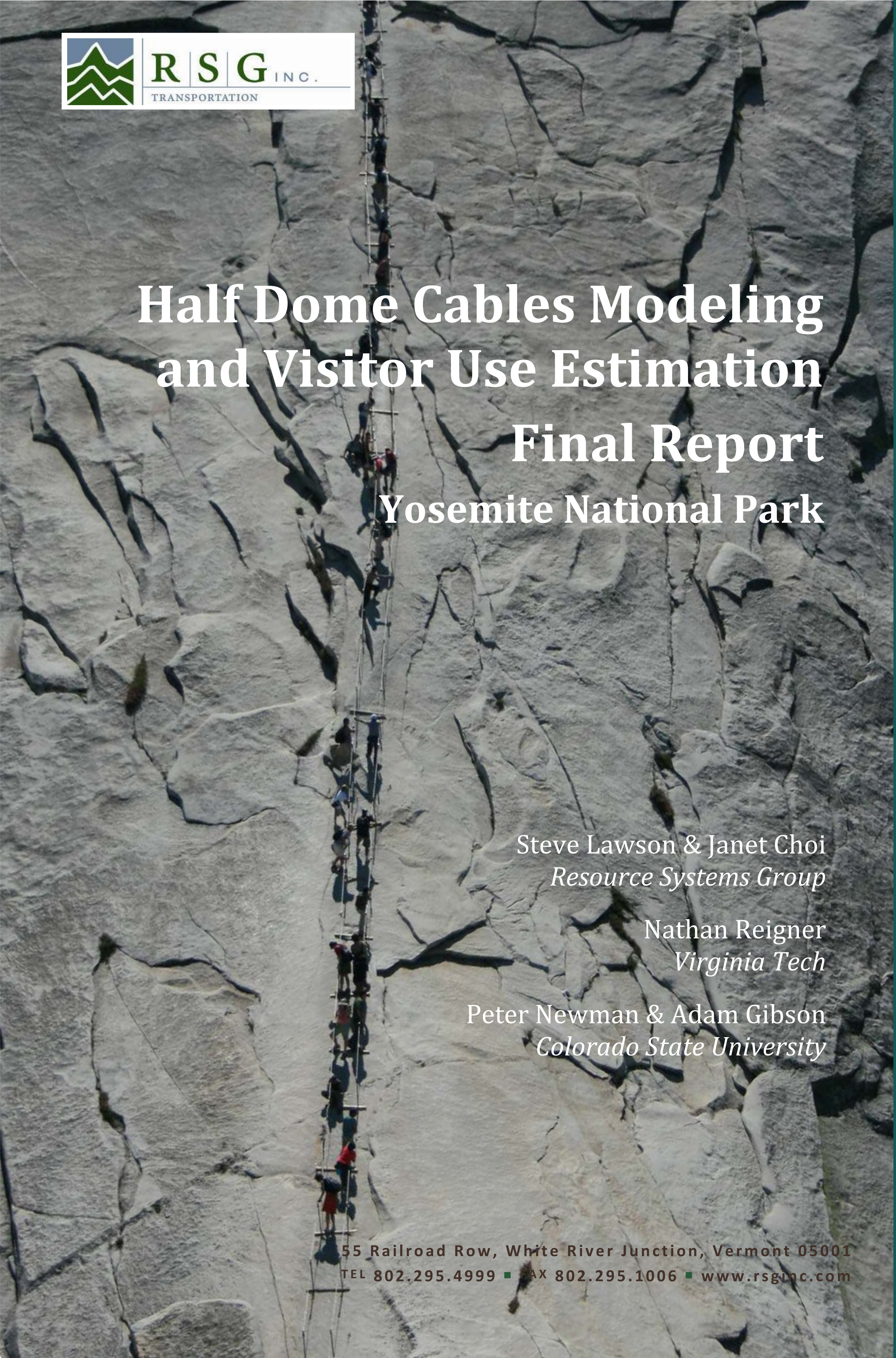

Half Dome Cables Modeling and Visitor Use Estimation Final Report

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Chapter 1: INTRODUCTION

In 1920, the Sierra Club developed a cable system that provides access to the summit of Half Dome for visitors without technical rock climbing ability. Today, the hike to the summit of Half Dome is arguably the most iconic and popular backcountry excursion for visitors to Yosemite National Park. The culmination of the hike involves ascending the last 400 vertical feet of Half Dome via the cable system. Most visitors ascend, and subsequently descend, the Half Dome summit between its two parallel cables. However, some visitors travel outside of the cables, incurring increased exposure to unarrested falls from the granite dome. The occurrence of this behavior, coupled with recent accidents involving falls from the cables, has made risk management on Half Dome a priority at the park. Much of the safety concern is related to the amount of time spent on the cables during periods of high use. Thus, the National Park Service (NPS) considers it paramount to understand how visitor numbers affect the length of time hikers are forced to stay on the cables for the ascent and descent, and to what extent length of time spent on the cables contributes to the prevalence of visitors traveling outside the cables. However, current information about visitor use of the cables is primarily anecdotal; scientifically defensible data are needed from which to develop management options that better address visitor safety issues on the Half Dome cables. Furthermore, the Half Dome Trail and cables route are located in Congressionally designated wilderness. The Wilderness Act defines wilderness as possessing "outstanding opportunities for solitude or a primitive and unconfined type of recreation." These areas "may also contain ecological, geological, or other features of scientific, educational, scenic, or historic value." Consequently, issues related to visitor use of the Half Dome Trail and cables route are salient within this study, not only with respect to visitor safety, but also in terms of the experiential wilderness values for which the NPS is mandated to manage the area.

