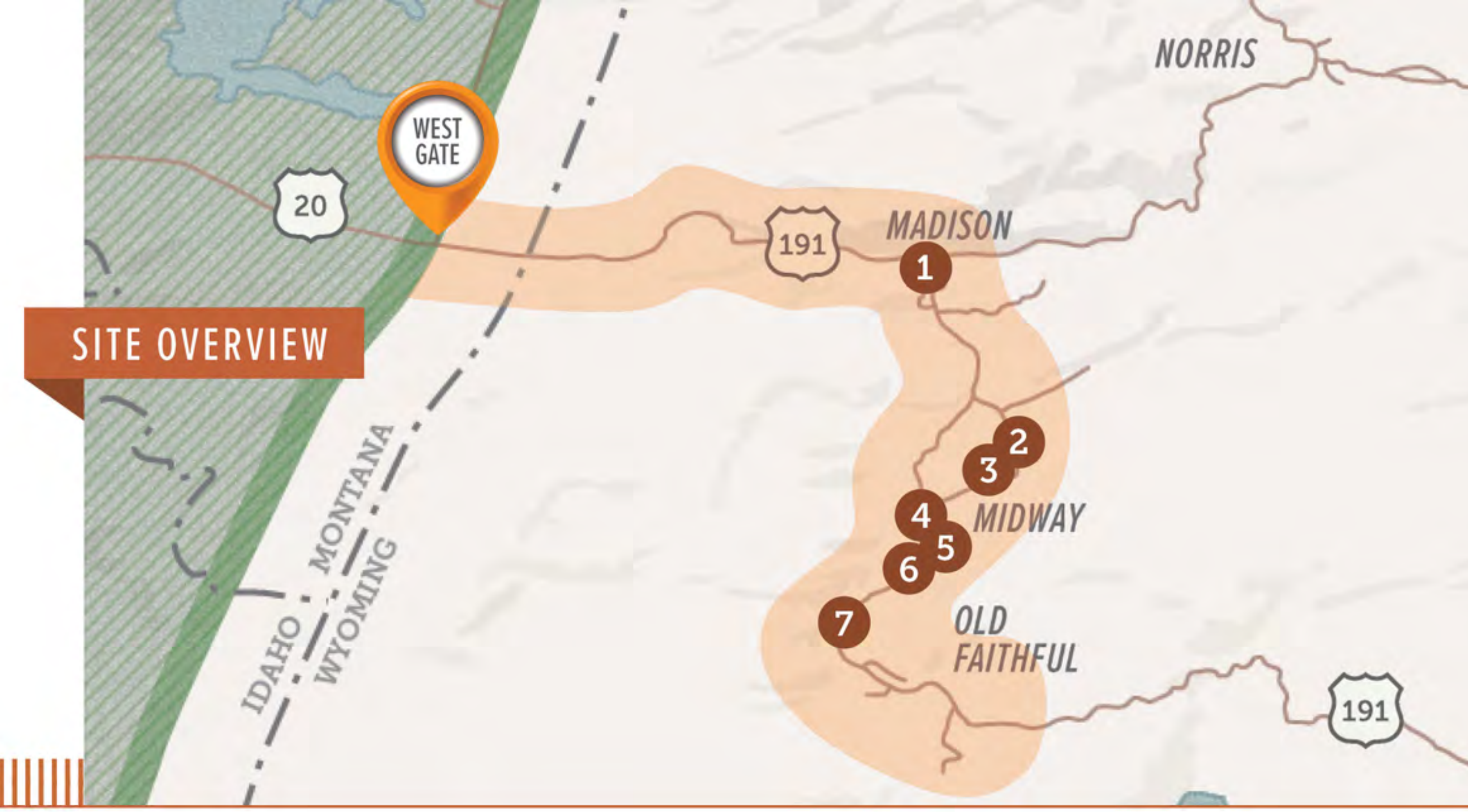
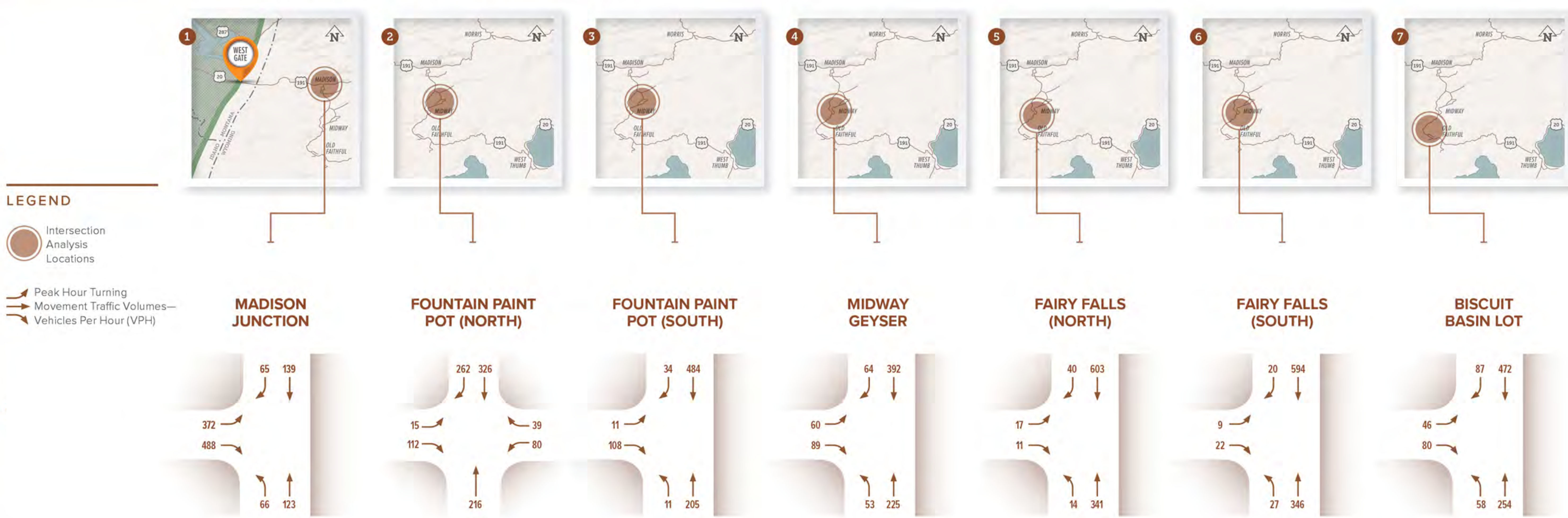


FIGURE 6.

INTERSECTION TURNING MOVEMENT COUNTS



PARKING LOT COUNTS

Parking occupancy counts were performed by YNP staff at the following areas: Fairy Falls, Midway Geyser, Old Faithful-East, Old Faithful-Central, Old Faithful-Inn, Old Faithful-Store, Norris Geyser, Canyon Visitor Center, North Rim, Upper Falls, and South Rim (Wapiti Lake and Artist Point).

The counts were performed at least once a week from the week of May 22, 2017 to the week of September 25, 2017 during peak perking periods (11:00 AM – 3:00 PM depending on the location). All counts were performed on a weekday between Monday and Thursday.

WEST GATE PERFORMANCE ANALYSIS

An analysis of the West Gate was performed on September 3rd. The analysis included a count of the number of vehicles that passed through each lane during each minute from 8:45 AM to 11:00 AM. The peak hour varied from lane to lane, but the overall peak processing period occurred during the 9:45-10:44 AM on that day. Table 2 shows a summary of the gate entrance results from that day with the overall peak hour from 9:45-10:44 AM emphasized in bold text. The lanes are numbered from south to north, with Lane 1 being the southernmost lane (Express Lane) and Lane 4 being the northernmost lane at the entrance gate.

TABLE 2. WEST GATE PROCESSING SUMMARY

TIME PERIOD	LANE 1 (EXPRESS)	LANE 2	LANE 3	LANE 4	TOTAL VOLUME
8:45-9:44 AM	342	150	87	91	670
9:00-9:59 AM	390	156	93	95	734
9:15-10:14 AM	428	145	95	101	769
9:30-10:29 AM	457	122	100	90	769
9:45-10:44 AM	482	105	99	99	785
10:00-10:59 AM	432	98	89	93	712

CLASSIFICATION OF VEHICLE TYPES

Using a combination of the pneumatic tube data collected in August 2016, and the gate processing data collected in September 2017, the classification of vehicle types was analyzed. Table 3 shows the vehicle classification throughout the park using the Federal Highway Administration (FHWA) vehicle classification categories.

TABLE 3. VEHICLE TYPE DISTRIBUTION

FHWA CLASS	DESCRIPTION	PERCENTAGE OF TOTAL DSITRIBUTION
Class 1	Motorcycles	4.3%
Class 2	Passenger Cars (Including Light Trailers)	56.8%
Class 3	SUVs, Vans, Pickup Trucks	26.5%
Class 4	Buses	1.3%
Class 5 & 6	Light Trucks (2-3 axles)	5.9%
Class 5 & 6	RVs and Campers	3.4%
Class 7-13	Heavy Trucks (4 or more axles)	1.8%

Source for FHWA Class: FHWA's Traffic Monitoring Guide, Appendix C (2014)

Because automatic vehicle classifiers have difficulty distinguishing RVs and Campers from other Single-Unit Trucks with two-three axles, and RVs and Campers are usually included in Vehicle Category Classification 5 and 6, but have been separated in this study due to the recreational nature of the park. As is shown in the table, tour buses and RVs, together, account for about 4.7% of the vehicle distribution in the park; about 1-in-21 vehicles in the park is a bus or an RV.

PARKING UTILIZATION

PURPOSE

This chapter summarizes the parking data collection, analysis methodology, and the analysis results to determine what the parking threshold is and when (season/month and seasonal duration) the key parking lots and roadways reach their capacity within YNP. The goal of this analysis is to understand the correlation of YNP visitor numbers (in terms of vehicles) to parking capacity.

The following parking areas are included in the parking study: Fairy Falls, Midway Geyser, Old Faithful-East, Old Faithful-Central, Old Faithful-Inn, Old Faithful-Store, Norris Geyser, Canyon Visitor Center, North Rim, Upper Falls, and South Rim (Wapiti Lake and Artist Point). Uncle Tom was closed to the public for construction during the study and therefore was not included in the analysis.

PARKING OCCUPANCY DATA COLLECTION & PROTOCOL

As stated in the previous chapter, the parking occupancy counts were performed by counting the number of parked vehicles in each parking lot. When the parking lots were full and if there was a standing queue of cars waiting for a free space, the number of cars in the standing queue were also counted (this was especially important for Midway Geyser, Norris Geyser, and North Rim). All vehicles parked in marked (designated) and non-marked (undesignated) spaces, landscaped areas, or any other non-authorized locations were counted. If present, vehicles parked on the Grand Loop Road were also counted at the key areas, especially at Midway Geyser and Norris Geyser. Old Faithful counts occurred between 60 minutes before an eruption up to the actual eruption time and not during the 30 minute period after an eruption.

All parking counts were performed by YNP staff at least once a week from the week of May 22, 2017 to the week of September 25, 2017. The exact day wasn't required to be consistent, but rather, all counts were performed on a weekday between Monday and Thursday. Usually, parking areas were counted on the same day each week; however, when it proved difficult to collect all the counts in the given time period on a single day, counts done on subsequent days was permitted. During those weeks, the following were grouped together on the same day:

- Old Faithful and Midway Geyser
- Norris Geyser, Canyon Village, North Rim, South Rim, and Brink of the Upper Falls

The counts occurred between the following time periods for each location. The counts were performed during times that were determined to be peak times of the day through the Transportation & Vehicle Mobility Analysis Phase 1 work performed in 2016:

- **Old Faithful:** 12:00pm - 3:00pm
- **Midway Geyser:** 12:00pm - 3:00pm
- **Norris Geyser:** 11:00am - 3:00pm
- **Canyon Village:** 12:00pm - 2:00pm
- **North Rim:** 12:00pm - 3:00pm
- **South Rim:** 12:00pm - 3:00pm
- **Brink of the Upper Falls:** 12:00pm - 3:00pm

Entrance gate data and Automated Traffic Recorder (ATR) was provided by YNP for the parking data collection days. The ATRs (primarily for the West and South gates) would count the number of vehicles that entered into the park and passed a certain point on the respective roadways. Sales transaction recordings, also provided by YNP, were used to determine the number of vehicles entering through the North, Northeast and East gates. That included vehicles with annual passes and commercial tour bus groups.

Appendix A includes graphs that summarize the results of the parking counts to show how full each of the parking lots were throughout the summer season in 2017. As is shown in the appendix, most of the lots experienced several days where parking demand far exceeded available parking capacity which led to vehicles parking illegally or waiting in long queues for an available parking spot.

ANALYSIS METHODOLOGY

The parking lot counts were graphed on a scatter plot against the volume of vehicles that entered in through each gate. Two additional scatter plots were also created: one combining all of the lower and upper Geyser Basin area parking lots, and another of all of the lots in the Norris and Canyon (Norris-Canyon) area. Trendlines for each graph were calculated to show approximately when each area of the park fills up depending on the number of visitors that the Park receives.

The R-squared values of each trendline were also calculated to show how close the trendlines fit each set of data. The R-Squared values as defined in the Institute of Transportation Engineers (ITE) *Trip Generation Handbook, 3rd Edition,* are "the percent of variance in the number of trips associated with the variance in the independent variable value. For example if the R-squared value is 0.75, then 75% of the variance in the number of trips is accounted for by the independent variable value. As the R-Square value increases toward 1.0, the better the fit; as R-squared value decreases to 0, the worse the fit." In the instance of this study, the same definition applies; the independent variable for this study is the number of inbound visitor vehicles to all YNP entrances, and the dependent variable is the percent occupancy for each parking lot.

ANALYSIS RESULTS

Figure 7 and Figure 8 show the results of the studies in the Geyser Basin area parking lots and the Norris-Canyon area parking lots, respectively. Each of the points on the figures represent an individual parking lot count during the peak period. The vertical axis shows how full the parking lots were (parking occupancy) for the different study areas during those counts, and the horizontal axis represents to total number of vehicles that entered into the park during the same day that the parking count was performed.

As stated in *The Dimensions of Parking, 5th Edition* (Urban Land Institute, 2010), "The level of occupancy at which optimum efficiency is achieved varies; generally, however, a parking facility operates most efficiently when occupancy is somewhere between 85 and 95 percent." For YNP, a target parking occupancy of 90% was used to define the "effective" capacity of a parking supply on a typical peak day. Therefore, any parking lot with occupancies over 90% are considered "over-capacity". The solid horizontal line shown in the figures illustrates the 90% capacity mark.

The trendlines in Figure 7 shows that the Geyser Basin area exceeds parking capacity after approximately 9,300 vehicles have entered the park. Figure 8 shows that the Norris-Canyon area exceeds capacity after approximately 10,600 vehicles have entered the park. Similar figures for the each individual parking area is shown in the appendix.

The R-squared values of the Geyser Basin area trendline is 0.91 indicating approximately a 91% confidence that the parking in that area will match the results of the trendline. In other words, the parking can be predicted based on gate volumes with approximately 91% confidence. The Norris-Canyon area has an R-squared value of 0.86 indicating approximately an 86% confidence that the parking in that area will match the results of the trendline.

It should be noted that the figures for Geyser Basin and Norris-Canyon areas are based on a distributed load of parking. In other words, this assumes that the parking volumes are spread evenly across all the lots to 90% parking utilization. That is, the capacity and occupancy of Geyser Basin includes the capacity of the Fairy Falls, Midway Geyser, and Old Faithful lots. The Norris-Canyon area includes the Norris, Canyon, North Rim, Upper Falls, and South Rim lots.

FIGURE 7. GEYSER BASIN PARKING OCCUPANCY

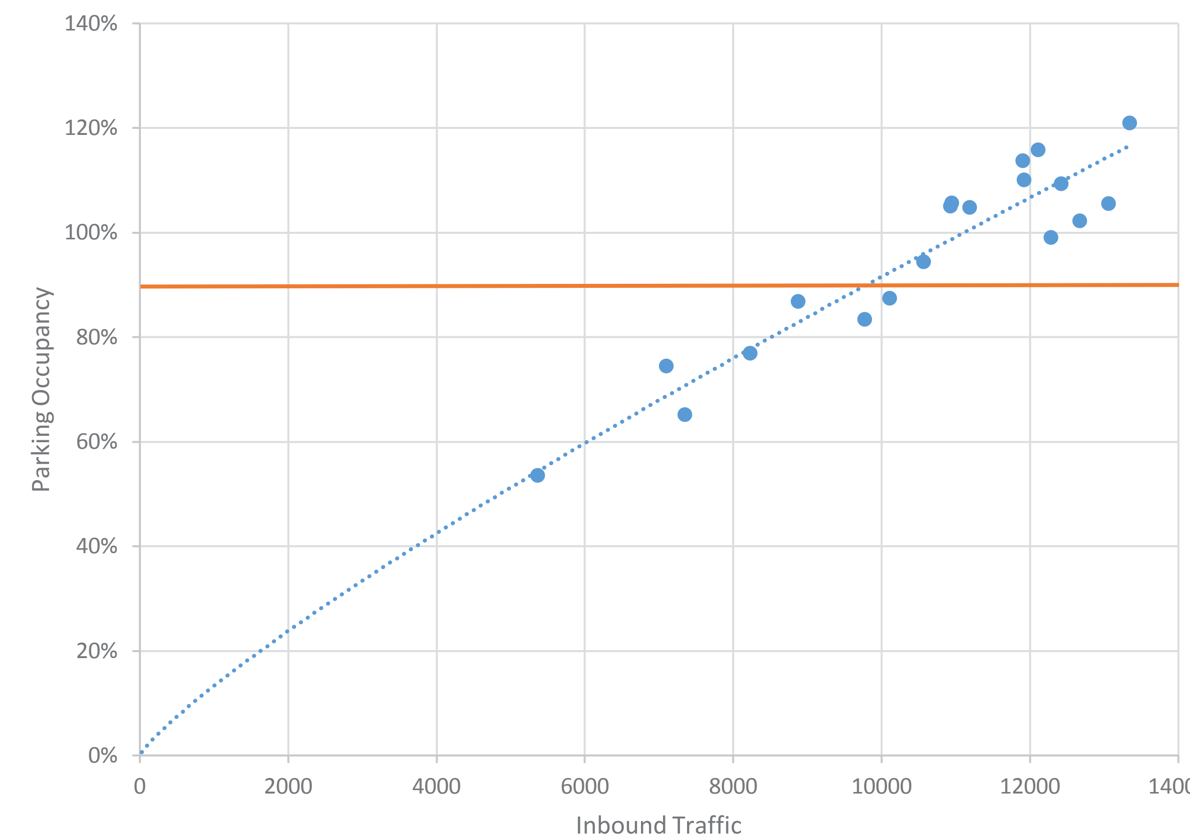


Table 4 and Table 5 show the results of applying the trendlines to the volume of all vehicles entering YNP through all five gates throughout the length of the study in order to approximate the times of the year that each lot will likely reach capacity. The tables show the distributed results of the Geyser Basin and Norris Canyon areas as well as capacities and occupancies from each respective lots. For example, based on the results of the parking study, the overall Geyser Basin area is likely to regularly reach parking capacity from the second week of June and the second week of September. However, the Old Faithful Inn parking lot is likely to be full from the last week of May to the fourth week of September. These results from the Geyser Basin area are different from the Old Faithful Inn because different areas within the Geyser Basin reach capacity before other areas; while the Old Faithfull Inn lot may reach capacity in early June, there may still be capacity available in other areas in the Geyser Basin area.

For the majority of the areas studied, the parking lots reached 90% occupancy between mid-June and mid-September, with some exceptions. The following three parking lots were at or above capacity during each count throughout the entire study: Midway Geyser, Norris Geyser, and the North Rim. Three other lots also never reached capacity in any of the counts but would theoretically reach capacity assuming an increase in visitors: Old Faithful Store, Canyon Visitor Center, and Upper Falls.

FIGURE 8. NORRIS-CANYON PARKING OCCUPANCY

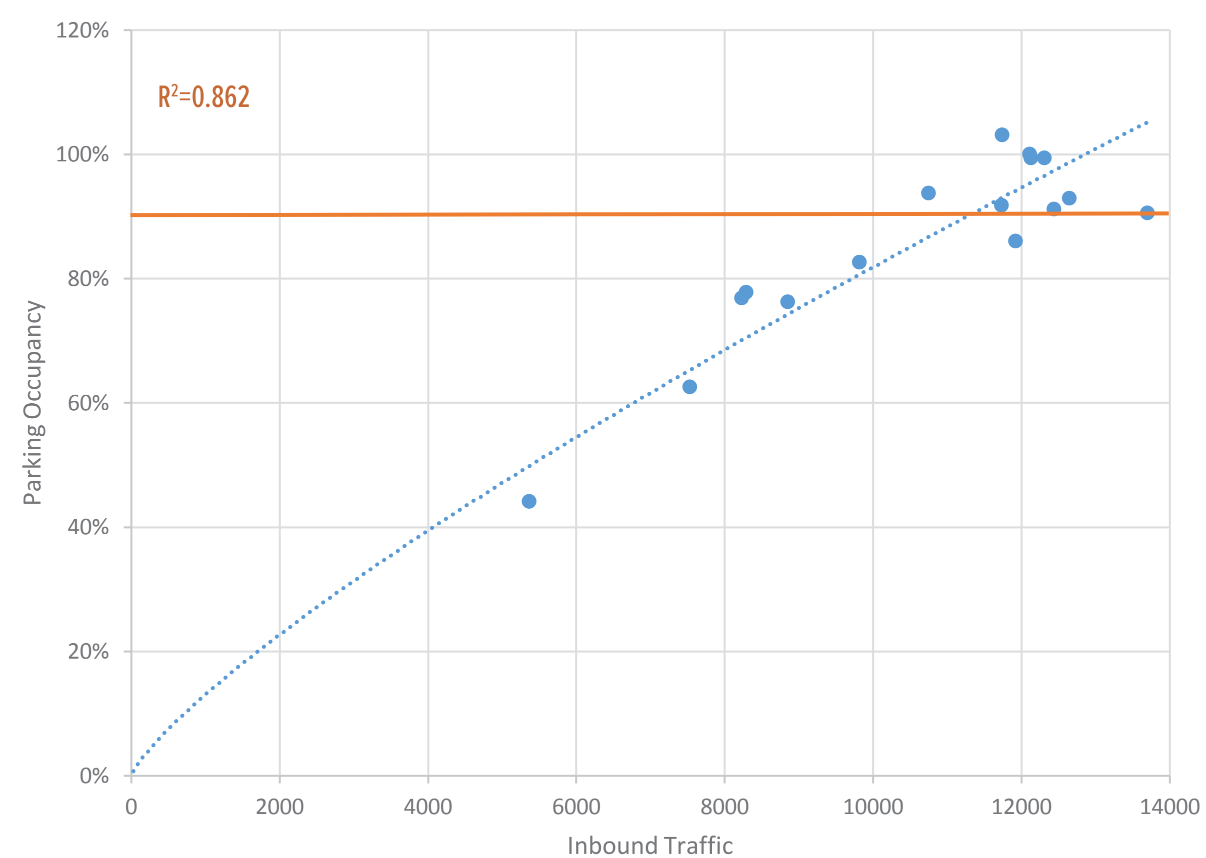


TABLE 4. GEYSER BASIN RESULTS

LOT NAME	ENTERING VEHICLES THRESHOLD[1]	PARKING REACHES CAPACITY	
		FIRST WEEK	LAST WEEK
GEYSER BASIN	9,300	Second week in June	Second week in September
Fairy Falls	7,000	Not Available[2]	Second week in September
Midway	200	Always Full[3]	Always Full[3]
OF East	8,600	First week in June	Second week in September
OF Central	10,600	Last week in June	Last week in August
OF Inn	7,000	Last week in May	Last week in September
OF Store	17,600	Never Full[4]	Never Full[4]

1. *Entering Vehicle Threshold is equal to the number of vehicles that would need to enter the park to have each location fill to exactly 90% according to the line of best fit for each area. All numbers are rounded to the nearest 100.*
2. *The Fairy Falls parking lot was not finished being built until midway through the summer, so an accurate "start week" cannot be provided for this lot.*
3. *Midway Geyser lot was full during every week of the study. Counts performed earlier and later in the year would be needed to find the approximate start and end weeks.*
4. *The lot at the Old Faithful Store never reached capacity in any of the days that were counted.*

TABLE 5. NORRIS-CANYON RESULTS

LOT NAME	ENTERING VEHICLES THRESHOLD[1]	PARKING REACHES CAPACITY	
		FIRST WEEK	LAST WEEK
NORRIS - CANYON	10,600	Last week in June	Last week in August
Norris	6,900	Always Full[3]	Always Full[3]
Canyon	13,400	Never Full[4]	Never Full[4]
North Rim	6,200	Always Full[3]	Always Full[3]
Upper Falls	18,300	Never Full[4]	Never Full[4]
Wapiti Lake5	12,700	Last week in August	Last week in August
Artist Point	8,400	First week in June	Second week in September

1. *Entering Vehicle Threshold is equal to the number of vehicles that would need to enter the park to have each location fill to exactly 90% according to the line of best fit for each area. All numbers are rounded to the nearest 100.*
2. *Norris and North Rim lots were full during every week of the study. Counts performed earlier and later in the year would be needed to find the approximate start and end weeks.*
3. *The lot at the Canyon visitor center and Upper Falls never reached capacity in any of the days that were counted.*
4. *Wapiti Lake only reached capacity in this model during one week, likely due to the heavy influx of vehicles from the Great American Eclipse event.*

TRAFFIC ANALYSIS

INTRODUCTION

Based on the data collected and shown in the existing conditions chapter and the analysis results shown in this chapter, Madison Junction operates at an unacceptable LOS for 2 hours of the day during the 10 busiest days of the season. In other words, during 5% of the 200 day season at YNP, Madison Junction fails for 13% of the 15 hours that visitors are most active in the park. While this may seem insignificant, the park has historically experienced an increase of approximately 5% more visitors each year. Assuming the growth rate continues, the park is likely to experience failing LOS more regularly. By the year 2025, Madison Junction is anticipated to exceed operational capacity for 11 hours (73% of the day) of more than 98 days (49% of the season). In consultation with the NPS, three scenarios of potential strategies were selected and analyzed using traffic simulation software to determine the efficacy of the potential strategies to improve transportation system performance in the study area.