The purpose of this study, therefore, is to assess relationships among: 1) the number of visitors per day embarking on hikes to the Half Dome Trail from Happy Isles; 2) visitor use on the Half Dome Trail; 3) the total number of people ascending and descending the Half Dome cables at one time; 4) the amount of time it takes visitors to ascend and descend the cables route; 5) the number of visitors who are forced or choose to travel outside the cables; and 6) visitors' perceptions of safety and crowding on the Half Dome cables route. The research conducted to achieve these objectives and presented in this report involves several interrelated components, including: 1) visitor counts; 2) hiking route surveys; 3) photographic observations of visitor use on the Half Dome cables; 4) a survey concerning visitors' perceptions of safety and crowding on the Half Dome Cables; and 5) statistical and simulation modeling of visitor use data.

The remainder of this report is organized as follows: Chapter 2 describes the study area and research methods used to conduct data collection via visitor counts, visitor surveys, and photographic observations; Chapter 3 presents descriptive results of the visitor counts, visitor surveys, and photographic observations; Chapter 4 presents the methods used to develop a computer simulation model of visitor use on the Half Dome Trail and cables route, and associated descriptive results; and Chapter 5 presents a series of briefing documents that summarize and highlight results of statistical and simulation modeling of relationships among visitor use on the Half Dome cables, the amount of time it takes visitors to ascend and descend the cables, and the prevalence of visitors ascending or descending the route outside the parallel cables. Appendices in the report include copies of the data collection instruments and log sheets used in the study, code sheets for the electronic data files compiled from the visitor surveys and photographic observations, and details concerning statistical analyses conducted to ensure the computer simulation model estimates generated in this study are sufficiently precise. All electronic data files and images associated with this study are archived with Yosemite National Park, including visitor count data, hiking route survey data, jpeg image files of visitor use on the cables route, crowding and safety survey data, and the visitor use model.

Chapter 2: METHODS

As stated, the purpose of this study is to estimate visitor use of the Half Dome Trail and cables route in Yosemite National Park, and to model relationships among use density on the cables, the amount of time visitors spend on the cables, and the extent to which visitors travel outside the cables while ascending and descending the granite dome. Further, the study is designed to assess visitors' perceptions of safety and crowding on the Half Dome cables, and attitudes toward alternative strategies to manage visitor use on the Half Dome Trail and cables route. This chapter describes the study site and reports the methods used to conduct the study.

2.1 Study Site

The study area includes the most popular day-use route to the summit of Half Dome, which begins at the Happy Isles trailhead (denoted as "X0" in Figure 1) in Yosemite Valley. The hiking route ascends via the Mist Trail and/or John Muir Trail to the John Muir Trail's junction with the Half Dome Trail (denoted as "X1" in Figure 1 and Figure 2). The Half Dome Trail ascends from the John Muir Trail along the northeast ridge of Half Dome to an area known as the subdome, a small false summit (denoted as "X2" in Figure 2). Upon reaching the subdome, visitors get their first view of the cables route and often use the area to rest and organize their groups before climbing the cables. The base of the cables route (denoted as "X3" in Figure 2) is located in a small saddle between the subdome and Half Dome's true summit, and the top of the cables (denoted as "X4" in Figure 1 and Figure 2) is located on the northeastern corner of Half Dome's broad, flat summit. The cables route extends approximately 600 feet at an average grade of approximately 100%. The route is furnished with two parallel steel cables extending its entire length, forming a double handrail. The cables are approximately 3' apart and are supported off the ground by stanchions spaced at intervals of approximately 10'.