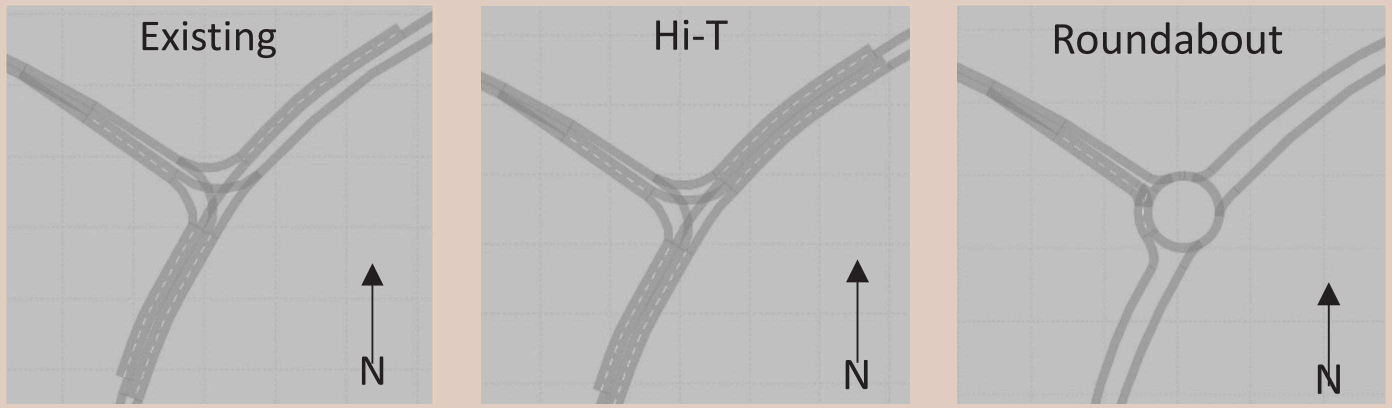
ANALYSIS APPROACH

The traffic analysis was completed using the microsimulation software platform PTV VISSIM to replicate existing conditions using traffic simulation and then analyze three scenarios of potential mitigation strategies along the corridor from the West Yellowstone Entrance Gate to Madison Junction and from Madison Junction to the Old Faithful turn-off. The VISSIM tool was selected due to its ability to replicate the observed congestion on the corridor and its versatility in analyzing complex intersection configurations and gate operations. Microsimulation works by replicating individual vehicles on the corridor that traverse through the park. The model is able to directly measure metrics such as individual vehicle delay and travel time. For this analysis, a total of five simulation runs were completed using varying random seeds, which resulted in a data set that was then evaluated. The existing condition VISSIM model was calibrated to real-world conditions by modifying driver behavior parameters from their default values. This included adjustments to car following behavior and lane change behavior to better match the behaviors observed at the gate and along the corridor. The resulting volume throughput, travel time and observed queues were validated against measured and observed conditions on the corridor. The VISSIM model was also calibrated to within 98% of actual travel time runs performed in the field. Acceptable industry standards is to calibrate within 90% accuracy. By performing this calibration and validation step, the model is able to replicate alternative and future conditions. This report demonstrates the results of the analysis scenarios and what effects the scenarios have on the traffic operations on this corridor.

The existing conditions scenario was calibrated based on turning movement counts and queue lengths collected at key intersections along Grand Loop Road, measured travel times in both directions from the West Gate to Old Faithful, and the operations at the West Gate including number of vehicles processed in the peak period and peak queue length at each service window. Sensitivity testing was also performed to observe the corridor operations when volumes were decreased by 5% and 10% of existing volumes to determine the level of traffic volumes that would allow the study intersections to operate at acceptable conditions. For the description of level of service (LOS) criteria and general intersection and roadway analysis approach, please refer to the ANALYSIS AND APPROACH section of the Phase 1, June 2017 report. The worst peak hour (the time of day when queues, intersection LOS, and roadway LOS are at their worst) of the day was analyzed for all scenarios. The analyzed peak hour was from 11:00 AM-12:00 PM.

In consultation with National Park Service staff, the following scenarios were selected for analysis:

- **Baseline Scenario:** Included analyzing the existing network geometry with gradually reduced volumes to determine at what point each intersection would begin to operate at acceptable LOS. Included analyzing the existing network geometry with existing traffic volumes. The model aimed to replicate the peak hour that was counted. In other words, the number of vehicles that entered and exited the lots were analyzed as well as key pullout areas and key on-street parking areas (i.e. Midway Geyser). Anaylzing the pullout and on-street parking areas allowed the traffic model to simulate the affects of these on the traffic flow on the Grand Loop Road. This also included analyzing the existing network with a 5% and a 10% reduction in existing traffic volumes to determine at what point each intersection would begin to operate at an acceptable LOS. These are referred to throughout this text as the "Existing -5%" and "Existing -10%" scenarios.
- **SCENARIO 1 – Intersection Design Changes:** Included analyzing two proposed alternative configurations at Madison Junction: a roundabout and a Hi-T configuration. A Hi-T intersection allows the eastbound to northbound left-turning vehicles to wait for a gap in the southbound traffic only, enter an acceleration lane, and then merge into the northbound traffic. With the vehicles only needing to find gaps in the southbound traffic to safely make their left-turn movement, this decreases the delay that is typically experienced at a traditional intersection to make a two-stage movement. This scenario also included analyzing the roundabout configuration with a 20% and 40% increase in existing traffic volumes to determine at what point the roundabout would would begin to operate at failing LOS. The Hi-T configuration was also analyzed with a 5%, 10% and 20% increase in traffic volumes to determine the limits of that configuration. Only the Roundabout +40% and the Hi-T +10% scenarios are included in the LOS analysis in this section, because those were the scenarios



that operated with the highest traffic volumes for those conditions before failing. The following figures show how Madison Junction currently is configured as well as conceptual configurations of the proposed Hi-T and roundabout intersections.

- **SCENARIO 2 – Distributed Traffic Demand:** Involved spreading the traffic demand throughout the day. The max number of peak hour vehicles allowed through Madison Junction before it fell below the acceptable LOS was determined – this was determined to be approximately 1,180 total vehicles through the intersection during the peak hour (which is about 6% less than current 1,260 vehicles in 2017 peak conditions). The remaining 80 vehicles were then distributed to earlier or later hours – thereby distributing the peak demand throughout more hours of the day. It was assumed that vehicles already in the park, for example those that stayed within the park, would still be on the roadways regardless of the changes at the park entrances. Based on the 2016 data collection, there is approximately 3,500 vehicles that start out in the park daily.
- **SCENARIO 3 – Managed Corridor:** Included restricting access to the Grand Loop Road between Madison Junction and West Thumb to a limited number of visitors to achieve 90% parking utilization at the parking lots (Midway Geyser, Fairy Falls, and Old Faithful) in that corridor. The number of vehicles allowed into the study corridor was based on the number of visitors that entered into the park on days that reached 90% parking capacity during the parking study performed in 2017. The number of vehicles to be allowed into the corridor was determined to be approximately 80% of existing volumes. The remaining 20% of visitors were re-routed away from the corridor between Madison Junction and West Thumb and are assumed to visit other areas of the park during the peak of the day. This scenario allowed approximately 800 vehicles (500 from Madison Junction and 300 from West Thumb) to enter the managed corridor per hour. This scenario was also performed with the Roundabout and Hi-T configurations at Madison Junction to evaluate the efficacy of possible mitigation strategies.

RESULTS

Fehr & Peers recorded the following metrics from the simulations: vehicle delay at each intersection in the study corridor, travel time from the West Gate to Old Faithful, and queue lengths at the West Gate, Madison Junction, Fountain Paint Pot, Midway Geyser, Fairy Falls and Biscuit Basin.

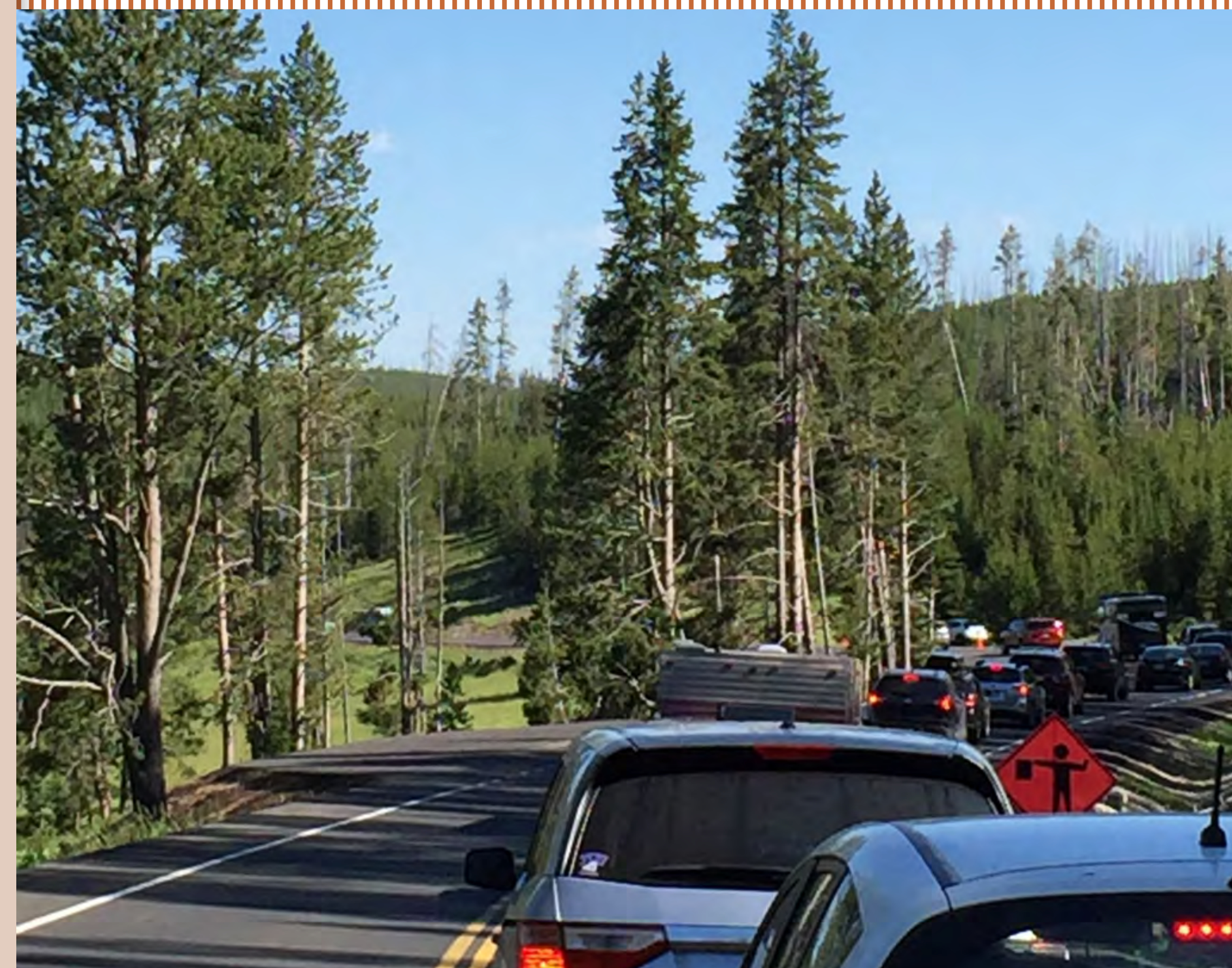


TABLE 6.
BASELINE LOS AND DELAY

INTERSECTION	EXISTING		EXISTING -5% VOLUME		EXISTING -10% VOLUME	
	LOS & DELAY	WORST MOVEMENT[2]	LOS & DELAY	WORST MOVEMENT[2]	LOS & DELAY	WORST MOVEMENT[2]
Madison Junction	E / 47	EB LT	D / 33	EB LT	C / 24	EB LT
Fountain Paint Pots (N)	F / 73	SB RT	E / 44	SB RT	D / 35	SB RT
Fountain Paint Pots (S)	B / 14	EB LT	B / 11	EB LT	B / 12	EB LT
Midway Geyser	F / >180	NB LT	F / >180	EB LT	F / 177	EB RT
Fairy Falls (N)	B / 15	EB LT	B / 14	EB LT	B / 13	EB LT
Fairy Falls (S)	B / 13	EB LT	C / 17	EB LT	C / 15	EB RT
Biscuit Basin	C / 17	EB LT	B / 15	EB LT	C / 16	EB LT

TABLE 7.
SCENARIO 1 LOS AND DELAY

INTERSECTION	ROUNDABOUT		ROUNDABOUT +40%		HI-T		HI-T +10%	
	LOS & DELAY	WORST MOVEMENT[2]	LOS & DELAY	WORST MOVEMENT[2]	LOS & DELAY	WORST MOVEMENT[2]	LOS & DELAY	WORST MOVEMENT[2]
Madison Junction	B / 10	-	20 / C	-	D / 29	EB LT	E / 36	EB LT
Fountain Paint Pots (N)	F / 86	SB RT	F / >180	SB RT	F / 80	SB RT	F / >180	SB RT
Fountain Paint Pots (S)	B / 13	EB LT	C / 15	EB LT	B / 13	EB LT	C / 17	EB LT
Midway Geyser	F / >180	NB LT	F / >180	NB LT	F / >180	NB LT	F / >180	NB LT
Fairy Falls (N)	B / 14	EB LT	F / >180	EB LT	B / 12	EB LT	C / 16	EB LT
Fairy Falls (S)	B / 15	EB LT	F / >180	EB LT	C / 17	EB LT	B / 14	EB LT
Biscuit Basin	C / 16	EB LT	D / 26	EB LT	C / 15	EB LT	C / 18	EB LT

INTERSECTION LOS & DELAY

For the purpose of this study and to remain consistent with the Phase 1, June 2017 study, LOS D is considered the threshold of capacity for intersections. Using VISSIM software and the Highway Capacity Manual (HCM) 2017 delay thresholds for LOS, the existing AM and PM peak hour LOS were computed for each study intersection. The results of this analysis are reported in Table 6, Table 7, Table 8, and Table 9 and are shown with turning movement volumes in Figures 9-17.

Table 7, the intersection at Madison Junction improved to acceptable LOS (LOS D or better) after implementing the Roundabout and Hi-T configurations. It should be noted that the Roundabout performed acceptably in the simulation even with an extra 40% of traffic at Madison Junction, and didn't begin to reach failing levels of delay until volumes were increased 60% above existing conditions. Conversely, the Hi-T configuration reached failing levels of delay in the simulation after volumes increased by only 10% above existing conditions.

Table 8 shows the results of displacing some of the traffic (80 vehicles) from the peak hour to the hours before and after the peak. While this was expected to have a "smoothing" affect on the inbound traffic, this was found to not have a positive effect on the LOS at the study intersections. The results show that shifting the 40 cars to before the peak hour served to increase the number of vehicles already in the park, effectively lengthening the duration of the peak hour.

TABLE 8.
SCENARIO 2 LOS AND DELAY

Madison Junction	F / 56	EB LT
Fountain Paint Pots (N)	F / 74	SB RT
Fountain Paint Pots (S)	B / 11	EB LT
Midway Geyser	F / >180	NB LT
Fairy Falls (N)	B / 13	EB LT
Fairy Falls (S)	C / 17	EB LT
Biscuit Basin	C / 18	EB LT

TABLE 9.
SCENARIO 3 LOS AND DELAY

Madison Junction	F / 64	EB LT	B / 11	-	D / 28	EB LT
Fountain Paint Pots (N)	D / 27	EB RT	C / 21	EB RT	C / 22	EB RT
Fountain Paint Pots (S)	B / 11	EB LT	B / 15	EB LT	B / 13	EB LT
Midway Geyser	F / >180	EB LT	F / >180	NB LT	F / >180	NB LT
Fairy Falls (N)	B / 12	EB LT	B / 13	EB LT	B / 14	NB LT
Fairy Falls (S)	B / 14	EB LT	B / 15	EB LT	B / 15	EB LT
Biscuit Basin	B / 16	EB LT	C / 15	EB LT	B / 14	EB LT

1. *Worst movement LOS and average delay (seconds/vehicle) for the stop-controlled intersections and overall intersection LOS and average delay for the roundabout intersections.*
2. *NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound, LT=Left-turn, RT=Right-turn, and TH=Through*

As is shown in Table 9, the managed volume on the corridor between Madison Junction and West Thumb corridor led to improved LOS at all study intersections except for Madison Junction; the increased delay at that intersection is likely due to the 20% of eastbound vehicles who would previously turn right, but instead were routed to the left-turn. This increased delay was found to be mitigated in the alternatives that included the roundabout or Hi-T configurations at Madison Junction.

SITE OVERVIEW

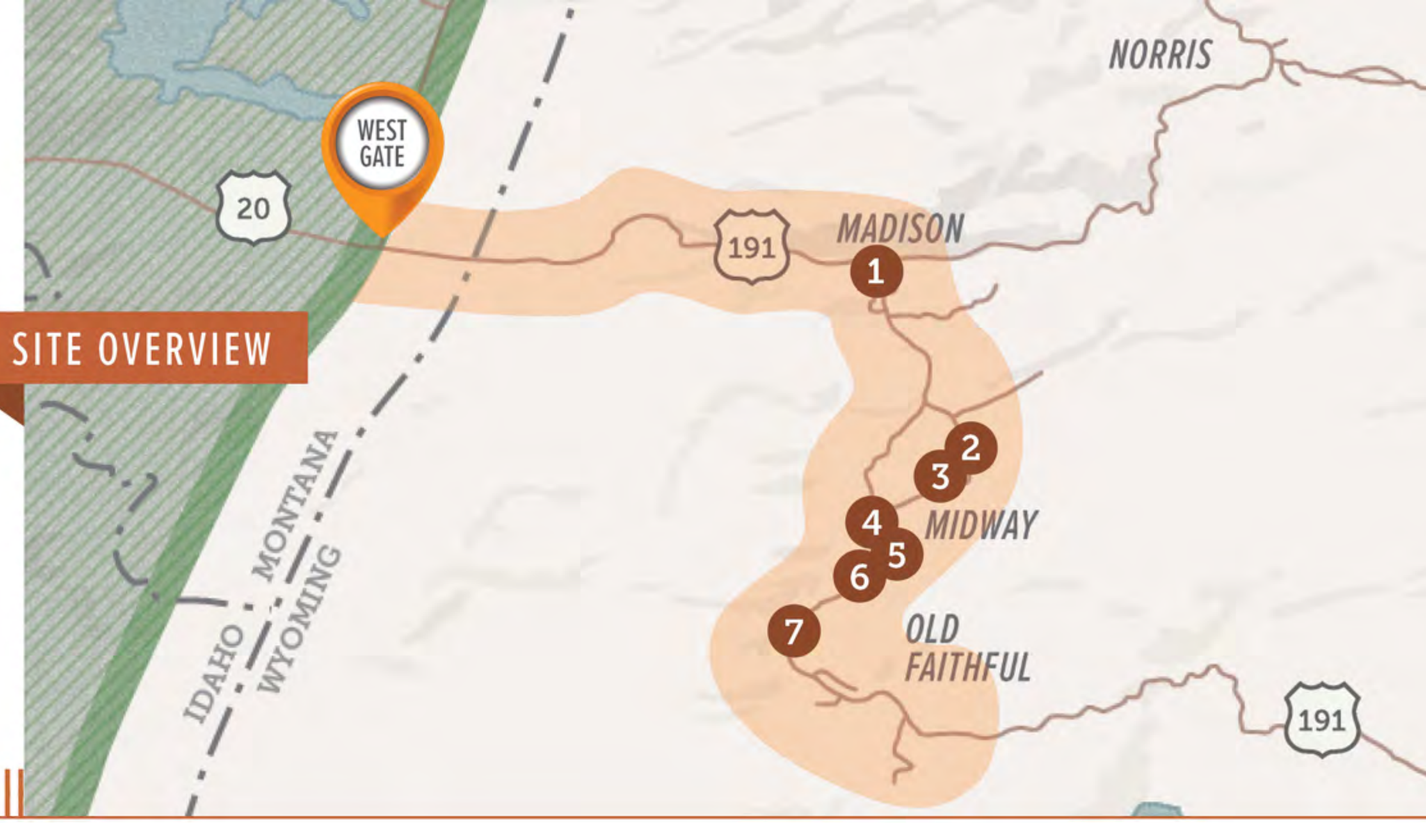
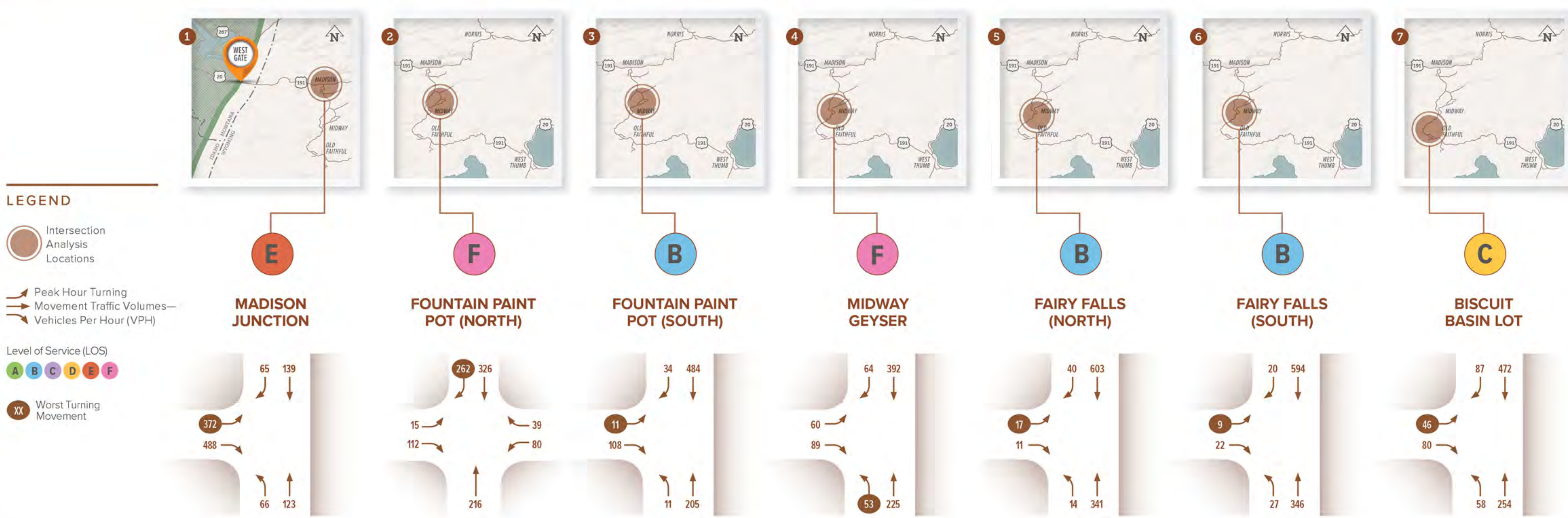


FIGURE 9.

BASELINE LEVEL OF SERVICE AND TURNING MOVEMENTS



SITE OVERVIEW

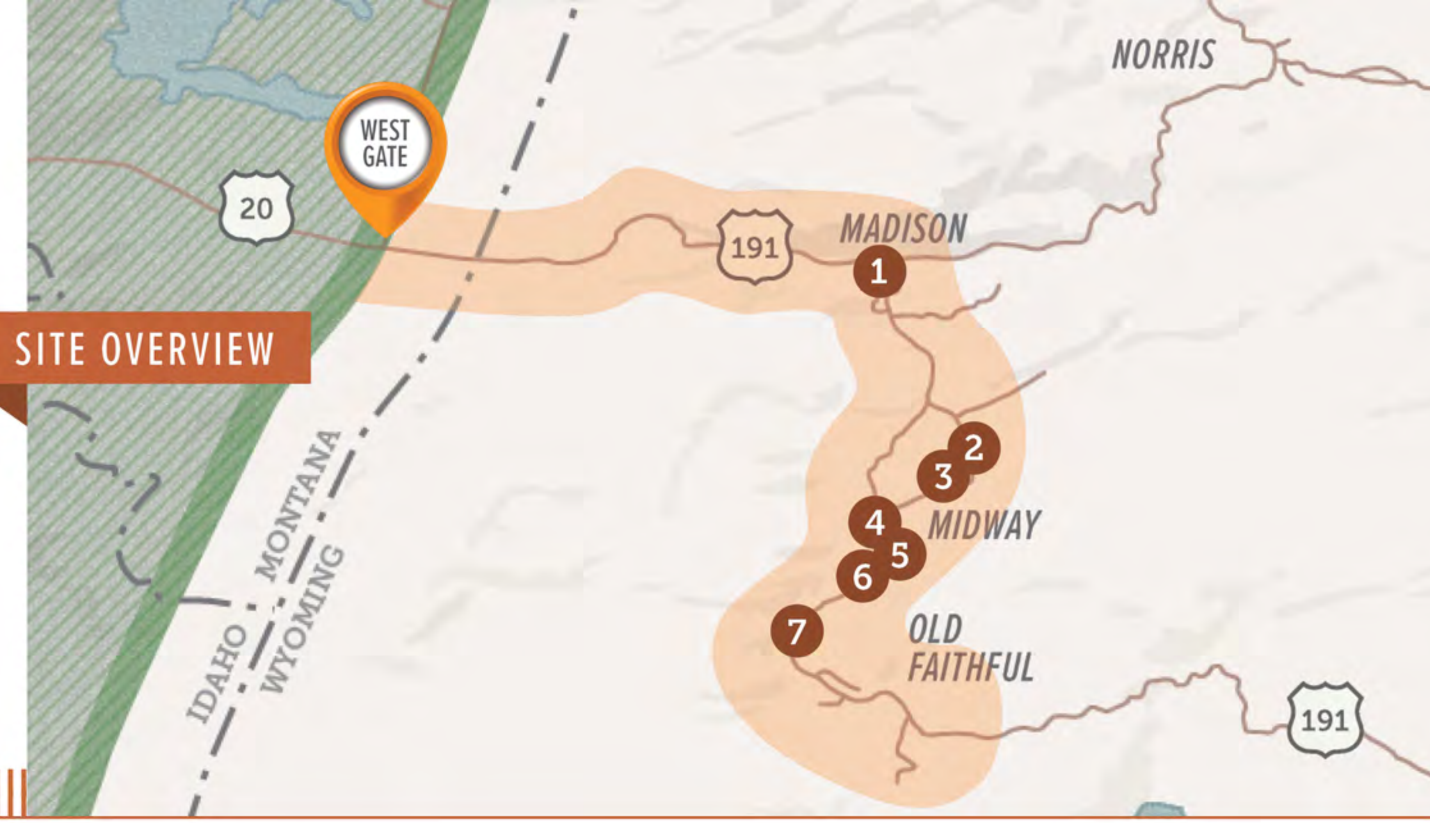
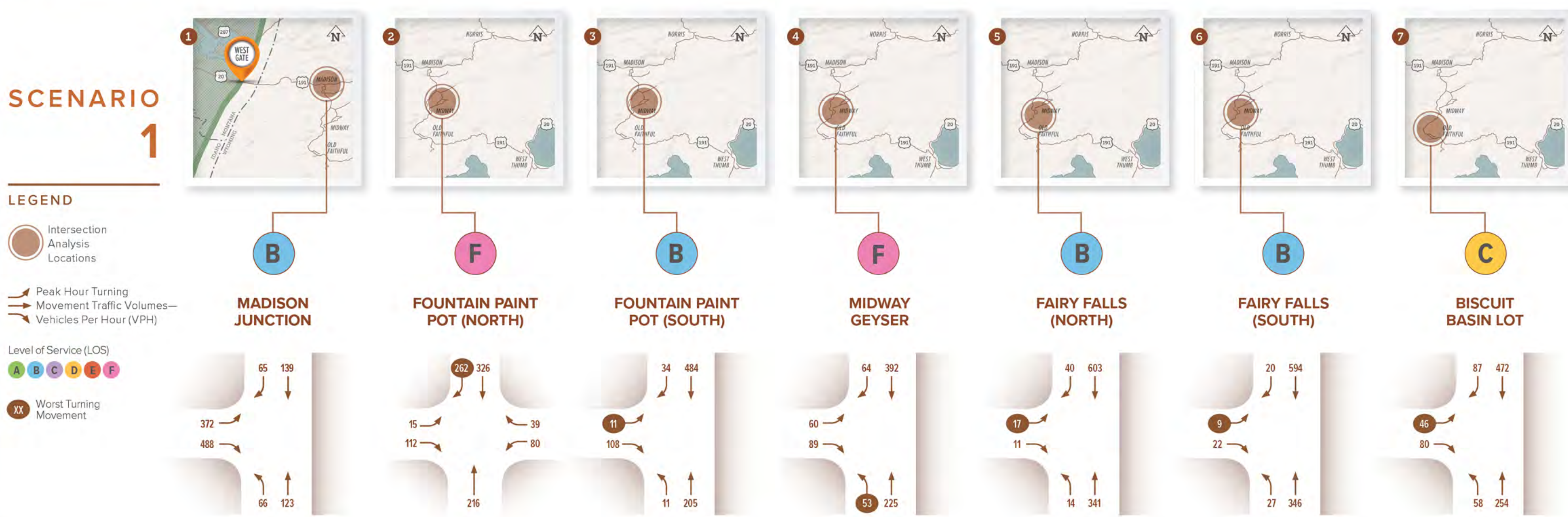


FIGURE 10.

ROUNDABOUT AT MADISON JUNCTION LOS AND TURNING MOVEMENTS



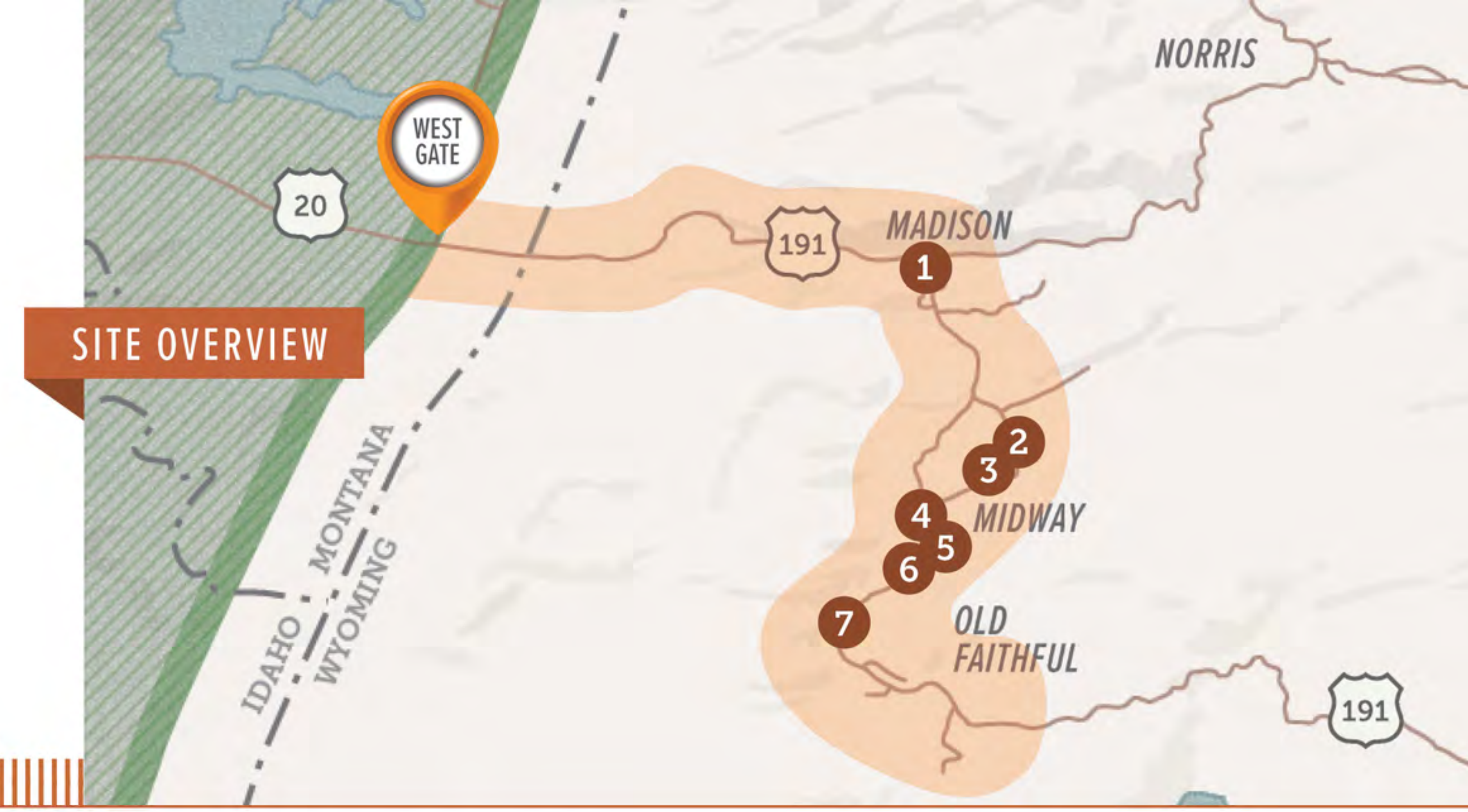


FIGURE 11. ROUNDABOUT AT MADISON JUNCTION WITH 40% ADDED TRAFFIC LOS AND TURNING MOVEMENTS

SCENARIO 1

LEGEND

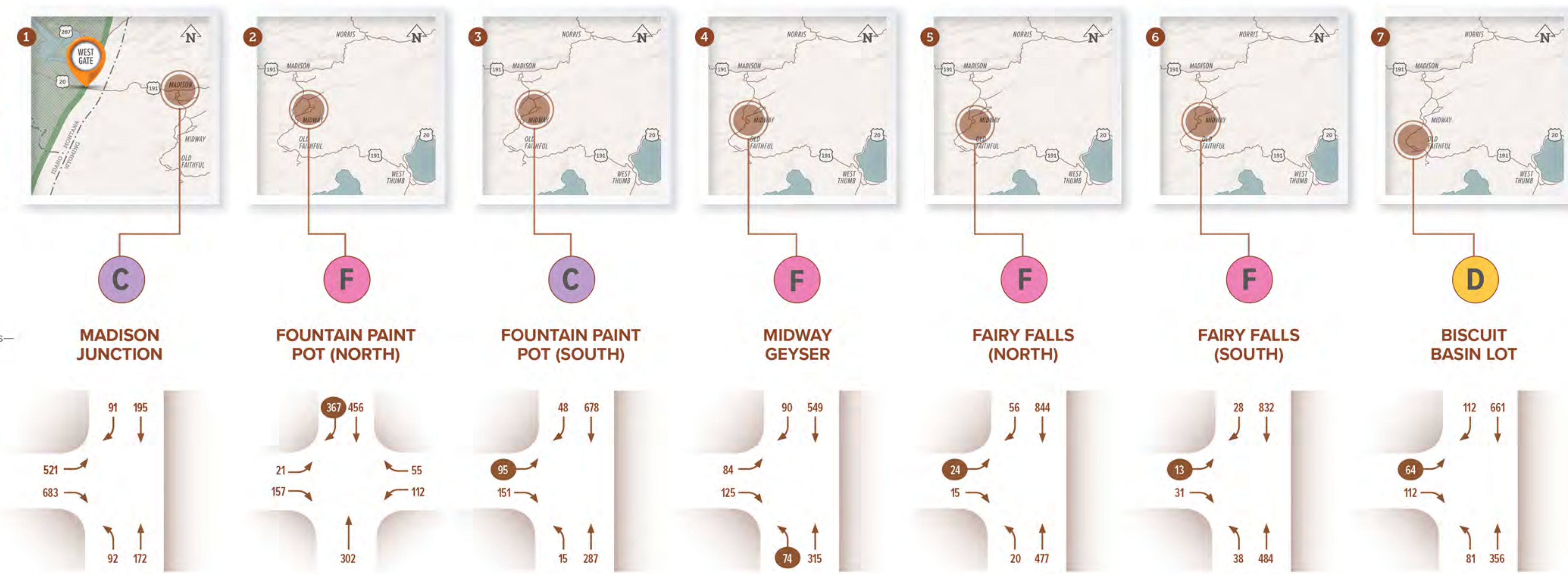
Intersection Analysis Locations

Peak Hour Turning Movement Traffic Volumes—Vehicles Per Hour (VPH)

Level of Service (LOS)

A B C D E F

XX Worst Turning Movement



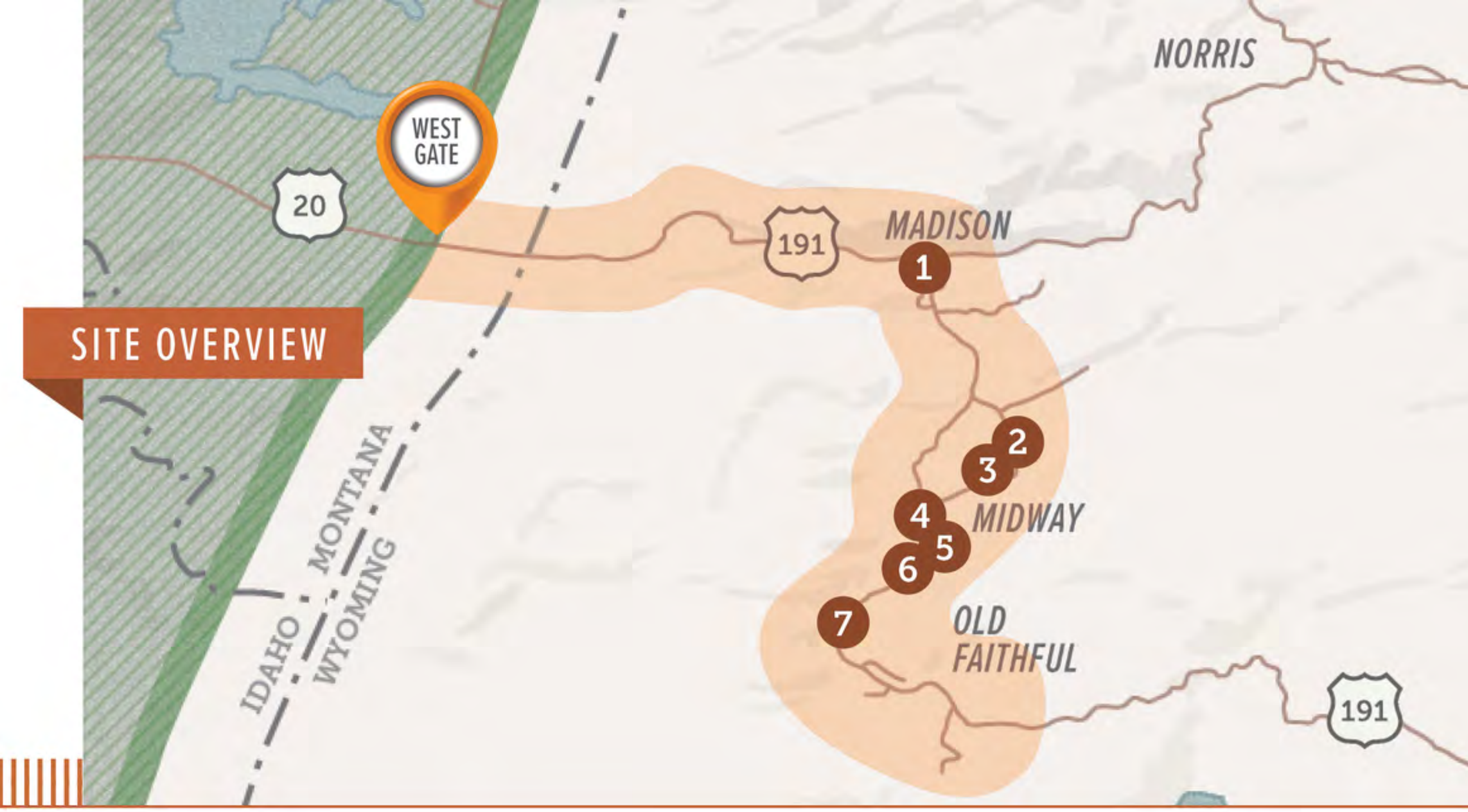


FIGURE 12. HI-T AT MADISON JUNCTION LOS AND TURNING MOVEMENTS

SCENARIO 1

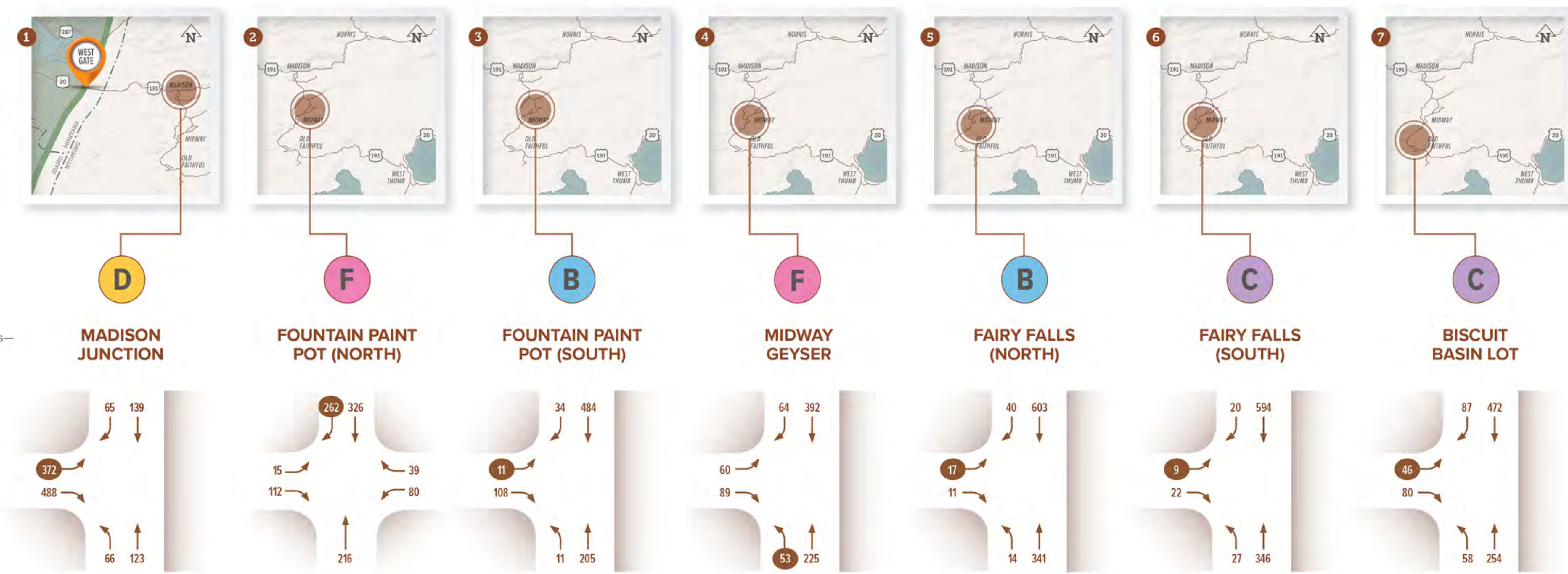
LEGEND

Intersection Analysis Locations

Peak Hour Turning Movement Traffic Volumes—Vehicles Per Hour (VPH)