Figure 1. Half Dome Study Area from Happy Isles to Half Dome Summit

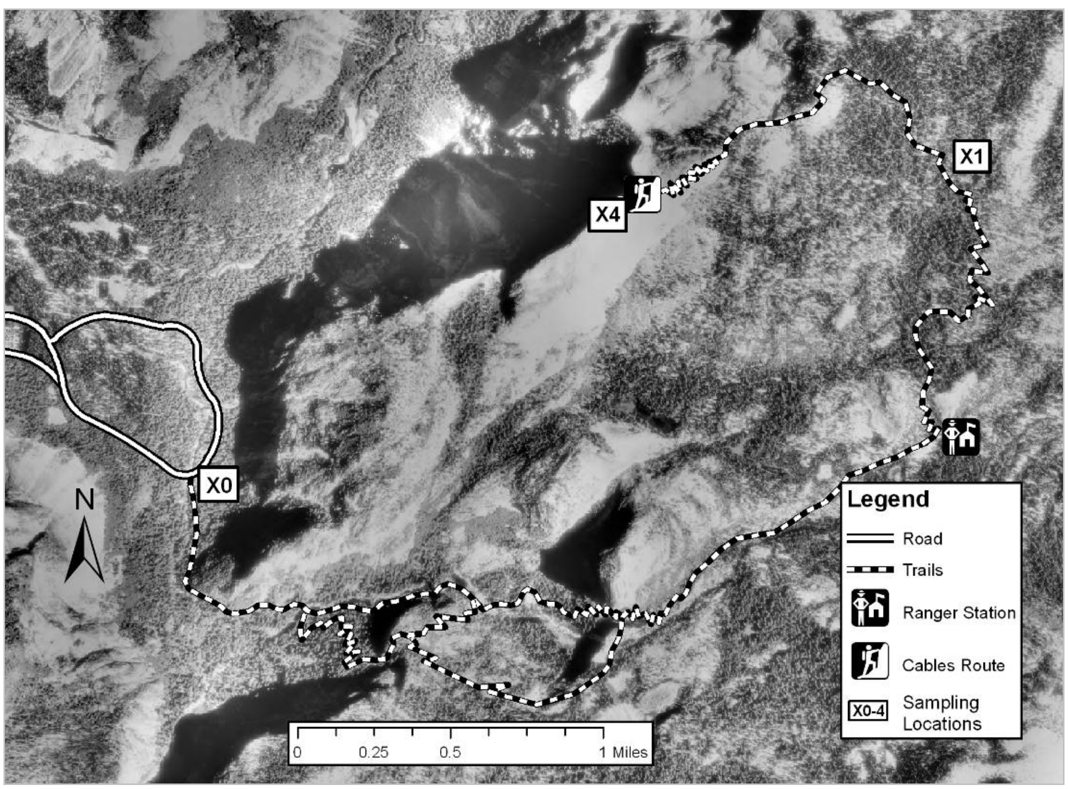
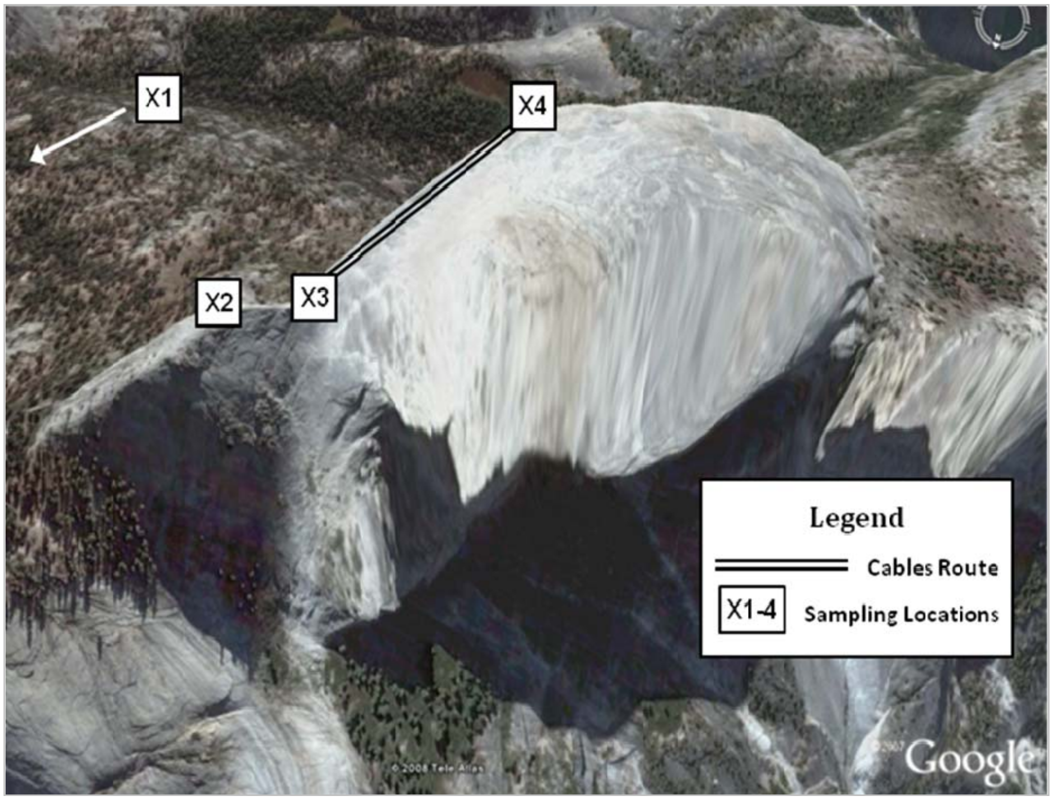


Figure 2. Half Dome Study Area from Half Dome Trailhead to Half Dome Summit



Within the study area, there were two primary types of sampling locations where field staff were stationed to conduct visitor surveys, visitor counts, and or photographic observations: 1) trailheads; and 2) destination points. Trailheads represent locations where visitors enter and exit the study area, while destination points mark the locations of key destinations along the hiking route (i.e., the subdome, base of the cables, and Half Dome summit). The sampling locations are marked on the schematic diagrams of the study area with text boxes numbered X0-X4 (Figure 1 and Figure 2).

2.2 Data Collection

Visitor counts, visitor surveys, and photographic observations were conducted during the summer of 2008 to collect information needed to estimate and model visitor use on the Half Dome Trail and cables route. This section of the report describes the data collection instruments and procedures used in this study, beginning with the visitor counts.

2.2.1 Visitor Counts

Visitor counts were conducted during July and August 2008 to document the number of Half Dome hikers embarking from the Happy Isles trailhead and total visitor use of the Half Dome Trail, by time of day and day of week. The visitor counts were conducted 24 hours per day at the Happy Isles trailhead and on the Half Dome Trail at its junction with the John Muir Trail (denoted as "X0" and "X1", respectively, in Figure 1) via mechanical trail traffic counters, beginning July 11, 2008 and ending August 10, 2008. Data needed to calibrate or correct the mechanical trail traffic counter data were collected via direct observation on a subset of the days during which the trail counters were in operation. The procedures used to collect visitor counts via mechanical trail traffic counters and associated calibration data were designed by researchers at Resource Systems Group and Virginia Tech, in consultation with Yosemite National Park, and are described in the following paragraphs.