Level of Service (LOS): A B C D E F

XX Worst Turning Movement



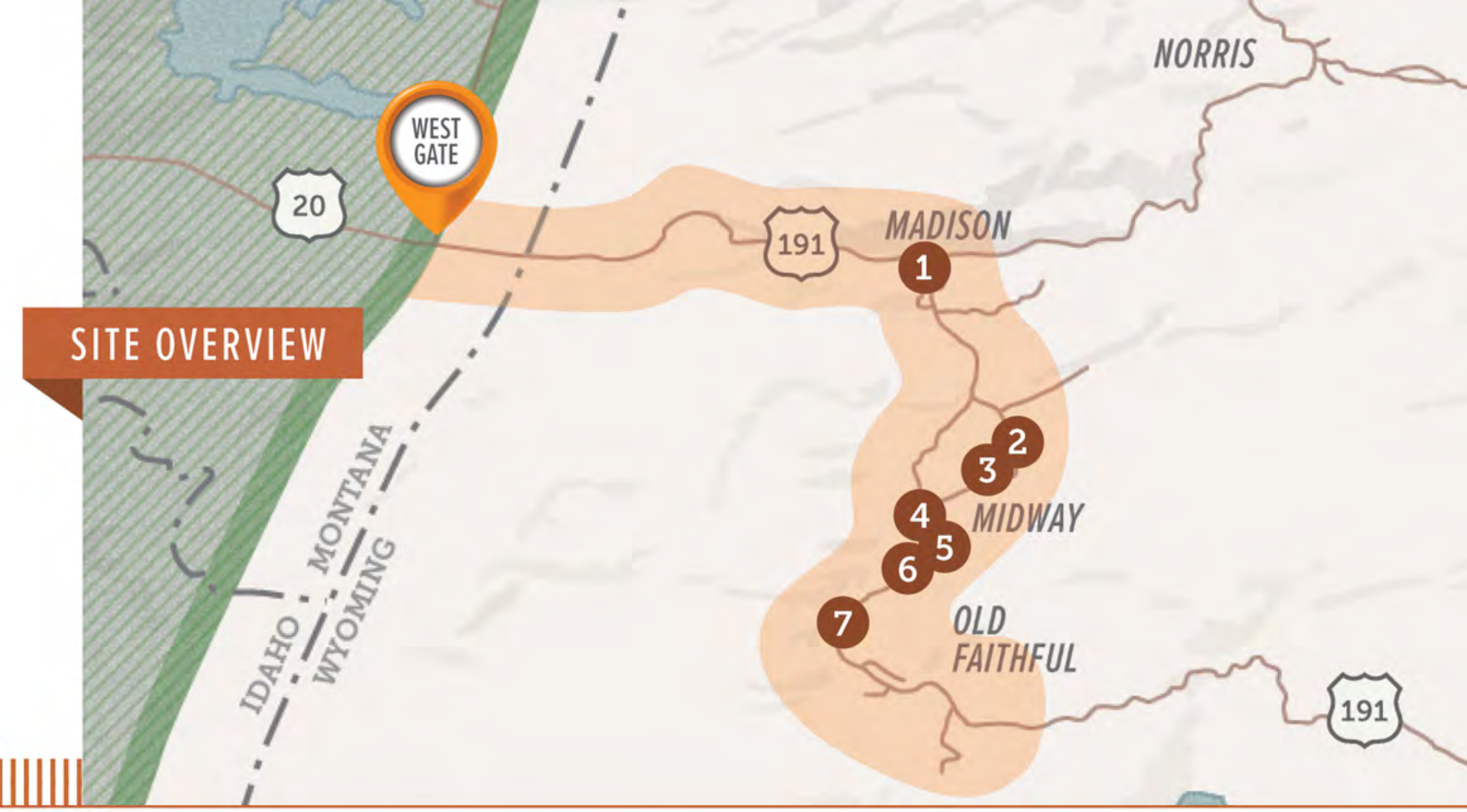


FIGURE 13. HI-T AT MADISON JUNCTION WITH 10% ADDED TRAFFIC LOS AND TURNING MOVEMENTS

SCENARIO 1

LEGEND

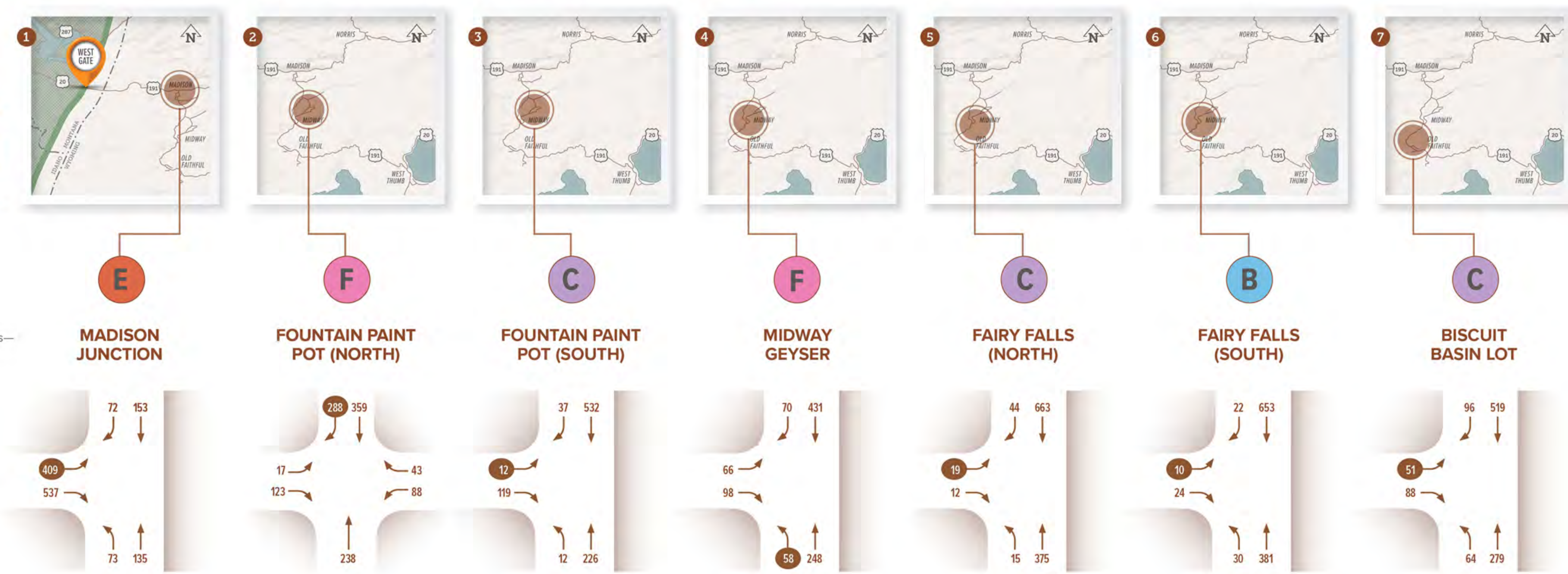
Intersection Analysis Locations

Peak Hour Turning Movement Traffic Volumes—Vehicles Per Hour (VPH)

Level of Service (LOS)

A B C D E F

XX Worst Turning Movement



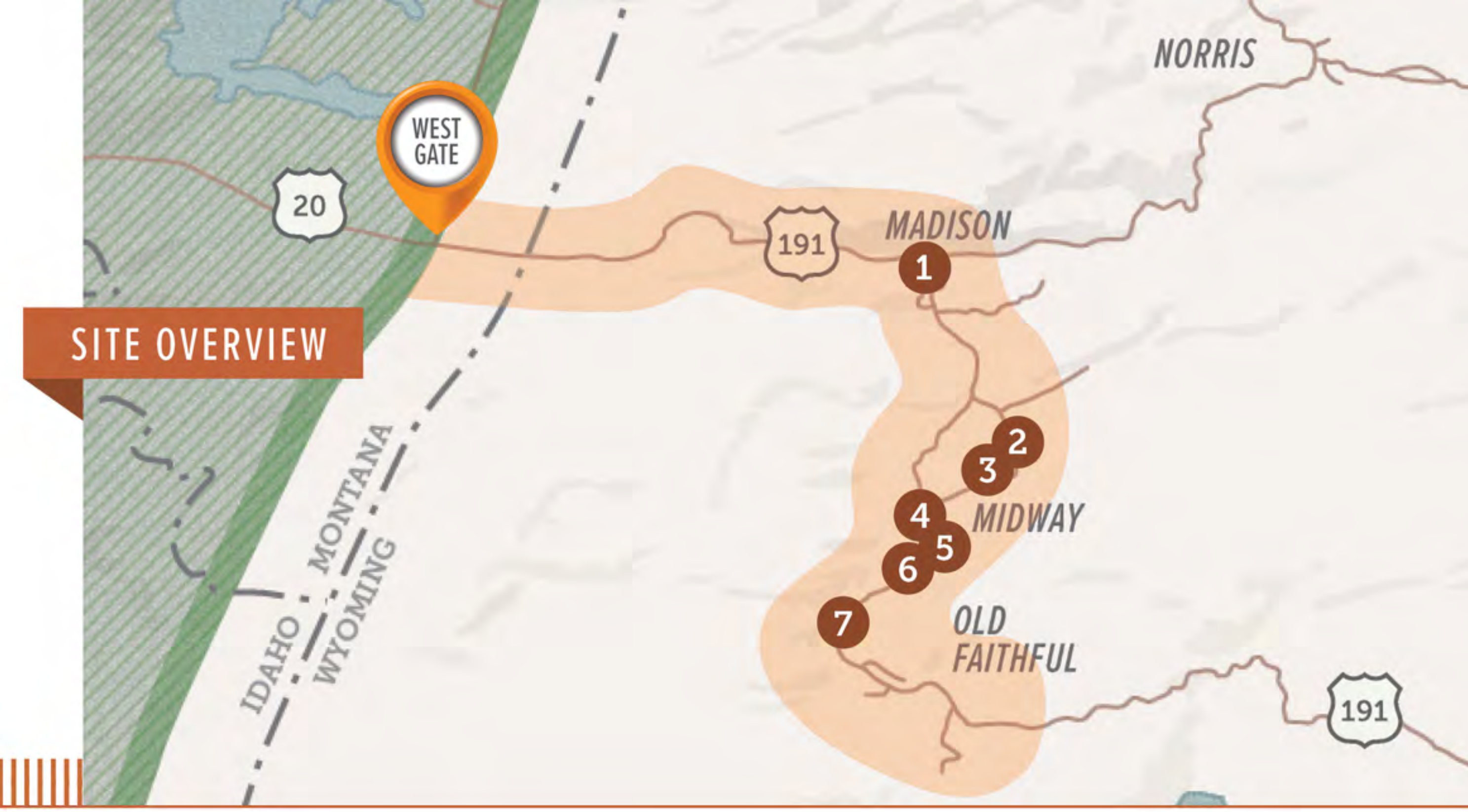
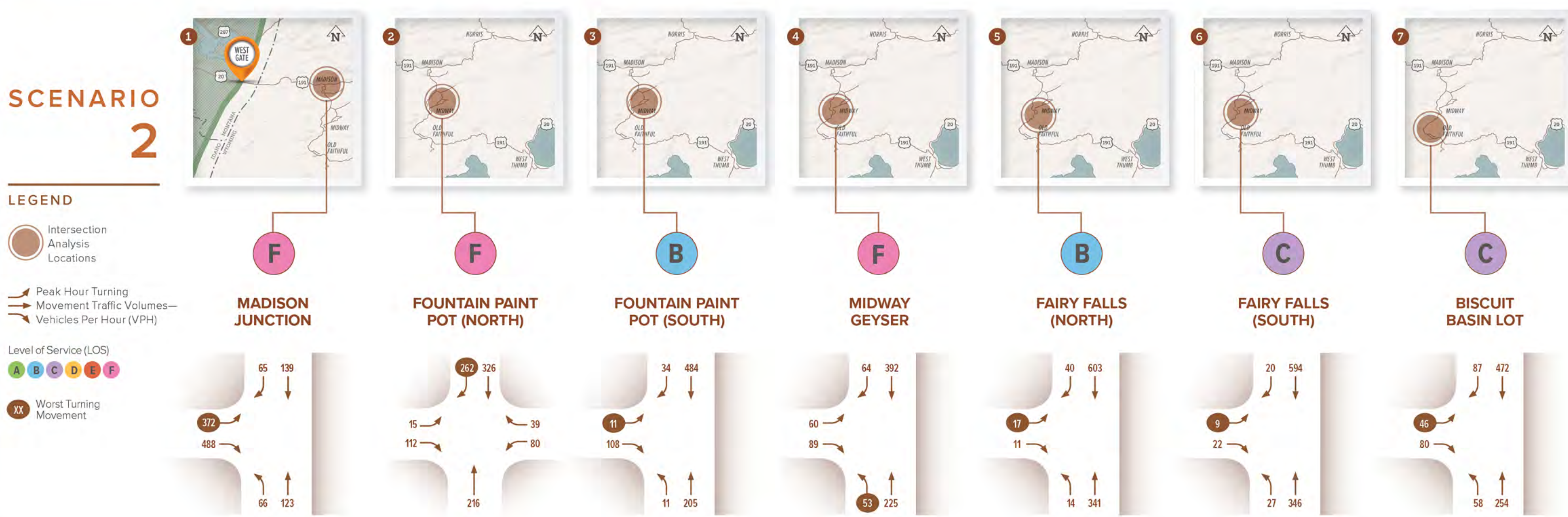


FIGURE 14.

DISTRIBUTED TRAFFIC DEMAND LOS AND TURNING MOVEMENTS



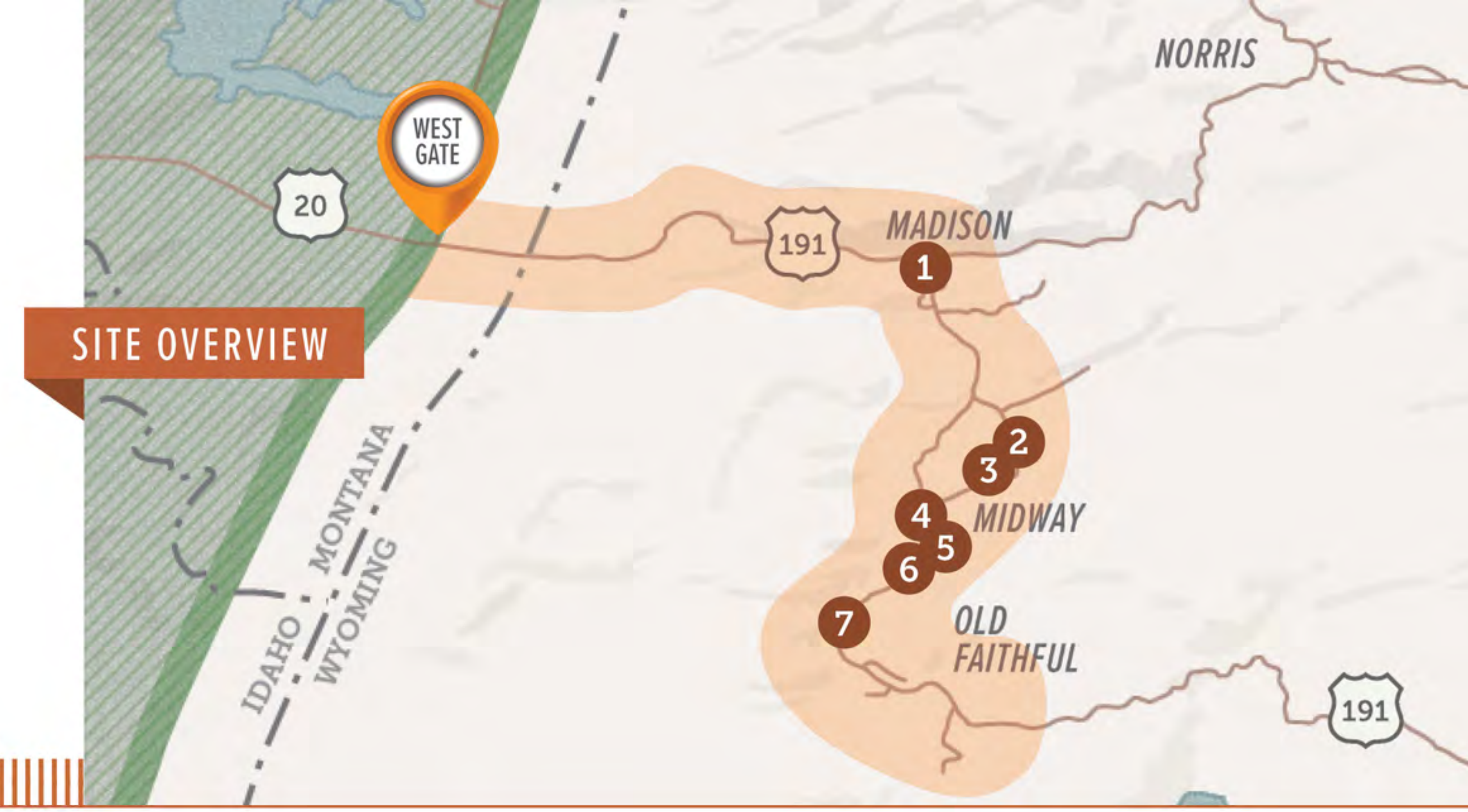
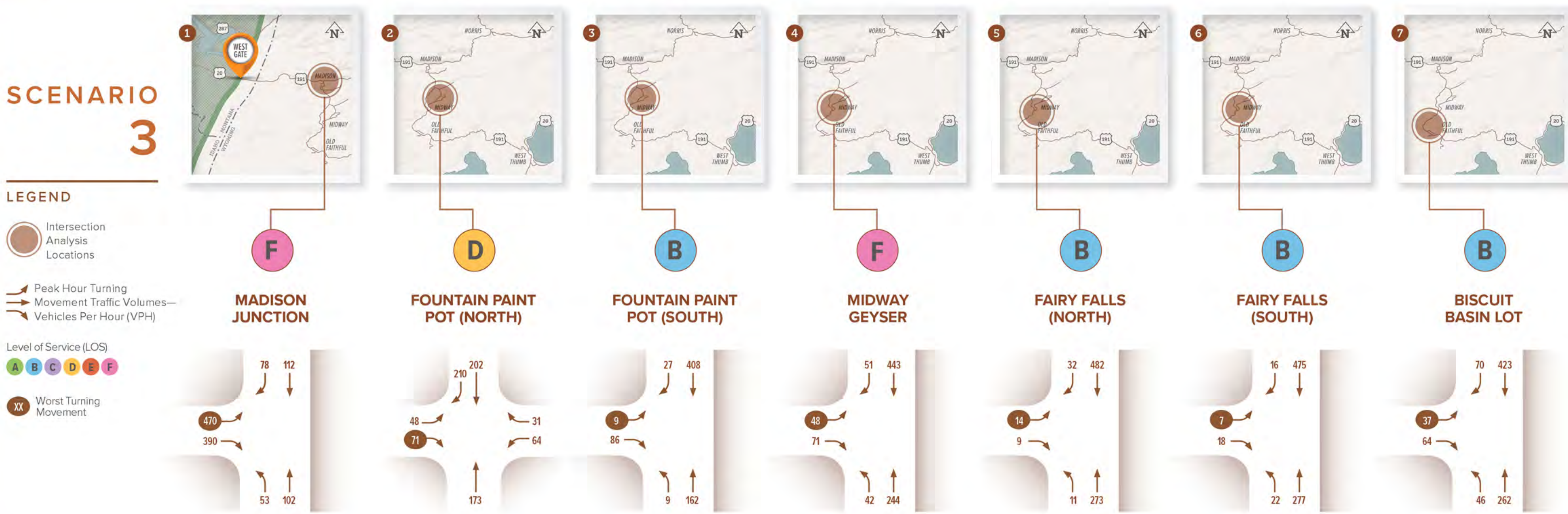


FIGURE 15. MANAGED CORRIDOR LOS AND TURNING MOVEMENTS



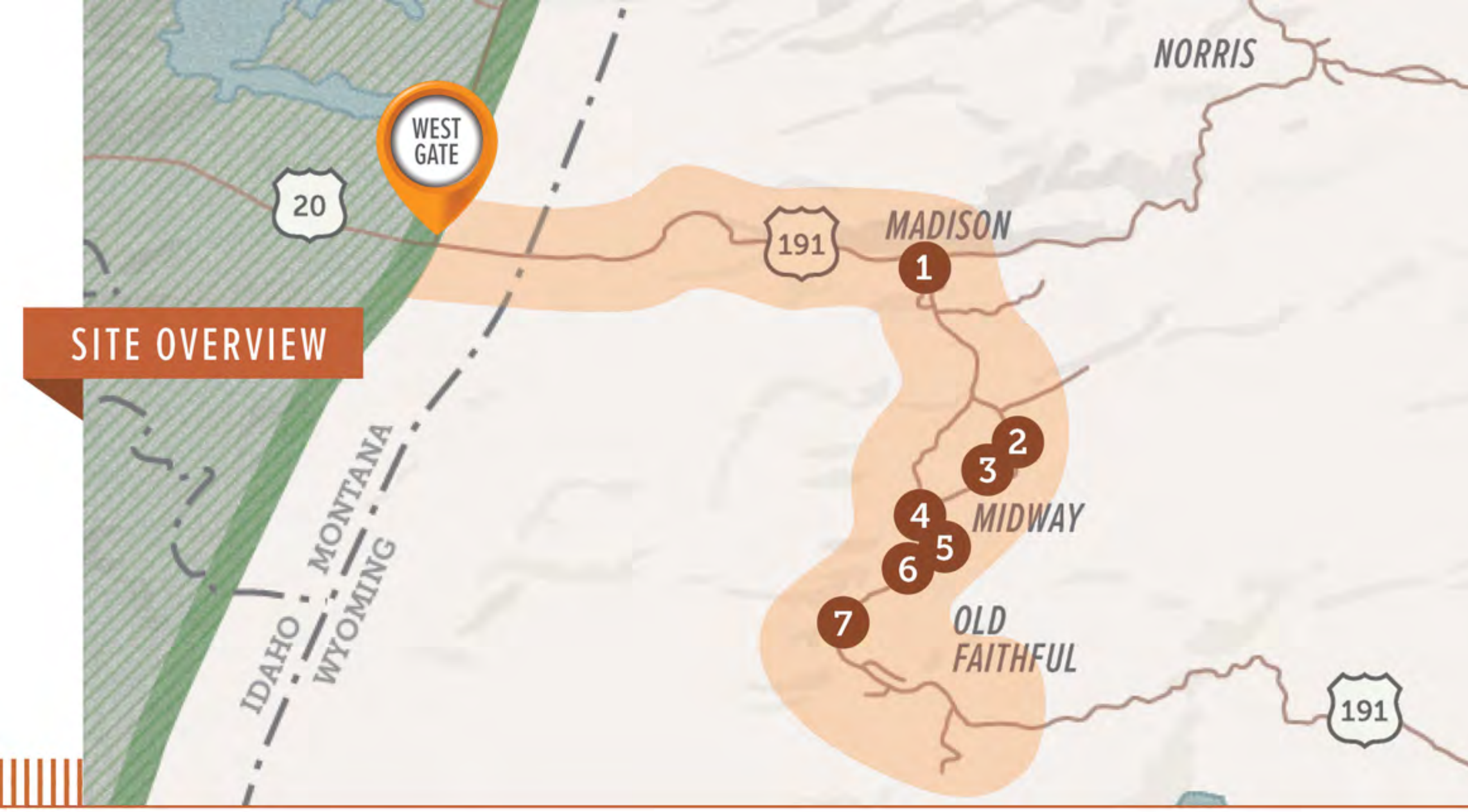


FIGURE 16.

MANAGED CORRIDOR WITH MADISON ROUNDABOUT LOS AND TURNING MOVEMENTS

SCENARIO 3

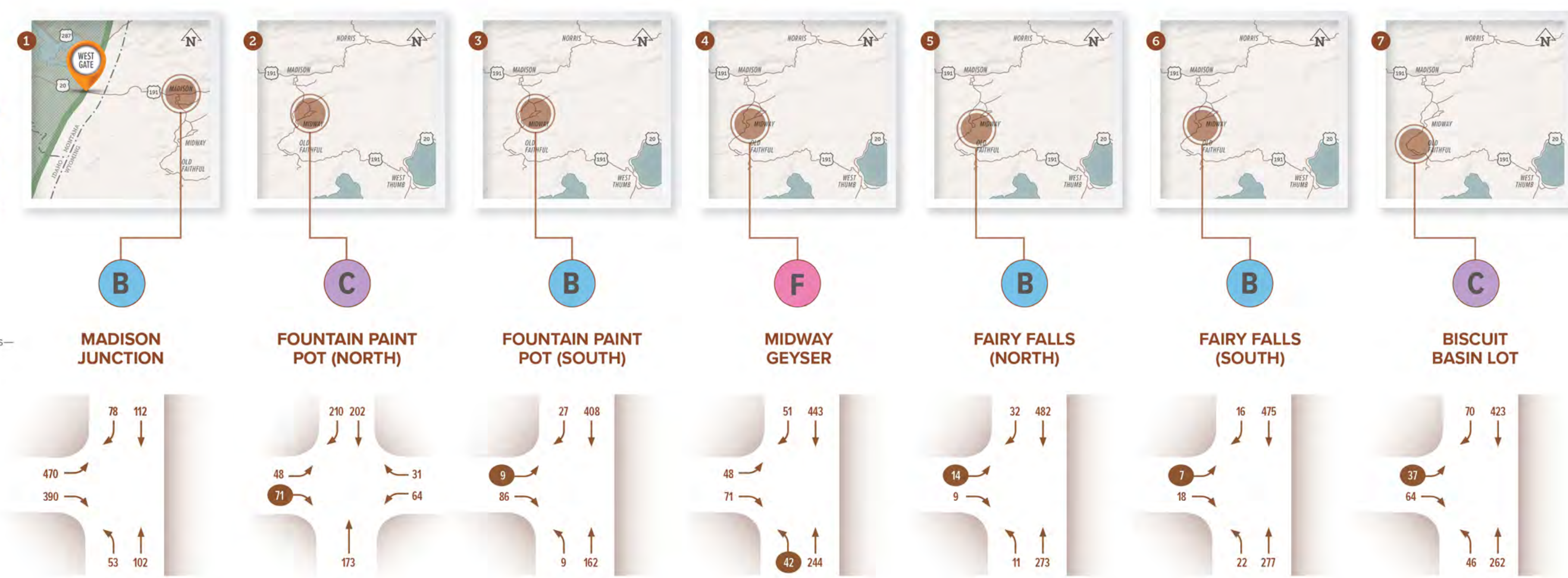
LEGEND

Intersection Analysis Locations

Peak Hour Turning Movement Traffic Volumes—Vehicles Per Hour (VPH)

Level of Service (LOS)
A B C D E F

XX Worst Turning Movement



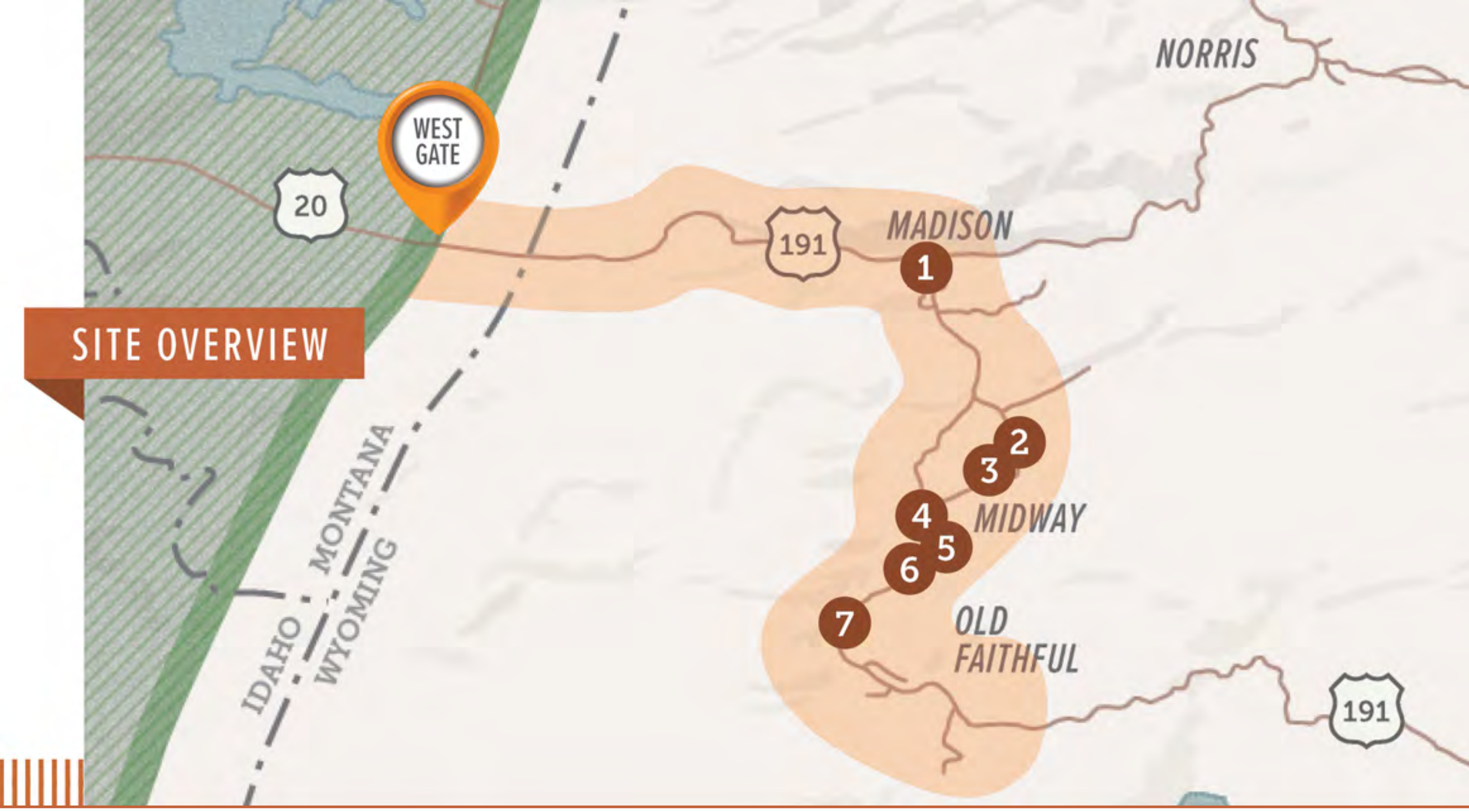
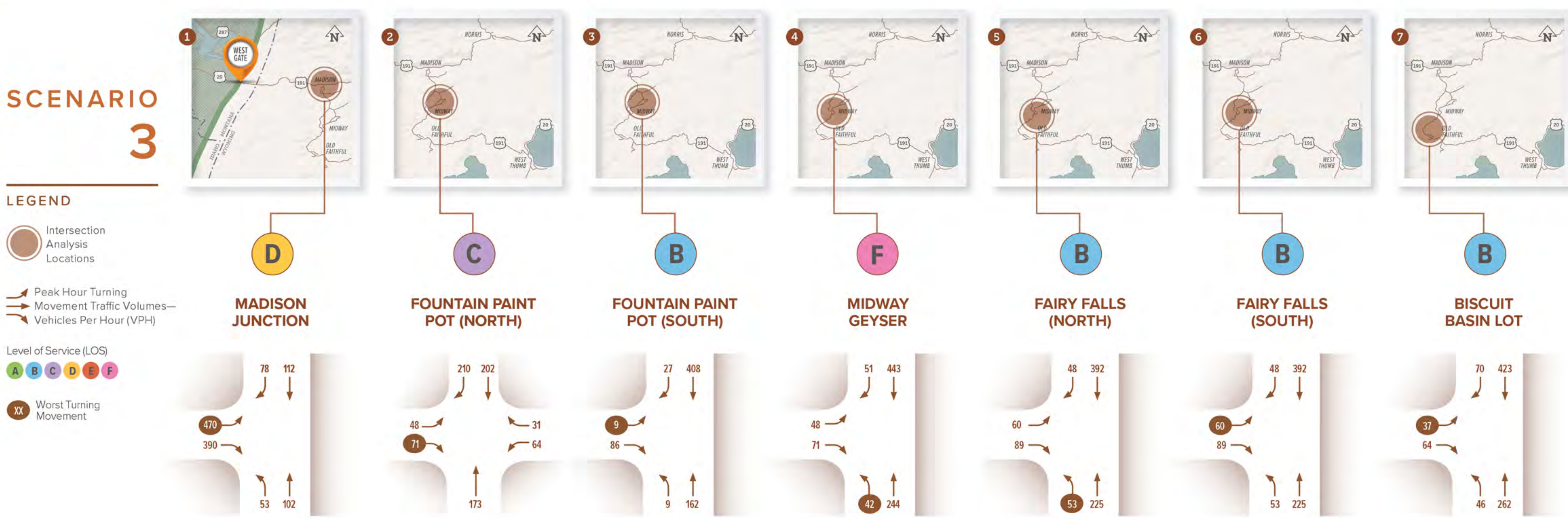


FIGURE 17.

MANAGED CORRIDOR WITH MADISON HI-T LOS AND TURNING MOVEMENTS



ROADWAY LOS & PERCENT TIME SPENT FOLLOWING

For the purpose of this study and to remain consistent with the Phase 1, June 2017 Study, LOS C is considered the threshold of capacity for roadways. Roadway LOS was only calculated for the Managed Corridor scenario (Scenario 3) since changes to the roadway volumes in scenarios 1 and 2 were not applicable and/or insignificant. An adjustment factor was applied to the demand flow rate of seven roadway segments from Phase 1 of the Yellowstone Transportation and Vehicle Mobility Study to replicate the Managed Corridor scenario. That is, since the Managed Corridor scenario would require 20% of the volume on Grand Loop Road between Madison Junction and West Thumb to be re-routed to other areas of the park, 20% of the volume from that roadway segment of Grand Loop Road was re-allocated to the other segments of the Grand Loop Road. Using the managed demand flow rate, the Percent Time Spent Following (PTSF) along the seven segments of Grand Loop Road was recalculated. Of those segments, the two that led directly to/from Old Faithful showed a reduction in PTSF, but remained the same LOS. Four other roadway segments increased in PTSF due to the increased demand flow rate, but those also remained in the same LOS category. The detailed results of the analysis are shown below in Table 10 and Figures 18 and 19. Only the segments that had altered volumes in this scenario are included in the table. The rest of the segments remained the same as in existing conditions. Please refer to Table 01 in the ANALYSIS AND APPROACH section of the Phase 1, June 2017 report for the roadway level of service standards and methodology.

TABLE 10.
PEAK SEASON ROADWAY LOS FOR MANAGED CORRIDOR SCENARIO

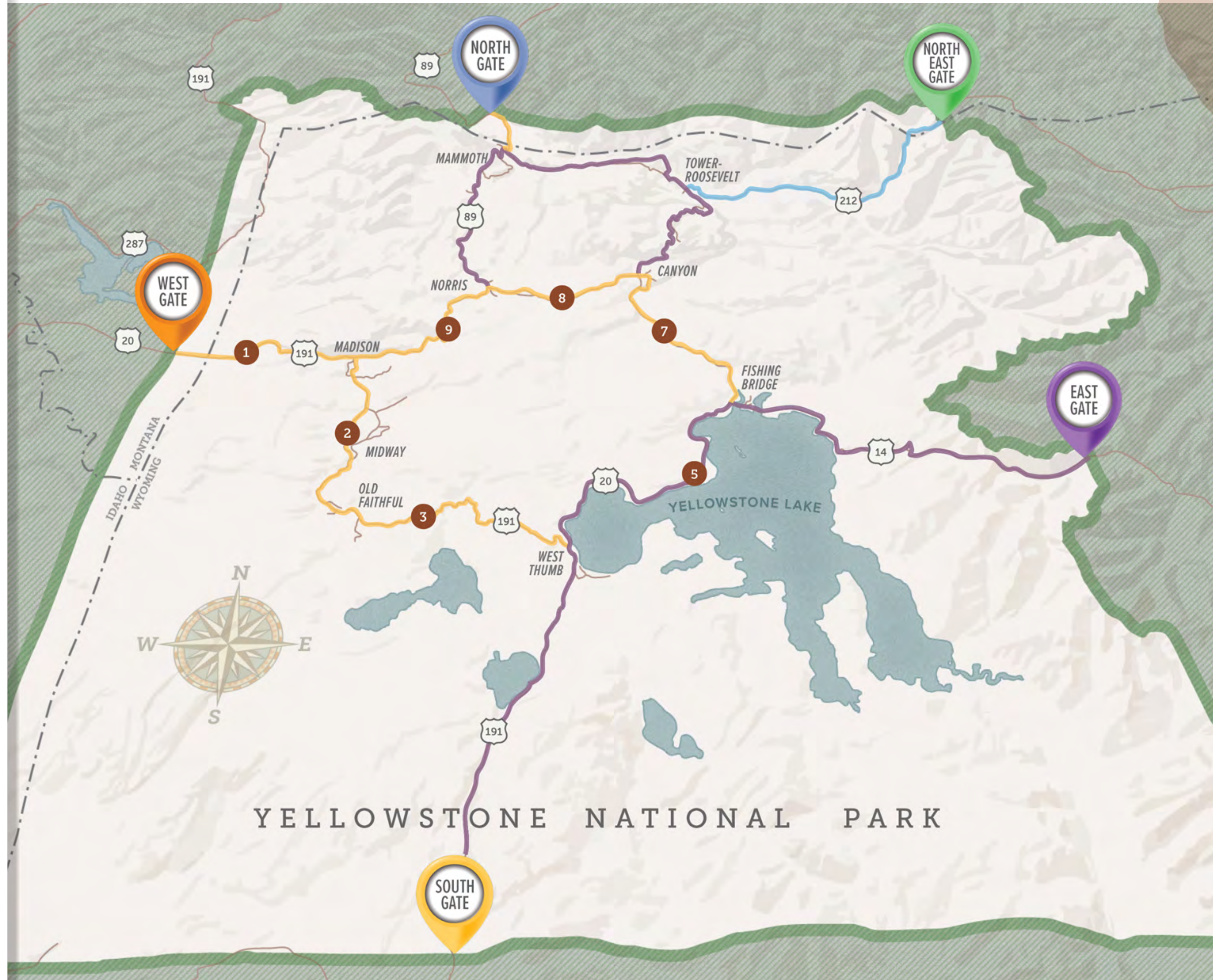
		EXISTING		MANAGED CORRIDOR	
	ROADWAY	LOS	PTSF	LOS	PTSF
1	West Gate to Madison	D	82%	D	82%
2	Madison to Old Faithful	D	78%	D	73%
3	Old Faithful to West Thumb	D	79%	D	73%
5	Fishing Bridge to West Thumb	C	64%	C	70%
7	Canyon to Fishing Bridge	D	71%	D	78%
8	Norris to Canyon	D	72%	D	77%
9	Madison to Norris	D	73%	D	79%

FIGURE 18. ROADWAY LEVEL OF SERVICE

LEGEND

A B C D E F

Level of Service (LOS)



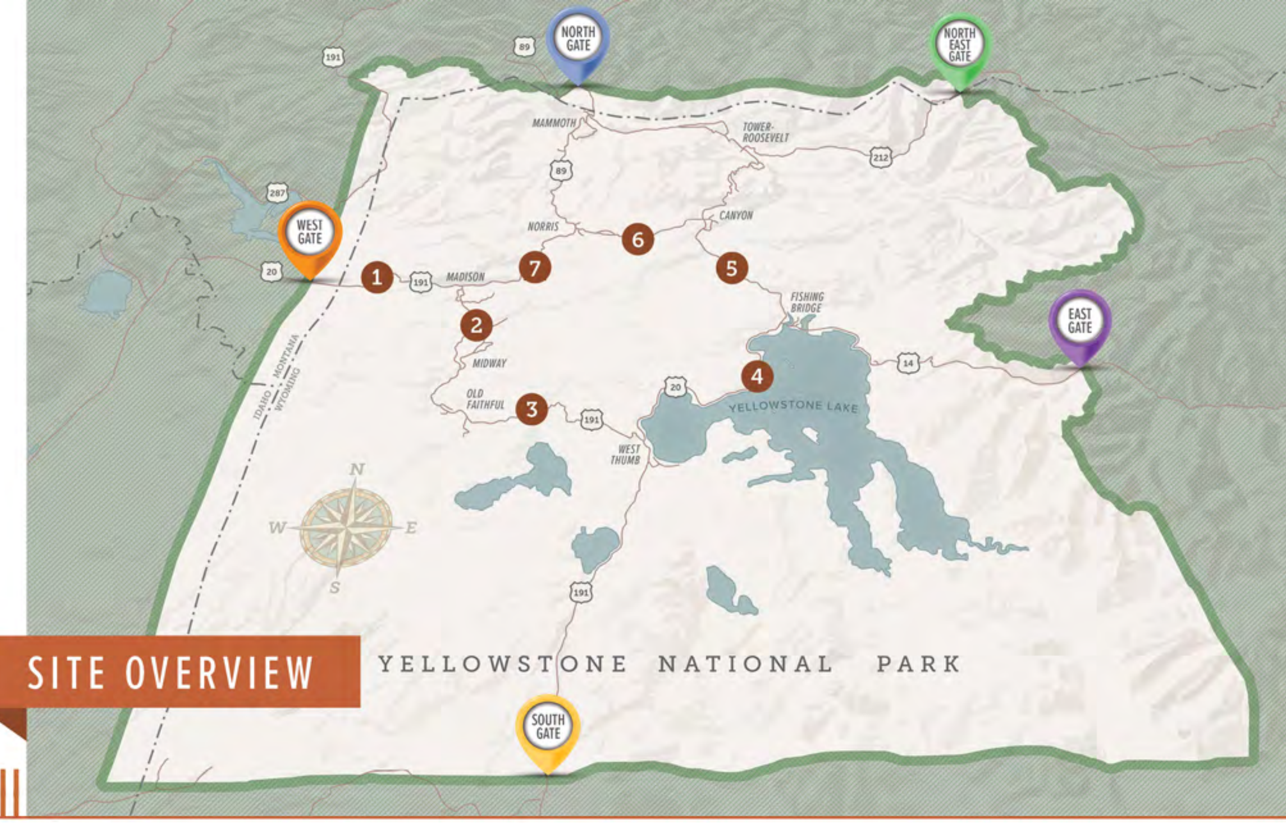


FIGURE 19.

PEAK HOUR WEEKDAY ROADWAY LEVEL OF SERVICE

ADJUSTED TO AVERAGE WEEKDAY IN JULY

ROAD SEGMENT
WEST GATE TO MADISON

ROAD SEGMENT
MADISON TO OLD FAITHFUL

ROAD SEGMENT
OLD FAITHFUL TO WEST THUMB

ROAD SEGMENT
FISHING BRIDGE TO WEST THUMB

ROAD SEGMENT
CANYON TO FISHING BRIDGE

ROAD SEGMENT
NORRIS TO CANYON

ROAD SEGMENT
MADISON TO NORRIS

LEGEND

XX%

Level of Service (LOS)
A B C D E F

Percent Time Spent Following Another Vehicle (PTSF)

QUEUE LENGTH

The length of vehicles that were waiting to enter into and exit from the study corridor's parking lots during peak hour were recorded in each scenario. One of the purposes of this analysis is to understand the downstream impacts of the scenarios. In other words, this analysis assesses the impacts of each potential mitigation at all areas throughout the park instead of just at the area where the mitigation was implemented. At the Madison Junction, Fountain Paint Pot (North and South), and Midway Geyser parking lots, the longest queues were the queues of vehicles intending to enter into the parking lot. However, at the Fairy Falls and Biscuit Basin lots, there was no standing queue to enter into the lot—primarily left-turns out; the longest queues at those two lots were the queue of vehicles to exit the lot and turn onto the main road. The results of the queuing analysis (rounded to the nearest 10 feet) are shown in Table 12, Table 13, Table 14, and Table 15. For additional reference, 25 feet if queue is the approximate equivalence of one vehicle—which accounts for the vehicle length plus the buffer space in front and back of the vehicle. It should also be noted that the model provided 1000 feet of on-street parking (approximately 50 additional parking spaces) on the west side of Grand Loop Road to account for the overflow parking at Midway Geyser Basin lot.

TABLE 12. BASELINE SCENARIO QUEUE LENGTH (FT)

	EXISTING		EXISTING -5%		EXISTING -10%	
INTERSECTION	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX
Madison Junction	90	670	10	260	110	1220
Fountain Paint Pots (N)	190	420	210	470	680	780
Fountain Paint Pots (S)	<10	60	<10	70	<10	70
Midway Geyser	570	1060	850	1320	4320	5030
Fairy Falls (N)	<10	80	<10	80	40	130
Fairy Falls (S)	<10	90	<10	90	<10	90
Biscuit Basin	10	100	10	110	20	130

TABLE 13. SCENARIO 1 QUEUE LENGTH (FT)

	EXISTING		ROUNDABOUT		ROUNDABOUT +40%		HI-T		HI-T +10%	
INTERSECTION	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX
Madison Junction	90	670	10	260	110	1220	50	430	120	910
Fountain Paint Pots (N)	190	420	210	470	680	780	190	450	560	770
Fountain Paint Pots (S)	<10	60	<10	70	<10	70	<10	50	<10	70
Midway Geyser	570	1060	850	1320	4320	5030	630	1210	1660	2270
Fairy Falls (N)	<10	80	<10	80	40	130	<10	80	<10	80
Fairy Falls (S)	<10	90	<10	90	60	140	<10	90	<10	90
Biscuit Basin	10	100	10	110	20	130	10	110	10	130

TABLE 14. SCENARIO 2 QUEUE LENGTH (FT)

	EXISTING		DISTRIBUTED DEMAND	
INTERSECTION	AVERAGE	MAX	AVERAGE	MAX
Madison Junction	90	670	130	820
Fountain Paint Pots (N)	190	420	210	460
Fountain Paint Pots (S)	<10	60	<10	50
Midway Geyser	570	1060	590	1210
Fairy Falls (N)	<10	80	<10	80
Fairy Falls (S)	<10	90	<10	90
Biscuit Basin	10	100	10	110

TABLE 15. SCENARIO 3 QUEUE LENGTH (FT)

	EXISTING		MANAGED CORRIDOR		MANAGED CORRIDOR + ROUNDABOUT		MANAGED CORRIDOR + HI-T	
INTERSECTION	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX	AVERAGE	MAX
Madison Junction	90	670	230	800	20	310	60	410
Fountain Paint Pots (N)	190	420	70	250	70	240	60	240
Fountain Paint Pots (S)	<10	60	<10	50	<10	50	<10	50
Midway Geyser	570	1060	320	500	400	610	320	540
Fairy Falls (N)	<10	80	<10	80	<10	80	<10	80
Fairy Falls (S)	<10	90	10	100	10	100	10	100
Biscuit Basin	10	100	10	110	10	100	10	110

WEST GATE PERFORMANCE ANALYSIS

The West Gate was analyzed in all scenarios to measure the length of the queue that spilled back from each service window. In Table 16 and Table 17 below, the four service windows are labeled as Lane 1 through Lane 4 in order from south to north. It should be noted that Lane 1 was the "express lane" designated for people with park passes and re-entries so that it would operate faster than the other three service windows.

It should also be noted that the scenarios with increased volumes were simulated with two "express lanes" at Lane 1 and Lane 2 instead of just one "express lane". This was done to allow enough vehicles into the park to simulate an increased volume of visitors throughout the entire study corridor instead of just at the gate. These scenarios also show that the gate can likely still operate at acceptable levels with increased volume as long as the gate allows a second lane to operate as an "express lane." This would require enough visitors to be prepared to use an "express lane" (re-entries, prepaid entrance passes, annual passes, etc.) before approaching the gate.

Figures 20 and 21 depict the same data shown in Tables 16 and 17, but in bar chart format. It should be noted that while the queue lengths do change between the Existing scenario, the Roundabout scenario and the Hi-T scenario, the total queue across all three lanes remains within ±70 total feet between the existing, and the roundabout and Hi-T configurations (approximately three vehicle lengths). Small differences like this are likely due to randomization in the model simulations. These variations in queue lengths can happen at the gate happen in any given hour of any day.