A TRAFx infrared trail counter was installed on the John Muir Trail, approximately 90 feet beyond the Happy Isles Trailhead, and a second TRAFx counter was installed on the Half Dome Trail, approximately 100 feet beyond its junction with the John Muir Trail. Both counters were programmed with a 0.75 second minimum interarrival time. Because of the relatively high number of "events" (i.e., visitors passing the counter and triggering counts to be registered) at the Happy Isles trailhead and associated data storage capacity constraints of the counter, the counter at that location was programmed to record counts in hourly "bins." The number of "events" on the Half Dome Trail was sufficiently low to program the counter there to record counts as individual timestamps (i.e., date and time of each count, to the second).

To collect data needed to calibrate or correct the mechanical trail traffic counter data, visitor counts were conducted via direct observation on a sample of nine days, including two Saturdays, during July and August, 2008. Calibration counts were conducted at both locations on each of the nine sampling days, with counts being conducted from 5:00 AM to 7:00 PM at the Happy Isles trailhead and from 9:00 AM to 4:00 PM on the Half Dome Trail at its junction with the John Muir Trail. A PDA-based program was used to record timestamp data for calibration counts at the Happy Isles trailhead, while mechanical hand-counters and log sheets were used to record calibration counts in 15 minute intervals on the Half Dome Trail (see Appendix A for a copy of the log sheet used to record calibration counts on the Half Dome Trail). Information recorded with the calibration counts includes: 1) time of day for each passing visitor; and 2) direction of travel of each passing visitor (i.e., arriving or departing the corresponding trail).

These data provided the empirical basis to calibrate or correct raw mechanical counter data via regression analyses, the results of which are reported in Chapter 3. In addition, the direction of travel data collected during calibration counts were used to convert calibrated mechanical counter data to estimates of trailhead arrivals or visitation. Specifically, visitation was estimated by multiplying hourly calibrated counts by the proportion of arriving visitors in the corresponding hour, as derived from the direction of travel data.

The visitation estimates were summarized to report estimates of: 1) the number of Half Dome hikers embarking from the Happy Isles trailhead, by time of day and day of week; and 2) visitor use of the Half Dome Trail, by time of day and day of week. The summary results of visitor counts are reported in Chapter 3. The visitor count data were also used as a primary input into a computer simulation model of visitor use of the Half Dome Trail and cables route. Computer modeling methods are presented in Chapter 4, and results of simulation modeling of the visitor count and hiking route survey data are reported in Chapter 4 and Chapter 5.

2.2.2 Happy Isles and Half Dome Trail Hiking Route Surveys

Hiking route surveys were administered to random samples of visitors at the Happy Isles trailhead and on the Half Dome Trail, at its junction with the John Muir Trail (denoted as "X0" and "X1", respectively, in Figure 1) during the summer of 2008. The purpose of the hiking route surveys was to collect information needed to model visitor use of the Half Dome Trail and cables route. Specific information collected in the hiking route survey administered at the Happy Isles trailhead includes visitors': 1) group sizes; 2) hiking destinations (i.e., Half Dome Trail or other locations); and 3) hiking times from the Happy Isles trailhead to the Half Dome Trail. Specific information collected in the hiking route survey administered on the Half Dome Trail includes visitors': 1) group sizes; 2) hiking times from the Half Dome Trail's junction with the John Muir Trail to the subdome; 3) lingering times at the subdome, by direction of travel; 4) times spent in queue at the base of the cables; 5) travel times to ascend and descend the cables route; 6) behavior on the cables route (i.e., whether they went outside the cables on ascent and/or descent); 7) lingering times on the Half Dome summit; and 8) hiking times from the subdome to the Half Dome Trail's junction with the John Muir Trail.

The hiking route survey cards administered at the Happy Isles trailhead and on the Half Dome Trail were designed by researchers at Resource Systems Group and Virginia Tech, in consultation with Yosemite National Park, and were reviewed and approved by the Virginia Tech Internal Review Board and the

Office of Management and Budget. Appendix B contains a copy of the hiking route survey card administered at the Happy Isles trailhead, and Appendix C contains a copy of the hiking route survey card administered to visitors on the Half Dome Trail. Copies of the survey logs used to record information about survey response rates at the Happy Isles trailhead and on the Half Dome Trail are contained in Appendix D and Appendix E, respectively. Electronic copies of the hiking route survey data are archived with Yosemite National Park and code sheets corresponding to these data files are contained in Appendix F and Appendix G. The survey administration procedures administered at Happy Isles differed from those administered on the Half Dome Trail, both of which are described in the following paragraphs.

Hiking route survey sampling was conducted on five days in July, 2008 at the Happy Isles trailhead from 5:00 AM to 12:15 PM, resulting in a total of 150 useable hiking route survey cards (Table 1). On each sampling day for the survey administered at the Happy Isles trailhead, one survey administrator was located at the Happy Isles trailhead (denoted as "X0" in Figure 1) and one was located at the Half Dome Trail's junction with the John Muir Trail (denoted as "X1" in Figure 1 and Figure 2). At the start of the sampling period, the surveyor stationed at the Happy Isles trailhead contacted the first arriving group and asked them if they intended to hike to the Half Dome Trail, and if so, if they would be willing to participate in the survey. The surveyor continued to contact arriving visitor groups until a group hiking to the Half Dome Trail agreed to participate. The surveyor repeated this survey recruitment process at 10 minute intervals throughout the sampling day. Each time the surveyor contacted a visitor group to participate in the survey, the surveyor recorded on the survey log whether the group agreed to participate or refused, as well as the group size and time of contact for each intercepted group. For those groups who agreed to participate in the survey, the surveyor recorded on a survey card the size of the visitor group, the date, and the current time. The surveyor then handed the card to the visitor group and instructed them to carry the card during their hike to the Half Dome Trail and to hand the card to the survey administrator stationed at the junction of the John Muir Trail and Half Dome Trail. In addition to hiking route survey recruitment, the surveyor stationed at the Happy Isles trailhead attempted to ask verbally, rather than with a written questionnaire, all arriving visitor groups if they intended to hike to the Half Dome Trail and cables, or if they were hiking to other destinations. While the surveyor attempted to ask all arriving groups to report their hiking destinations, a few groups were missed due to the logistical challenges of contacting all visitor groups. While administration of the hiking route survey at Happy Isles ended at 12:00 PM each sampling day, a surveyor remained at the Happy Isles trailhead until 5:00 PM to ask visitor groups whether they were hiking to the Half Dome Trail or to other hiking destinations. The surveyor stationed at the Half Dome Trail's junction with the John Muir Trail collected cards from arriving groups between the hours of 8:00 AM and 4:00 PM and recorded the current time on each card as it was collected. Thus, the survey cards provide a measure of each participating group's hiking time from the Happy Isles trailhead to the Half Dome Trail.

Table 1. Happy Isles Hiking Route Survey Sampling Effort

Date	Day of Week	Solicitations	Accept	Refuse	LB Refusal [a]	Unusable [b]
7-24-08	Thursday	34	33	1	1	2
7-25-08	Friday	32	30	2	1	0
7-26-08	Saturday	39	36	3	1	7
7-27-08	Sunday	40	35	5	1	3
7-28-08	Monday	37	32	5	0	4
	Total	182	166	16	4	16

[a] "LB Refuse" were refusals due to a language barrier with the potential respondent.

[b] Includes cards that were not returned and those that contained illegible, incomplete, or otherwise unusable data.

Hiking route survey sampling was conducted on 11 days in July 2008 on the Half Dome Trail, resulting in a total of 976 useable hiking route survey cards (Table 2). On each sampling day for the hiking route survey administered on the Half Dome Trail, one survey administrator was located at each of the following locations: 1) the junction of the John Muir Trail and Half Dome Trail (denoted as "X1" in Figure 1 and Figure 2); 2) the point at which visitors hiking from the Half Dome Trail's junction with the John Muir Trail first reach the subdome (denoted as "X2" in Figure 2); 3) the base of the Half Dome cables route (denoted as "X3" in Figure 2); and 4) the top of the Half Dome cables route (denoted as "X4" in Figure 1 and Figure 2).

Table 2. Half Dome Trail Hiking Route Survey Sampling Effort.

Date	Day of Week	Solicitations	Accept	Refuse	LB Refuse [a]	Unusable [b]
7-2-08	Wednesday	92	87	5	0	7
7-3-08	Thursday	96	92	4	0	8
7-4-08	Friday	113	104	9	3	18
7-5-08	Saturday	166	151	15	0	21
7-6-08	Sunday	74	70	4	1	10
7-7-08	Monday	113	107	6	2	11
7-18-08	Friday	118	112	6	1	10
7-19-08	Saturday	166	153	13	0	32
7-20-08	Sunday	61	57	4	1	11
7-21-08	Monday	107	103	4	1	20
8-2-08	Saturday	108	100	8	0	12
	Total	1214	1136	78	9	160

[a] "LB Refuse" were refusals due to a language barrier with the potential respondent.
[b] Includes cards that were not returned and those that contained illegible, incomplete, or otherwise unusable data.

Visitor groups were recruited on the Half Dome Trail at its junction with the John Muir Trail for participation in the Half Dome Trail hiking route survey from 9:00 AM to 1:00 PM. At the start of the sampling period, the surveyor stationed at the Half Dome Trail's junction with the John Muir Trail contacted the first arriving group and asked them to participate in the survey. The surveyor continued to contact arriving visitor groups until a group agreed to participate. Each time the surveyor contacted a visitor group to participate in the survey, the surveyor recorded on the survey log whether the group agreed to participate or refused, as well as the group size and time of contact for each intercepted group. When the surveyor recruited a visitor group for the survey, the surveyor recorded on a survey card the size of the visitor group, the date, the current time, and whether the group started their hike at Happy Isles that day or not. The surveyor then handed the card to the visitor group and instructed them to carry the card during their hike on the Half Dome Trail and cables route, and to hand the card to each survey administrator they passed during their hike. Surveyors stationed at the subdome, base of the cables route, and top of the cables route collected hiking route survey cards from study participants each time they passed their survey locations, and recorded the current time. Surveyors then returned the survey cards to participants, and instructed them to continue carrying the cards and to hand the cards to each surveyor they passed during their hike. Hiking route survey cards were collected from visitor groups as they were departing the Half Dome Trail onto the John Muir Trail until 4:00 PM on each sampling day. The surveyor recorded the current time when the card was collected from departing visitors and asked visitors if they had traveled outside the cables on ascent or descent of the cables route, and if so, to select from a list of reasons on the survey card or give a different reason that best explained why they did. Beginning at 2:00 PM on each sampling day, the surveyor stationed at the subdome also collected survey cards from visitors departing the subdome area in the direction of the John Muir Trail and administered the final questions regarding behavior on the cables. Survey card collection at the subdome sampling location was started at 2:00 PM each sampling day to minimize the number of groups who still had hiking route survey cards in their possession when surveyors left the study area at the end of the sampling period (i.e., at 4:00 PM). In summary, the completed visitor survey cards contain information about the amount of time visitor groups spent: 1) hiking from the Half Dome Trail's junction with the John Muir Trail to the subdome; 2) lingering at the subdome; 3) ascending and descending the cables route; 4) lingering on the Half Dome summit; and 5) hiking from the subdome back to the Half Dome Trail's junction with the John Muir Trail. These data provide an empirical basis to model relationships among: 1) use density on the cables; 2) the amount of time visitors spend on the cables; and 3) the extent to which visitors travel outside the cables while ascending and descending the granite dome. Further, these data serve as a primary basis for development of the computer simulation model of visitor use on the Half Dome Trail and cables route. Descriptive results of the hiking route surveys are reported in Chapter 3, while results of simulation and statistical modeling of the visitor count and hiking route data are reported in Chapter 4 and Chapter 5.