TABLE 16.
WEST GATE PROCESSING PERFORMANCE (AVERAGE QUEUE)

	SCENARIO	MAXIMUM QUEUE LENGTH (FEET)			
		LANE 1 (EXPRESS)	LANE 2	LANE 3	LANE 4
BASELINE	Existing	750	530	260	270
	Existing -10%	110	160	90	90
	Existing -5%	160	240	150	150
SCENARIO 1	Roundabout	720	500	290	370
	Roundabout +20%[1]	90	80	140	90
	Roundabout +40%[1]	600	620	450	350
	Hi-T	690	430	290	350
	Hi-T +5%[1]	45	40	50	60
	Hi-T +10%[1]	60	50	60	70
	Hi-T +20%[1]	100	80	130	100
SCENARIO 2	Distributed Traffic Demand	660	450	250	250
SCENARIO 3	Managed Corridor	780	560	260	270
	Managed Corridor + Roundabout	580	430	290	390
	Managed Corridor + Hi-T	610	350	280	360

1. Gate operations were modified to have two express lanes and two general purpose lanes

TABLE 17.
WEST GATE PROCESSING PERFORMANCE (MAXIMUM QUEUE)

	SCENARIO	MAXIMUM QUEUE LENGTH (FEET)			
		LANE 1 (EXPRESS)	LANE 2	LANE 3	LANE 4
BASELINE	Existing	1260	780	480	440
	Existing -10%	390	360	220	220
	Existing -5%	500	550	280	280
SCENARIO 1	Roundabout	1290	910	510	530
	Roundabout +20%[1]	340	320	250	240
	Roundabout +40%[1]	1210	1070	770	560
	Hi-T	1290	680	440	490
	Hi-T +5%[1]	230	240	160	170
	Hi-T +10%[1]	320	340	190	200
	Hi-T +20%[1]	380	330	270	250
SCENARIO 2	Distributed Traffic Demand	1550	850	470	400
SCENARIO 3	Managed Corridor	1380	830	440	440
	Managed Corridor + Roundabout	1000	730	550	530
	Managed Corridor + Hi-T	1200	690	440	510

TRAVEL TIMES WITHIN THE CORRIDOR

The existing travel time data was manually collected using a floating car method by driving to Old Faithful from the West Gate and vice-versa. This means that a driver with a GPS unit would drive in a platoon of vehicles from the West Gate to Old Faithful and back again multiple times during the peak period and peak season over several days to establish an average travel time. The GPS travel times were performed on July 23rd, 24th, and 25th, and September 3rd, 4th, and 5th 2017 from approximately 8:00 AM to 1:00 PM. The existing condition VISSIM model was calibrated to match this set of travel times.

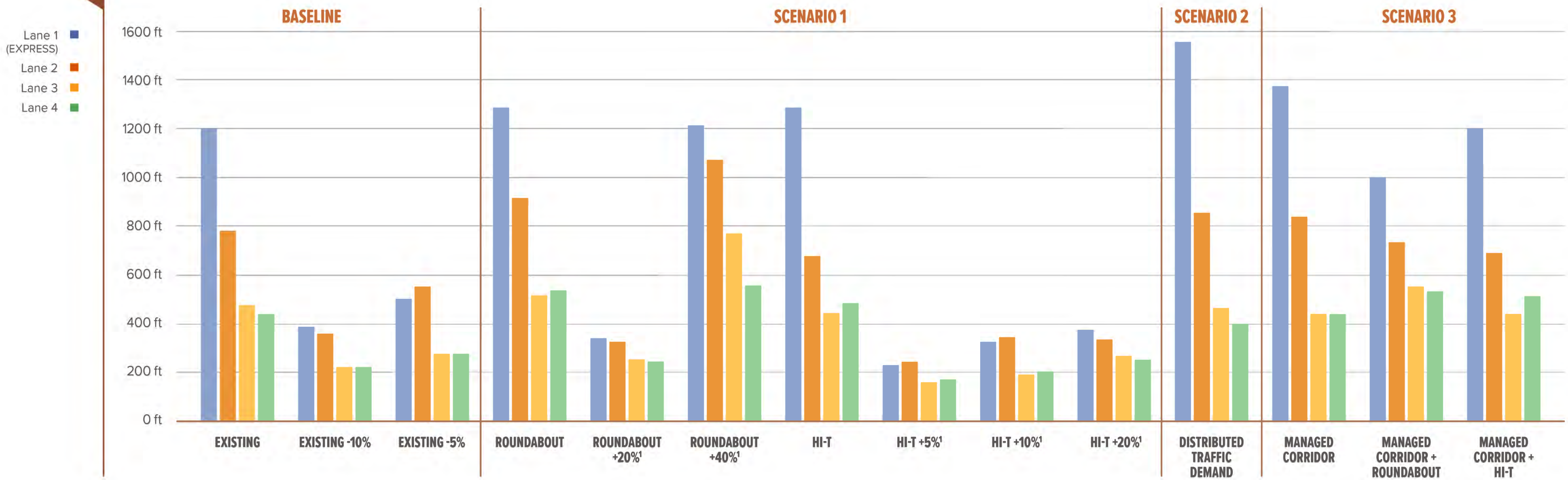
In the VISSIM models, vehicle travel times were measured once a vehicle passed through the west gate until they arrived at Old Faithful. Vehicles were also measured in the opposite direction as they left the Old Faithful area until they arrived at the west gate. It should also be noted that when vehicles diverted from a direct West Gate to Old Faithful (or vice-versa) path, the time spent traveling out of direction was not included in the measurement. This was done by segmenting the travel times to only record the direct path to and from Old Faithful and then adding those segments back together to attain an average travel time for the whole corridor. Table 11 below shows the results (rounded to the nearest 30 seconds) of the simulated travel time runs for each scenario.

TABLE 11.
SCENARIO 1 LEVEL OF SERVICE AND DELAY

		WEST GATE – MADISON JCT.		MADISON JCT. – OLD FAITHFUL		WEST GATE– OLD FAITHFUL	
	SCENARIO	NORTHBOUND	SOUTHBOUND	NORTHBOUND	SOUTHBOUND	NORTHBOUND	SOUTHBOUND
BASELINE	Existing	0:17:30	0:20:00	0:24:00	0:27:00	0:41:30	0:47:00
	Existing -10%*	0:17:30	0:20:00	0:22:00	0:27:00	0:39:30	0:47:00
	Existing -5%*	0:17:30	0:20:00	0:22:00	0:27:00	0:39:30	0:47:00
SCENARIO 1	Roundabout	0:18:00	0:19:30	0:24:00	0:27:30	0:42:00	0:47:00
	Roundabout +20%*	0:18:00	0:19:30	0:24:00	0:27:30	0:42:00	0:47:00
	Roundabout +40%*	0:18:00	0:20:00	0:53:30	0:44:00	1:11:30	1:04:00
	Roundabout +60%*	0:18:30	0:21:30	1:24:30	1:02:00	1:42:30	1:23:30
	Hi-T	0:17:30	0:20:00	0:24:30	0:27:00	0:42:00	0:47:00
	Hi-T +5%*	0:17:30	0:20:00	0:24:00	0:27:30	0:41:30	0:47:00
	Hi-T +10%*	0:17:30	0:20:00	0:26:30	0:28:00	0:44:00	0:48:00
	Hi-T +20%*	0:17:30	0:20:30	0:31:30	0:32:00	0:49:00	0:52:30
SCENARIO 2	Distributed Traffic Demand	0:17:30	0:20:00	0:23:00	0:27:00	0:40:30	0:47:00
SCENARIO 3	Managed Corridor	0:17:30	0:20:00	0:21:30	0:27:00	0:39:00	0:47:30
	Managed Corridor + Roundabout	0:18:00	0:19:30	0:22:00	0:27:00	0:39:30	0:47:00
	Managed Corridor + Hi-T	0:17:30	0:20:00	0:21:30	0:27:00	0:39:00	0:47:00

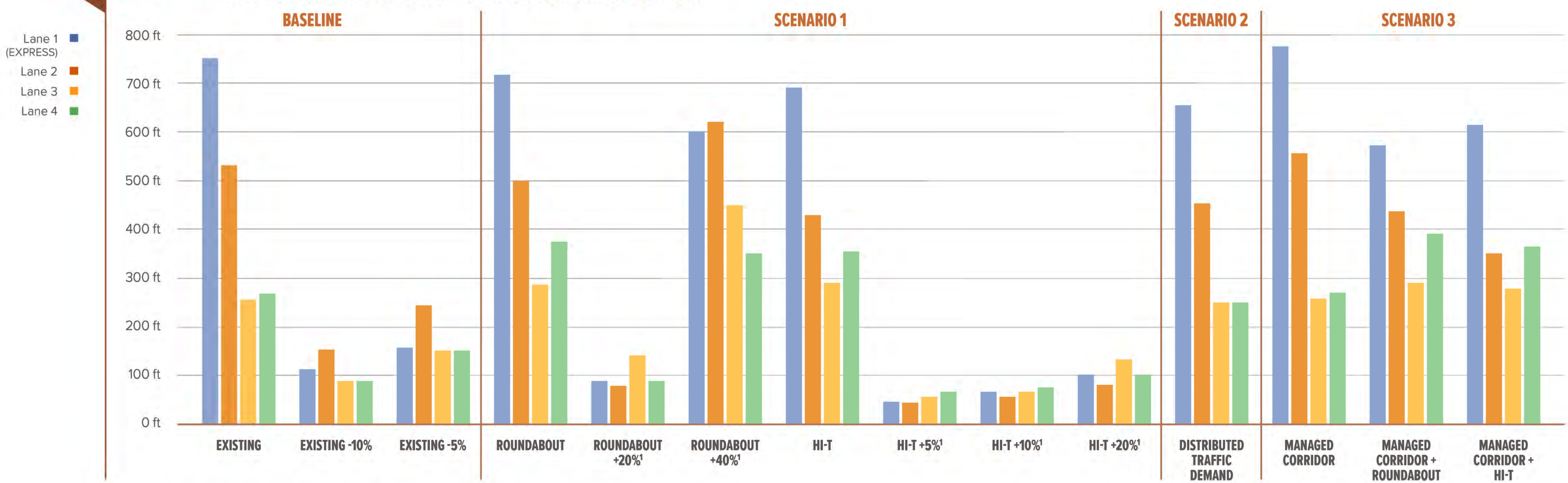
** This indicates that a percent of the existing volumes were subtracted from or added to the model inputs to simulate reduced or increased numbers of park visitors, respectively.*

FIGURE 20. WEST GATE PROCESSING PERFORMANCE (AVERAGE QUEUE)



1. *Gate operations were modified to have two express lanes and two general purpose lanes*

FIGURE 21. WEST GATE PROCESSING PERFORMANCE (MAXIMUM QUEUE)



1. Gate operations were modified to have two express lanes and two general purpose lanes

APPENDIX

WHAT DID WE LEARN?

As shown in the Parking Utilization section, the total number of vehicles that can enter Yellowstone National Park before Geyser Basin reaches capacity is about 9,300 vehicles. The simulations documented in the Traffic Analysis section show that Madison Junction currently functions at LOS E, but only for 13% of the day during 5% of the season. This is anticipated to increase to 73% of the day for 49% of the season by 2025. It should also be noted that each strategy that was analyzed to improve traffic or parking conditionsc has tradeoffs and possible unintended consequences - some strategies will improve traffic conditions in some areas while negatively impacting others. There are also benefits, as well as consequences, in managing a specific corridor vs. gate entries. Managing the corridor and parking does not fix all the intersection and roadway problems, but does alleviate a portion of the congestion on the study corridor.

This analysis helps validate that current visitation numbers are likely too high and no one mitigation strategy will solve all the traffic and parking conditions along the study corridor.