To track visitor survey response rates to the hiking route surveys administered at the Happy Isles trailhead and on the Half Dome Trail, surveyors recruiting study participants at the two locations recorded a survey log entry for each visitor group asked to participate in the study (see Appendix D and Appendix E for copies of the Happy Isles and Half Dome Trail hiking route survey logs, respectively). Information recorded on the survey log for each contacted group includes: 1) time of day when the contact was made; 2) visitor group size; 3) whether the group accepted or refused to participate; 4) the hiking route survey card ID number for those groups who participated; and 5) comments concerning the contact, as needed (e.g., if a group refused to participate due to a language barrier). Visitor groups who were unwilling or unable to participate in the study were thanked for their consideration.

The survey log data were intended to be used to examine whether those visitor groups who refused to participate in the hiking route surveys were systematically different than those visitor groups who did participate in the study (i.e., whether the hiking route survey data are biased due to non-response). However, response rates for both hiking route surveys were relatively high – 82.4% at Happy Isles and 80.4% on the Half Dome Trail (Table 3). Nonetheless, while there were too few refusals to conduct robust statistical tests for non-response bias within the Happy Isles hiking route survey data, such a test was conducted for the Half Dome Trail hiking route survey data. Results of an independent samples t-test of means suggest that groups who refused to participate in the Half Dome Trail hiking route survey were, on average, smaller groups than those that participated (refusal mean group size = 2.04, study participant mean group size = 2.41; $t = -1.974$, p-value = 0.05). However, mean group size differences between respondents and non-respondents are not substantive. The statistical results noted, coupled with the relatively high response rates for both hiking route surveys, suggest that the hiking route survey data are not likely to be biased due to systematic differences between study participants and visitor groups who did not participate in the study.

Table 3. Hiking Route Survey Response Rate

	Happy Isles Trailhead	Half Dome Trailhead
Response Rate	82.4%	80.4%

2.2.3 Photographic Observations

Photographic observations of visitor use on the Half Dome cables route were recorded on 16 days in July and August, 2008. The photographic observations were recorded to document the number of people at one time on the cables route, including the number of people ascending or descending the route outside the parallel cables. Each photograph also documents the presence or absence of a queue at the base of the cables. The photographic observations were recorded from the subdome (the approximate sampling location is denoted as "X2" in Figure 2) and capture visitor use on the visible portion of the cables from that vantage point, which is estimated to be a 600 foot section of the cables route. This estimate is based on the assumption that the stanchions supporting the parallel cables are spaced approximately 10' apart and the fact that there are sixty pairs of stanchions visible in each photograph. Thus, the visible portion of the cables captured in the study photographs is estimated to constitute roughly 95% of the total length of the Half Dome cables route.

The photographic observations were recorded at 20 minute intervals between 9:00 AM and 4:00 PM on all but one day (July 7, 2008) that visitor counts or Half Dome Trail hiking route surveys were conducted. This resulted in a total of 16 sampling days and 328 photographic observations (Table 4). The photographic observations were recorded with a digital SLR camera, saved as jpeg files, and catalogued using a photographic observation log sheet (Appendix H).

Table 4. Half Dome Cables Route Photographic Observation Sampling Effort.

Date	Day of Week	Period of Observations [a]	# of Observations
7-2-08	Wednesday	9:00AM – 4:00PM	22
7-3-08	Thursday	9:00AM – 4:00PM	22
7-4-08	Friday	9:00AM – 4:00PM	22
7-5-08	Saturday	9:00AM – 4:00PM	22
7-6-08	Sunday	9:00AM – 4:00PM	22
7-11-08	Friday	9:00AM – 4:00PM	22
7-12-08	Saturday	9:00AM – 4:00PM	21
7-13-08	Sunday	9:00AM – 1:40PM	15
7-14-08	Monday	9:00AM – 2:00PM	16
7-15-08	Tuesday	9:00AM – 4:00PM	22
7-18-08	Friday	9:00AM – 4:00PM	22
7-19-08	Saturday	9:00AM – 4:00PM	22
7-20-08	Sunday	9:00AM – 9:20AM, 11:20AM—2:20PM	12
7-21-08	Monday	9:00AM – 4:00PM	22
7-29-08	Tuesday	9:00AM – 4:00PM	22
8-2-08	Saturday	9:00AM – 4:00PM	22
		Total	328

[a] Photographic observation was suspended during hazardous weather in the Half Dome area as indicated by truncated or discontinuous sampling periods.

Visitors ascending or descending the Half Dome cables within each photo were coded based on their location relative to the two parallel cables (Figure 3 on following page). In particular, those visitors whose abdominal midpoints appear to be between the cables were coded as inside the cables, and marked in green. Those visitors whose abdominal midpoints appear to be outside of the cables were coded as being outside the cables, and marked in red. Visitors who appear to be waiting at the base of the cables to begin ascending the route were coded as being in queue, and marked in yellow. Each color coded photo was used to compute several measures of visitor use at the time the photo was taken, including: 1) the total number of visitors on the cables route; 2) the number of visitors ascending or descending the route inside the cables; 3) the number of visitors ascending or descending the route outside the cables; and 4) the number of visitors in queue at the base of the cables. Coded image files in jpeg format, as well as an Excel file containing numeric visitor use data derived from the photos, are archived with Yosemite National Park. A code sheet for the visitor use data file derived from the photographic observations is contained in Appendix I.

The visitor measures derived from the photographic observations, coupled with the Half Dome Trail hiking route survey data, provide an empirical basis to model relationships among: 1) use density on the cables; 2) the amount of time visitors spend on the cables; and 3) the extent to which visitors travel outside the cables while ascending and descending the granite dome. To conduct analyses relating information from the two sampling efforts, the visitor use measures derived from the photographic observations of the cables route were merged with the Half Dome Trail hiking route survey data. Specifically, photo-based measures of visitor use on the cables route were matched to hiking route survey observations of starting times to ascend and descend the cables. This matching process produced four new "synthetic" variables for each case within the hiking route survey dataset, including: 1) total number of people on the cables during each hiking route survey participant's ascent of the cables; 2) number of people outside the cables during each hiking route survey participant's ascent of the cables; 3) total number of people on the cables during each hiking route survey participant's descent of the cables; and 4) number of people outside the cables during each hiking route survey participant's descent of the cables. These variables were instrumental in modeling relationships among cables route use density, the amount of time it takes visitors to ascend and descend the cables, and the prevalence of visitors ascending or descending the route outside the parallel cables. Results of statistical modeling of the photographic observation and hiking route survey data are reported in Chapter 5.

Figure 3. Coded Photographic Observation Depicting the Cables Route and Queue at its Base

2.2.4 Visitor Survey Concerning Perceptions of Safety and Crowding

A normative visitor survey was conducted in the summer of 2008 at the subdome on the Half Dome Trail (the sampling location is denoted as "X2" in Figure 2). The purpose of the survey was to explore visitors' perceptions of risk, safety, crowding, and acceptability of management actions, all with respect to the Half Dome cables route. Thus, survey results are intended to support NPS management decisions designed to address visitor safety and crowding issues on the Half Dome cables route.

The normative survey was designed by researchers at Colorado State University, in consultation with researchers at Resource Systems Group and Virginia Tech, as well as staff from Yosemite National Park. The survey instrument and sampling protocol were reviewed and approved by the Colorado State University Internal Review Board and the Office of Management and Budget. Appendix J contains a copy of the visitor survey. The specific types of information collected via the visitor survey include: 1) the general characteristics of Half Dome visitors; 2) visitors' perceptions of safety, risk, and crowding on the cables; 3) visitor-based crowding and safety standards for the number of people at one time on the cables route; and 4) visitors' support or opposition for potential management actions designed to address visitor safety and crowding on the cables route. The questions contained within the survey instrument to measure visitor-based crowding and safety standards were accompanied by digitally edited photographs depicting varying numbers of people at one time on the cables route (Appendix K). Respondents were asked to rate each photograph in terms of how safe and how crowded they would feel using 9-point Likert scale-bars that ranged from -4 "Very Unacceptable" to +4 "Very Acceptable."

The normative survey was administered to a random sample of visitors at the subdome on the Half Dome Trail on 3 weekdays and 2 weekend days between August 3 and August 16, 2008 (Table 5). The sampling location was strategically chosen in order to facilitate sampling visitors shortly after they had descended the cables route, as well as those who hiked to the subdome but chose not to ascend the cables route to the Half Dome summit. At the start of each sampling day, one of the two surveyors stationed at the subdome approached the first visitor group departing the subdome area and asked a randomly selected member of their group if he/she would be willing to participate in the survey. Visitors who agreed to participate in the study were instructed to obtain the survey instrument from the second surveyor, who provided verbal instructions to visitors about how to complete the questionnaire. Visitors who were unwilling or unable to participate in the survey were thanked for their consideration. After completing each contact with a visitor group, the surveyor completed an entry on the survey response log (Appendix L) and then asked the next departing visitor group to participate. This process continued throughout the sampling day. Of 323 people asked to participate in the study, 291 completed the survey. The overall response rate for the survey was 90%, thus supporting a high degree of confidence that the survey data are not subject to non-response bias.

Table 5. Half Dome Trailhead and Cables Route Normative Visitor Survey Sampling Effort.

Date	Day of Week	Solicitations	Accept	Refuse	LB Refuse [a]
8-3-08	Sunday	53	47	6	1
8-4-08	Monday	70	64	4	0
8-5-08	Tuesday	68	60	8	1
8-15-08	Friday	59	52	7	1
8-16-08	Saturday	74	68	5	3
	Total	324	291	30	6

Chapter 3: Descriptive Results: Visitor Counts, Hiking Route Survey, Photographic Observations, and Crowding and Safety Perceptions Survey

This chapter of the report presents descriptive results of the visitor counts, hiking route surveys, and photographic observations conducted to estimate and model visitor use of the Half Dome Trail and cables route. The chapter also reports results of the survey concerning visitors' perceptions of crowding and safety on the Half Dome cables. The chapter begins by reporting descriptive results of the visitor counts conducted at the Happy Isles trailhead and on the Half Dome Trail. Next, descriptive results of the Happy Isles and Half Dome Trail hiking route surveys are reported, followed by results of visitor use measures derived from the photographic observations of the Half Dome cables route. The chapter concludes with descriptive results of the visitor survey concerning perceptions of crowding and safety on the Half Dome cables route.