FIGURE A-1

FAIRY FALLS PARKING LOT

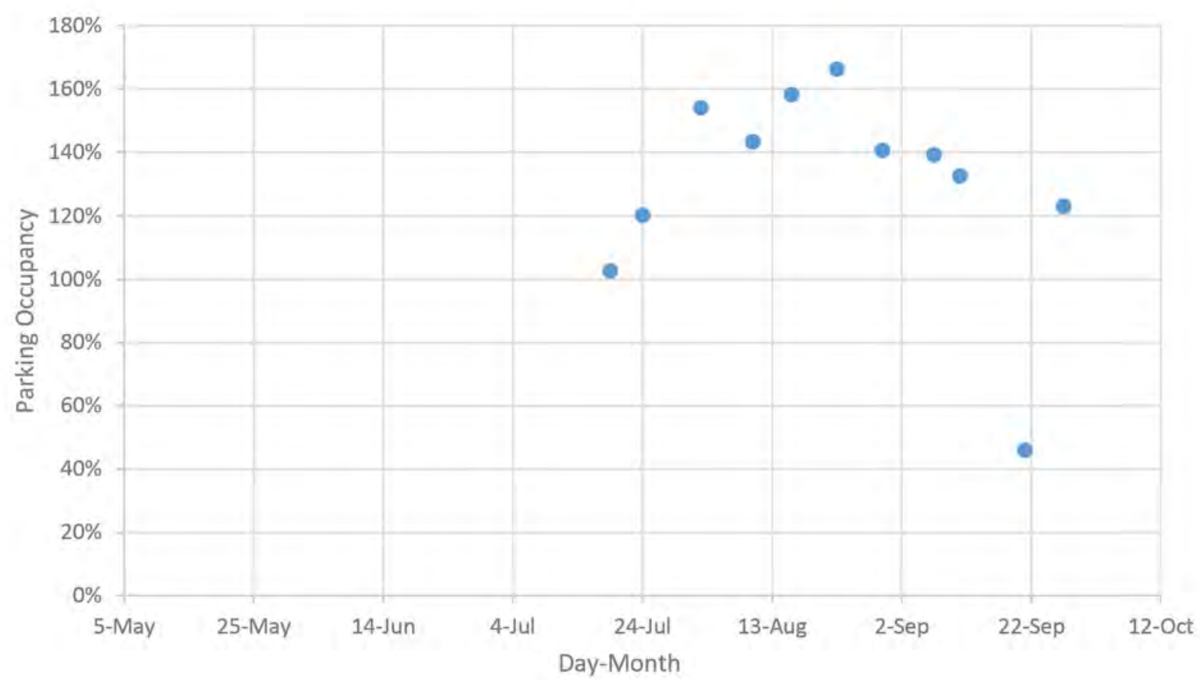


FIGURE A-2

MIDWAY PARKING LOT

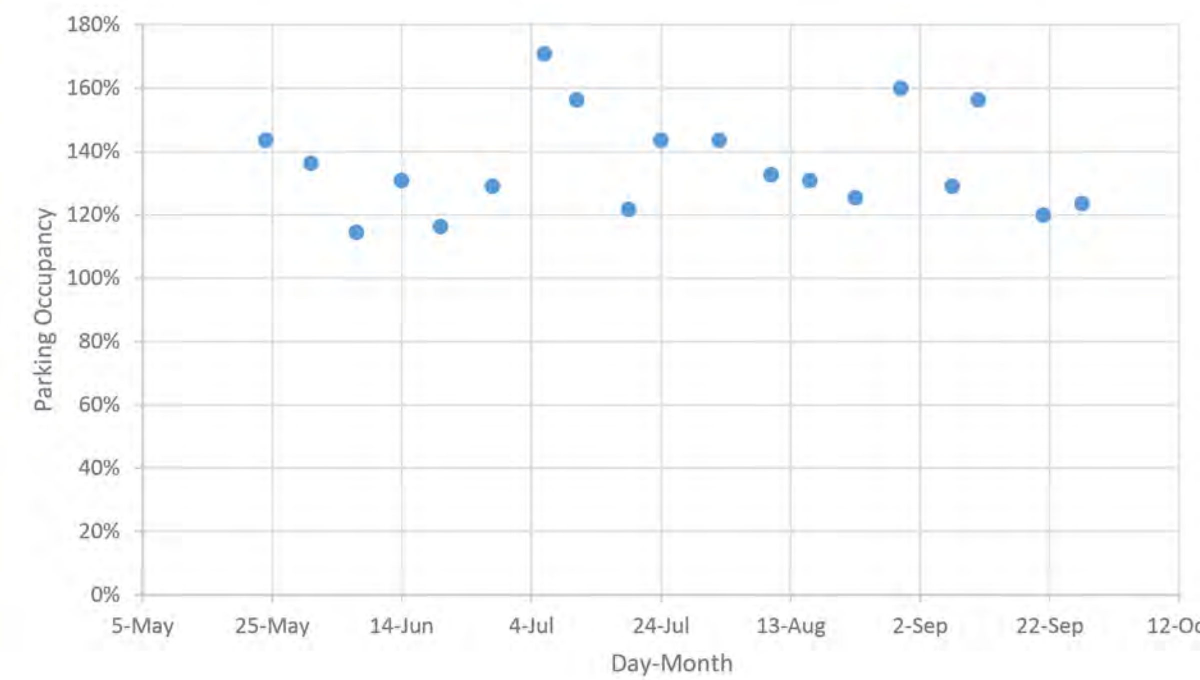


FIGURE A-3

OLD FAITHFUL EAST PARKING LOT

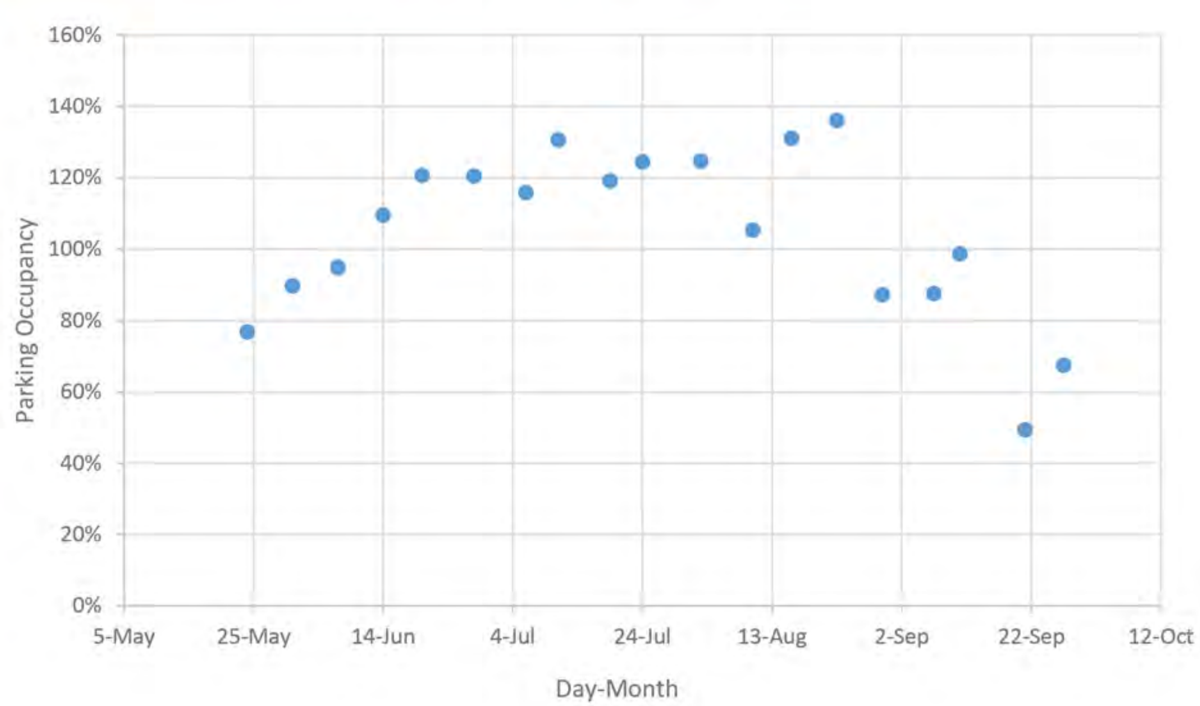


FIGURE A-4

OLD FAITHFUL CENTRAL PARKING LOT

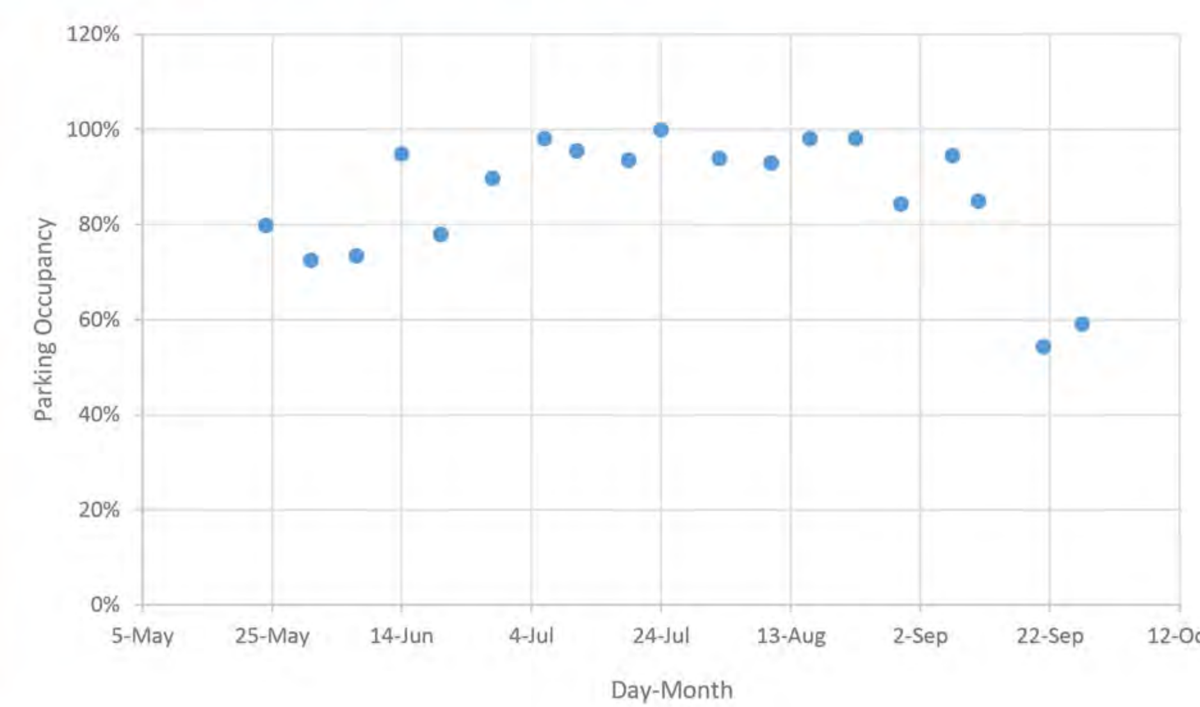


FIGURE A-5

OLD FAITHFUL INN PARKING LOT

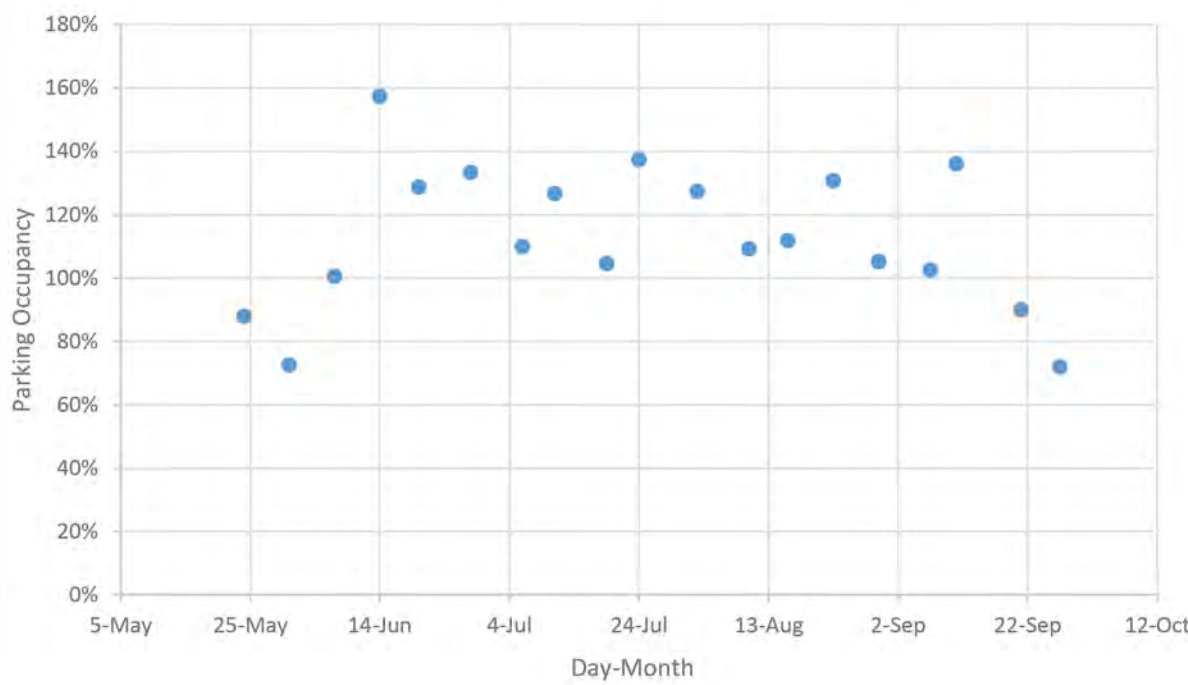


FIGURE A-6

NORRIS GEYSER PARKING LOT

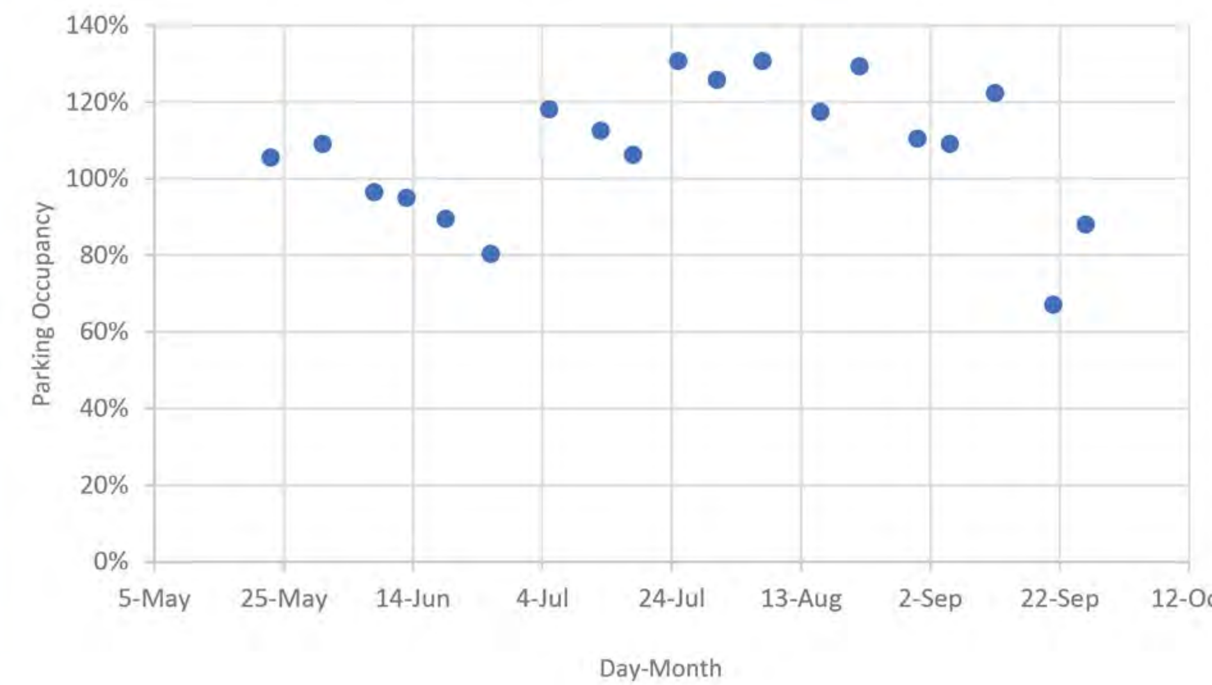


FIGURE A-7

OLD FAITHFUL STORE PARKING LOT

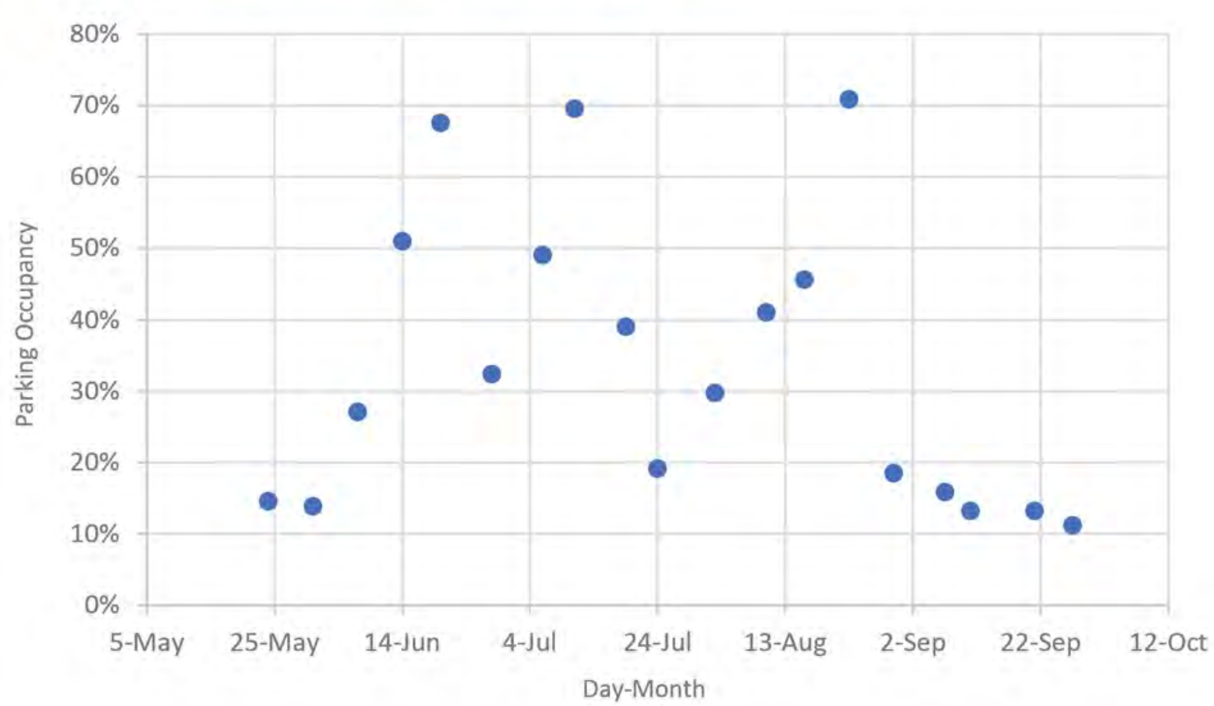


FIGURE A-8

CANYON VISITOR CENTER PARKING LOT

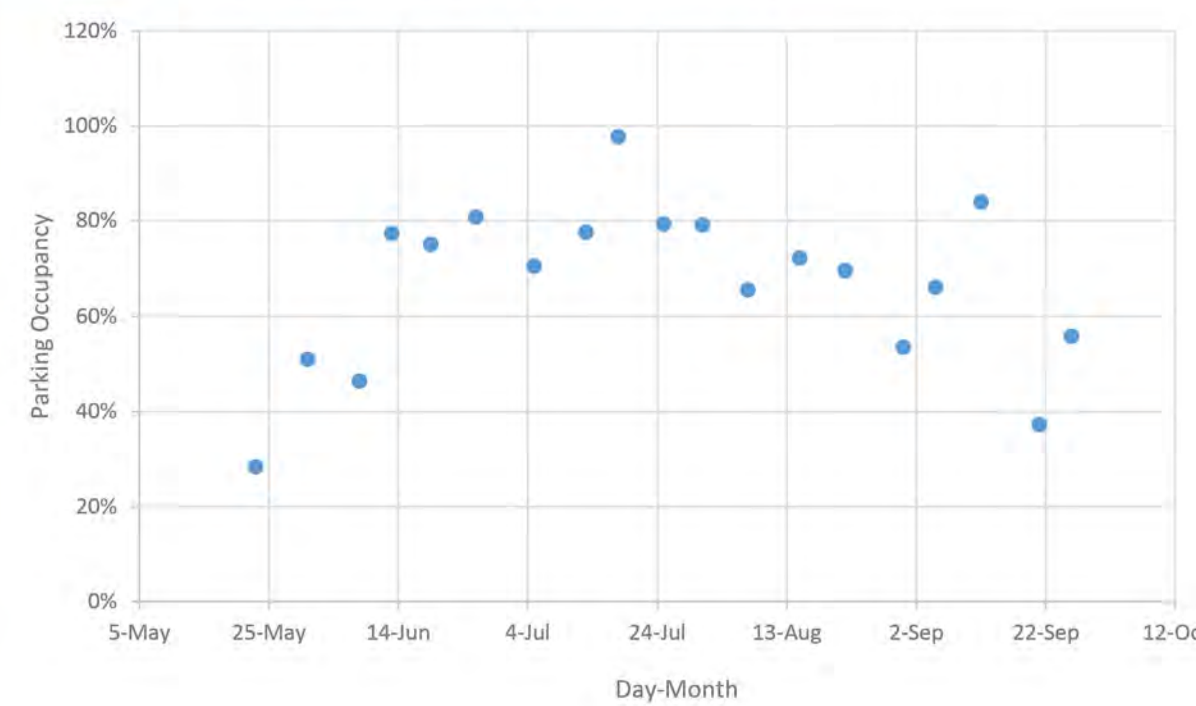


FIGURE A-9

NORTH RIM PARKING LOT

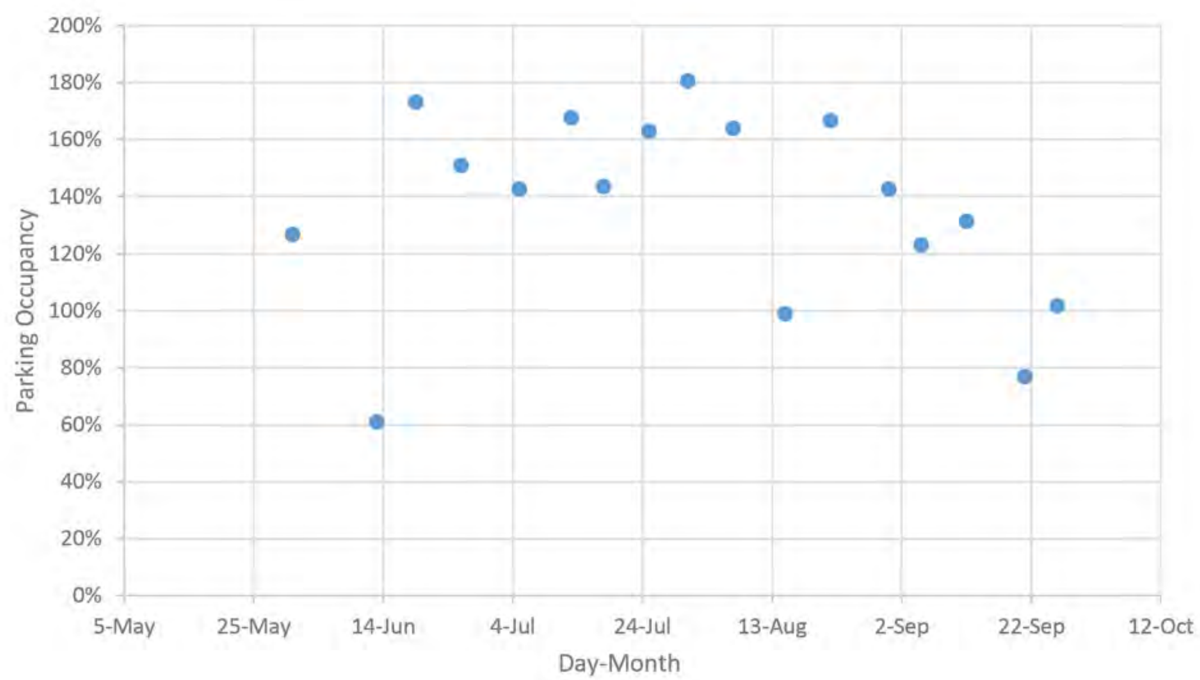


FIGURE A-10

WAPITI LAKE PARKING LOT

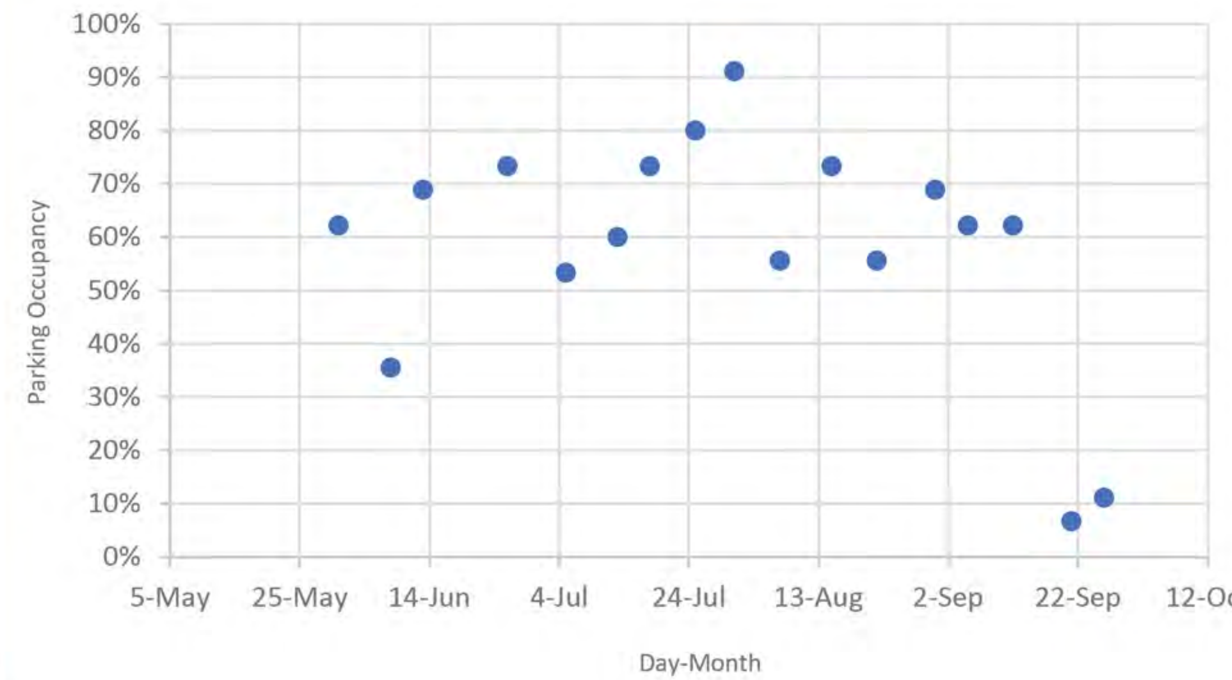


FIGURE A-11

UPPER FALLS PARKING LOT

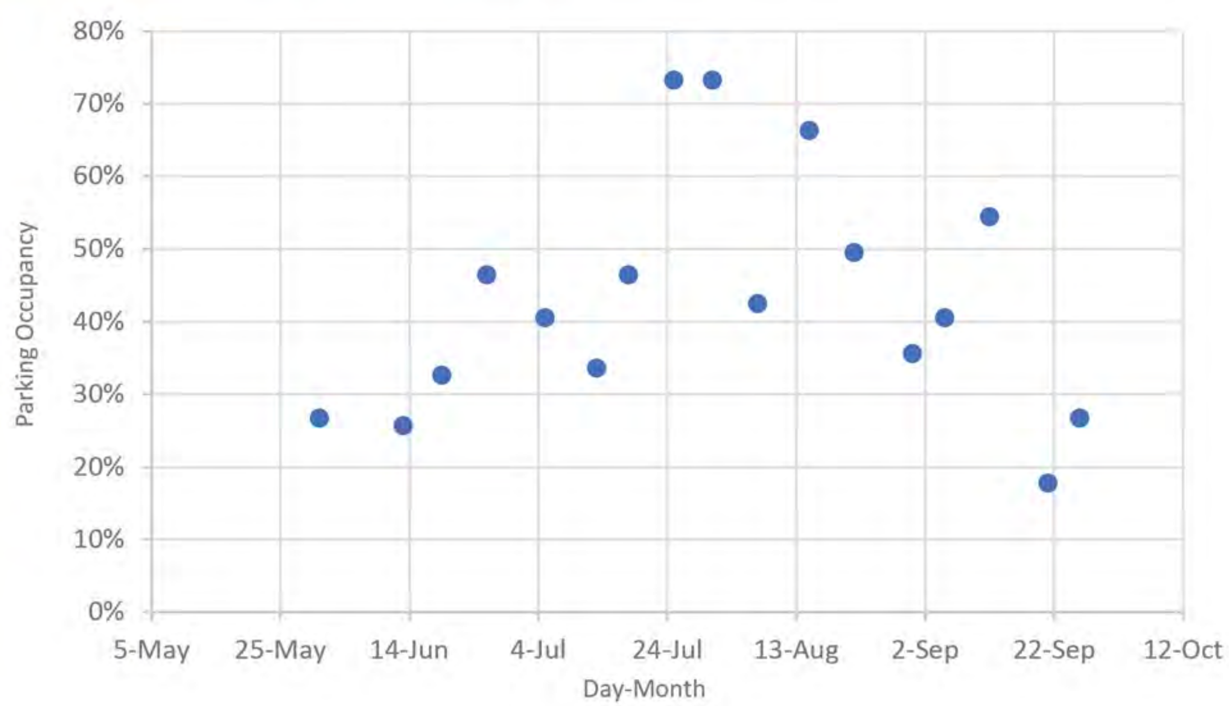


FIGURE A-12

ARTIST POINT PARKING LOT

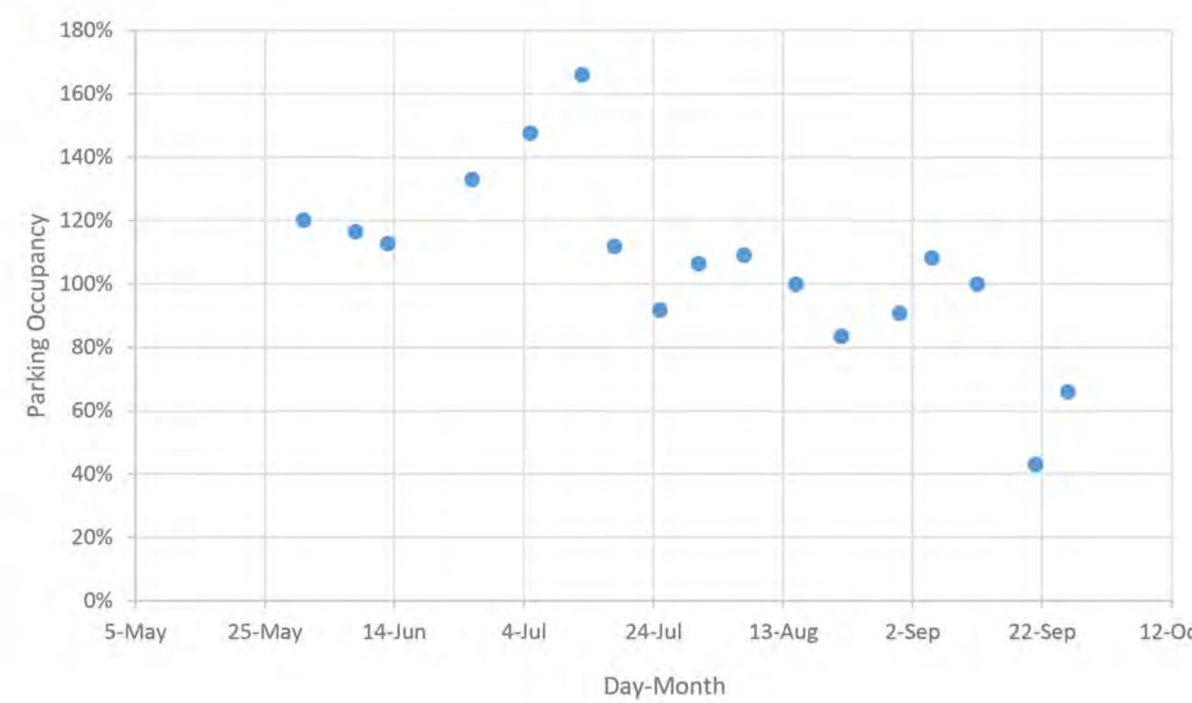


FIGURE A-13

FAIRY FALLS PARKING LOT

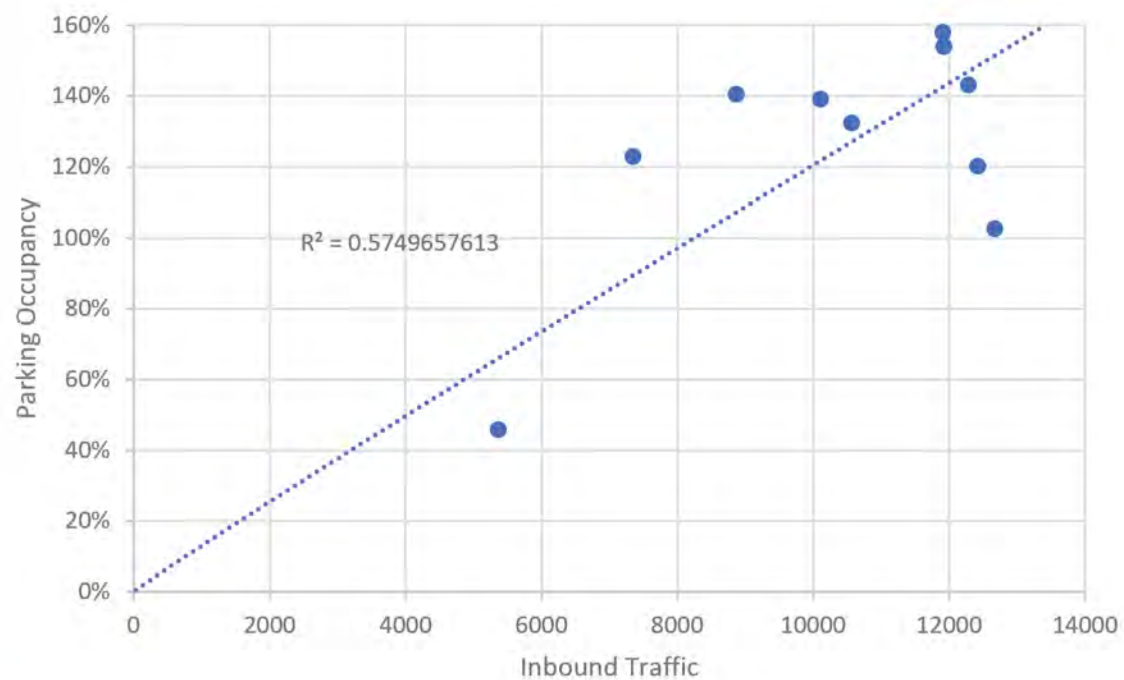


FIGURE A-14

MIDWAY PARKING LOT

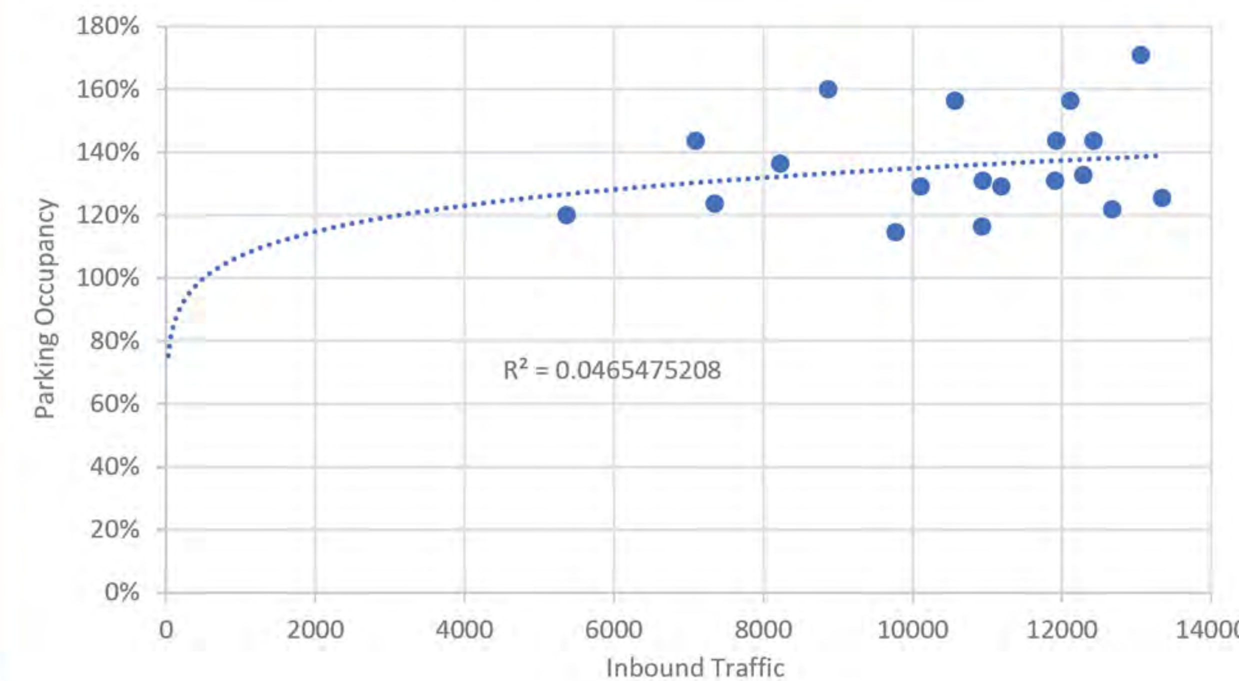


FIGURE A-15

OLD FAITHFUL EAST PARKING LOT

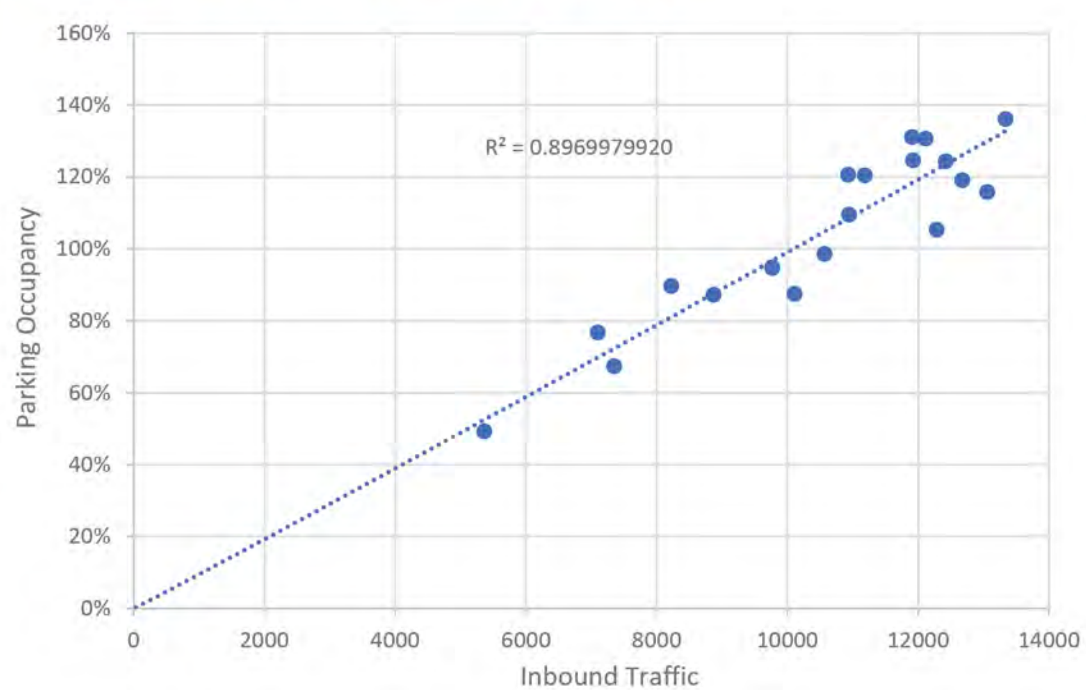


FIGURE A-16

OLD FAITHFUL CENTRAL PARKING LOT

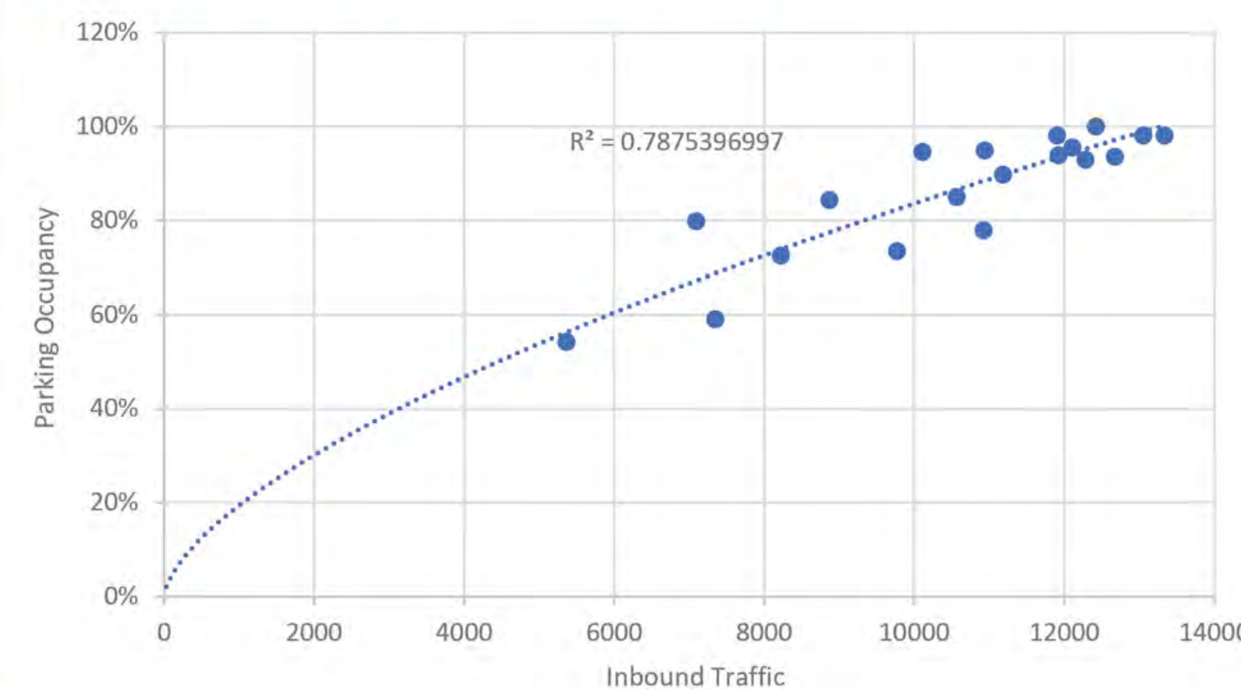


FIGURE A-17

OLD FAITHFUL INN PARKING LOT

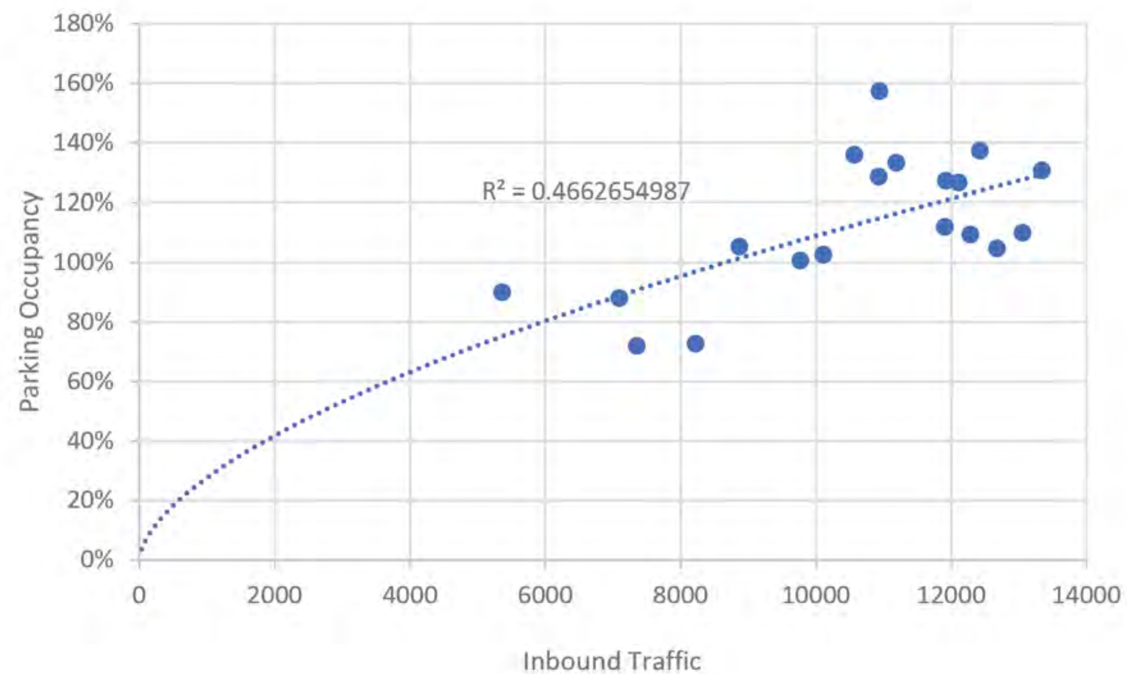


FIGURE A-18

OLD FAITHFUL STORE PARKING LOT

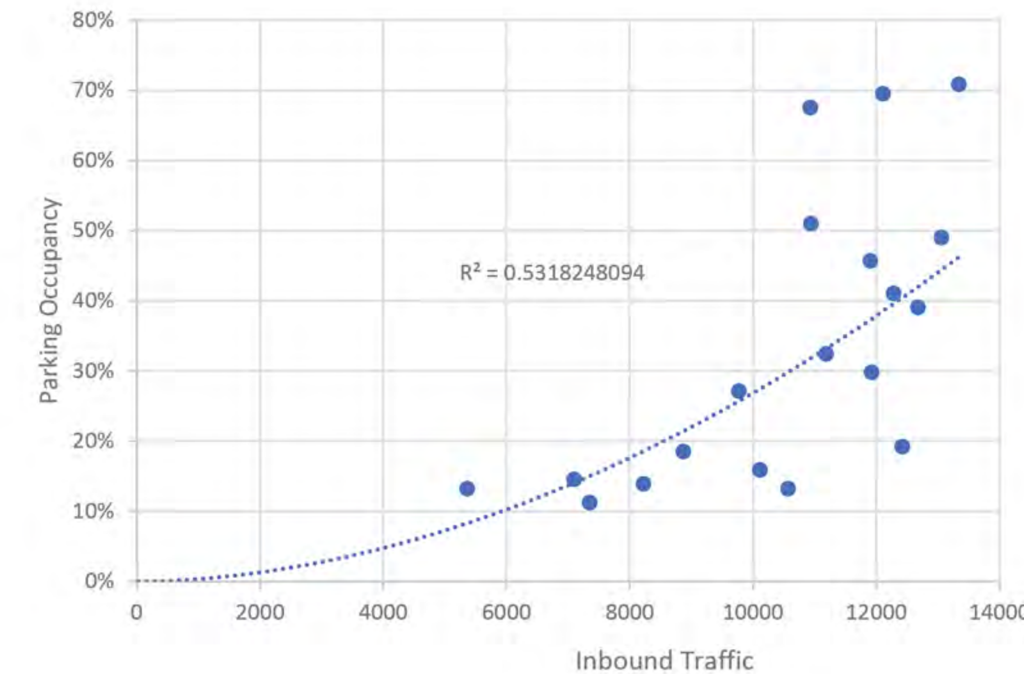


FIGURE A-19

NORRIS GEYSER PARKING LOT

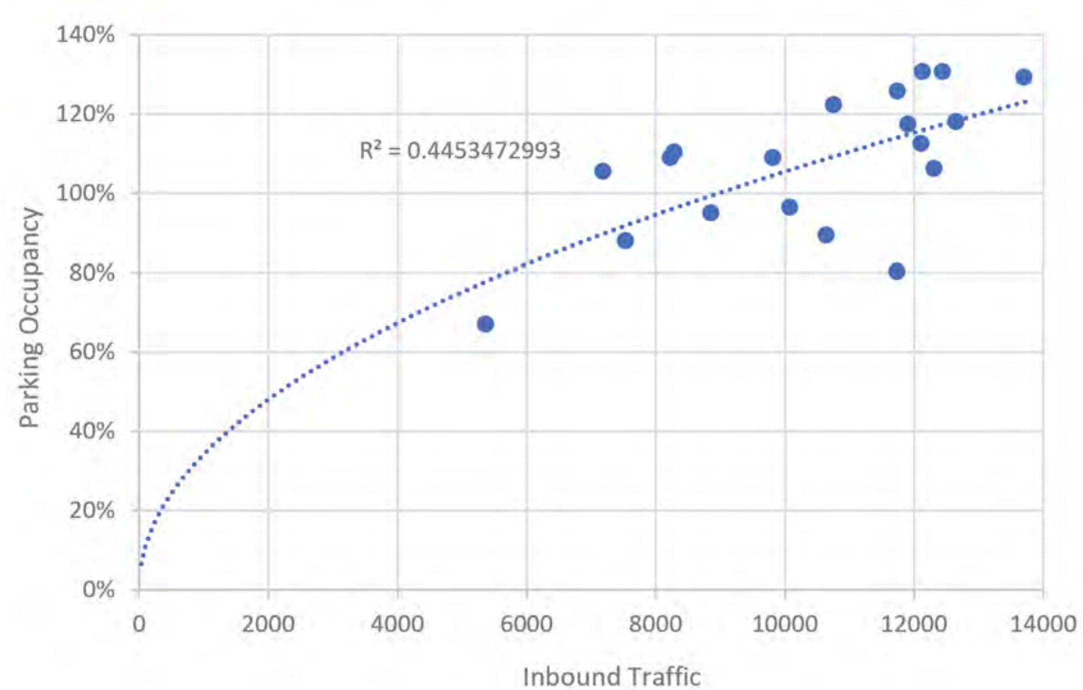


FIGURE A-20

CANYON VISITOR CENTER PARKING LOT

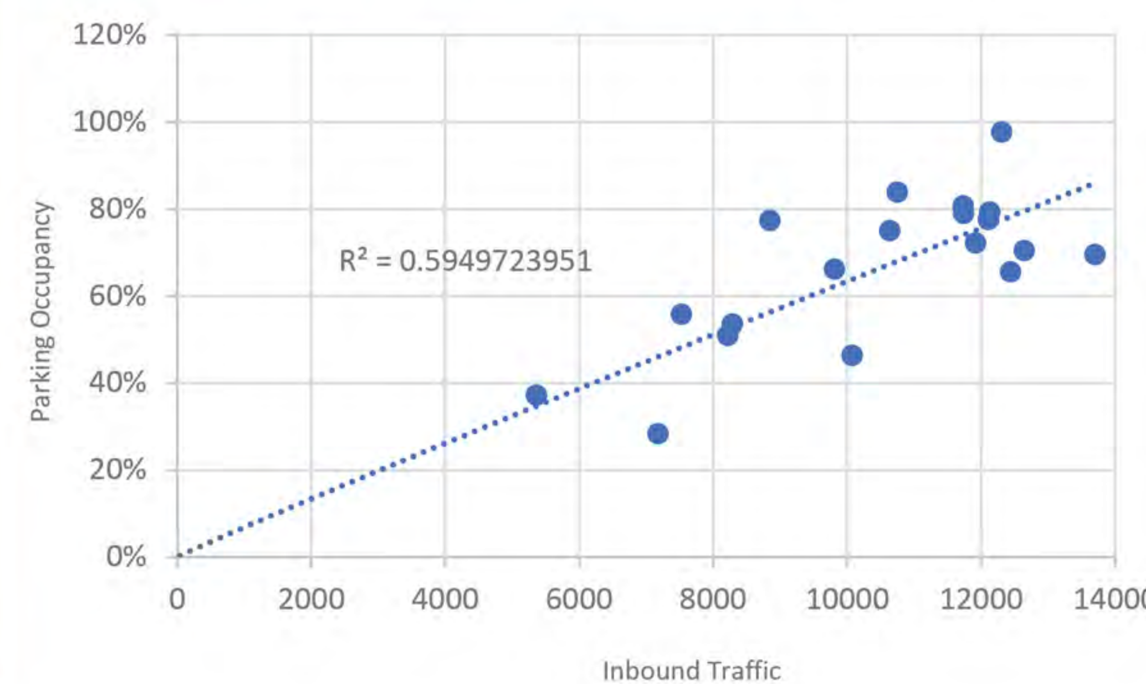


FIGURE A-21

NORTH RIM PARKING LOT

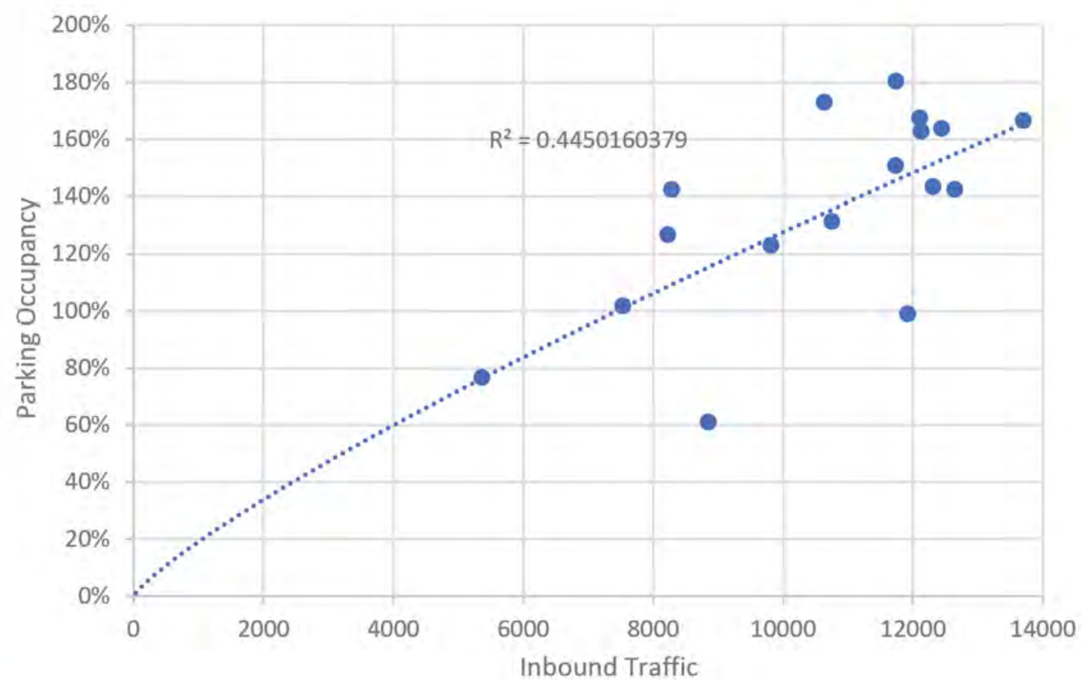


FIGURE A-22

WAPITI LAKE PARKING LOT

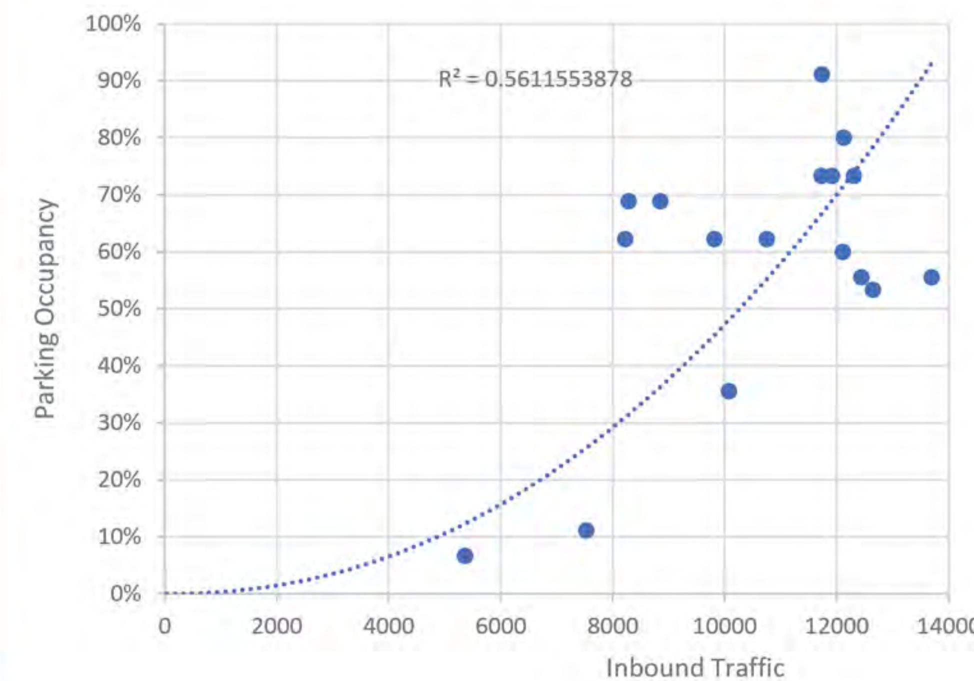


FIGURE A-23

UPPER FALLS PARKING LOT

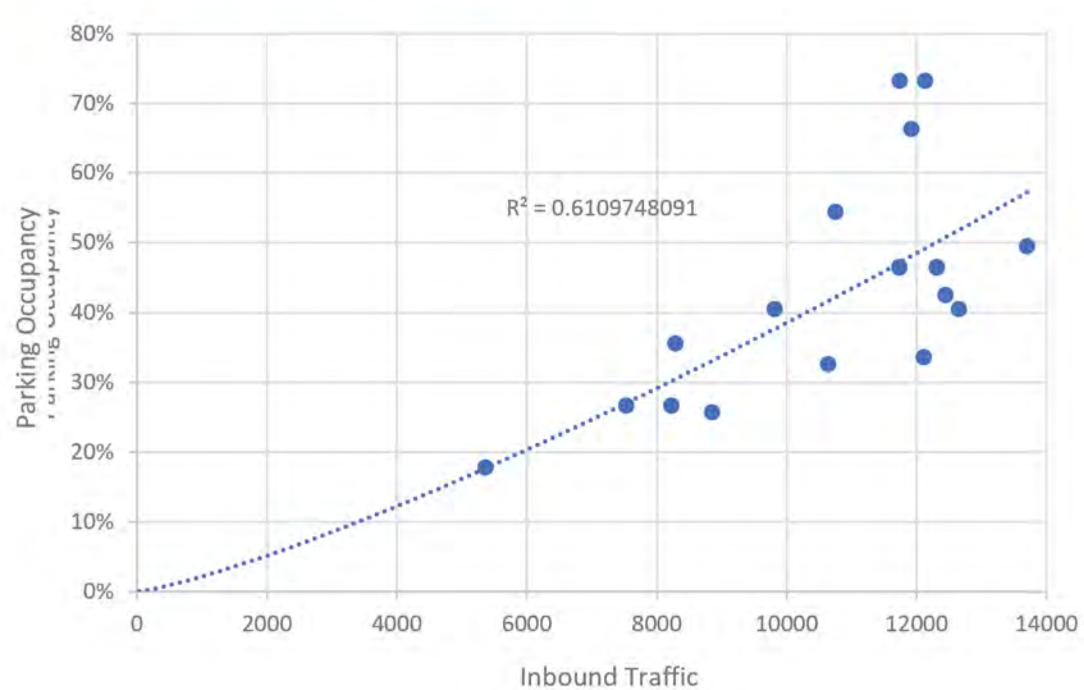


FIGURE A-24

ARTIST POINT PARKING LOT