3.1 Visitor Counts

As noted, regression analyses were conducted to model the relationship between raw mechanical counter data and the calibration counts collected via direct observation. The purpose of the regression analyses was to derive an empirical basis to convert raw mechanical counter data to estimates of the actual number of visitors passing the counter per hour. Separate regression models were estimated based on the Happy Isles and Half Dome Trail counts, with the direct observation counts treated as "true" measures of visitor use and specified as the dependent variable in both models. The mechanical counter counts were entered as the independent or explanatory variable in each of the two regression models. The results of these regression analyses are reported in Table 6.

Table 6. Regression Results for Calibration of Mechanical Counters, by Trailhead Location

	Happy Isles Trailhead	Half Dome Trailhead
b1	1.17*	0.895*
R-square	0.931	0.830

*Denotes significance at $\alpha = 0.001$.

Table 7 reports the proportion of arriving and departing visitors, by time of day, at the Happy Isles trailhead and on the Half Dome Trail, at its junction with the John Muir Trail. These data were recorded as part of the direct observations conducted to collect calibration data for the mechanical counter data. The proportions of arrivals, by hour of the day and location, were applied to the calibrated counter data to estimate trailhead visitation, by time of day and location.

Table 7. Mean Hourly Proportion of Arriving and Departing Visitors, by Location

	Happy Isles Trailhead				Half Dome Trail at John Muir Trail Junction			
	Saturday/Holiday		Sunday-Friday		Saturday/Holiday		Sunday-Friday	
Time of Day	Arriving	Departing	Arriving	Departing	Arriving	Departing	Arriving	Departing
5 AM-6 AM	98%	2%	99%	1%	-	-	-	-
6 AM-7 AM	97%	3%	100%	0%	-	-	-	-
7 AM-8 AM	98%	2%	98%	2%	-	-	-	-
8 AM-9 AM	96%	4%	98%	2%	-	-	-	-
9 AM-10 AM	91%	9%	95%	5%	84%	16%	96%	4%
10 AM-11 AM	88%	12%	89%	11%	86%	14%	87%	13%
11 AM-12 PM	82%	18%	80%	20%	77%	23%	74%	26%
12 PM-1 PM	61%	39%	58%	42%	58%	42%	43%	57%
1 PM-2 PM	45%	55%	43%	57%	35%	65%	28%	72%
2 PM-3 PM	31%	69%	34%	66%	15%	85%	20%	80%
3 PM-4 PM	39%	61%	24%	76%	11%	89%	10%	90%
4 PM-5 PM	22%	78%	22%	78%	-	-	-	-
5 PM-6 PM	14%	86%	13%	87%	-	-	-	-
6 PM-7 PM	9%	91%	11%	89%	-	-	-	-

Table 8 reports the proportion of arriving visitors at the Happy Isles Trailhead whose destination is the Half Dome Trail and summit, versus those with another hiking destination, by time of day. These data were recorded as part of the Happy Isles trailhead hiking route survey and used to convert Happy Isles trailhead visitation estimates to estimates of Half Dome hikers at the Happy Isles trailhead, by time of day.

Table 8. Mean Hourly Proportion of Half Dome Hikers versus Other Hikers at the Happy Isles Trailhead

	Half Dome Hikers n = 567		Hikers with Other Destinations n = 2131	
Time	Mean	Percent	Mean	Percent
5 AM-6 AM	16	96%	1	4%
6 AM-7 AM	32	87%	5	13%
7 AM-8 AM	33	78%	9	22%
8 AM-9 AM	18	48%	20	52%
9 AM-10 AM	8	17%	39	83%
10 AM-11 AM	3	5%	71	95%
11 AM-12 PM	1	2%	69	98%
12 PM-1 PM	0	0%	65	100%
1 PM-2 PM	0	0%	47	100%
2 PM-3 PM	1	1%	45	99%
3 PM-4 PM	0	0%	32	100%
4 PM-5 PM	0	0%	25	100%

Table 9, Figure 4, Figure 5, Figure 6, and Figure 7 summarize results of the visitor counts conducted at the Happy Isles trailhead and on the Half Dome Trail. The numbers in the table and figures represent estimates of Half Dome hiker visitation, by time of day, day of week, and location, and are based on calibrated mechanical counter data, adjusted to reflect trailhead arrivals of Half Dome hikers.

Table 9. Mean Hourly Half Dome Hiker Visitation, by Day of Week Category and Location

Time of Day	Happy Isles		Half Dome Trail			
	Saturday/ Holiday	Sunday-Friday	Saturday/ Holiday	Saturday/ Holiday Excl. Potential Outliers	Sunday-Friday	Sunday-Friday Excl. Potential Outliers
12 AM-1 AM	21	5	1	1	1	0
1 AM-2 AM	11	3	3	2	1	1
2 AM-3 AM	9	3	17	4	2	2
3 AM-4 AM	13	2	31	9	5	3
4 AM-5 AM	20	12	25	4	4	3
5 AM-6 AM	84	39	7	4	4	4
6 AM-7 AM	126	66	17	9	8	8
7 AM-8 AM	125	67	51	44	25	24
8 AM-9 AM	111	46	113	77	52	48
9 AM-10 AM	58	32	135	106	78	75
10 AM-11 AM	25	12	159	117	88	83
11 AM-12 PM	12	6	139	115	76	73
12 PM-1 PM	0	1	112	100	41	39
1 PM-2 PM	0	1	60	52	24	24
2 PM-3 PM	0	3	26	22	19	19
3 PM-4 PM	0	0	14	13	8	7
4 PM-5 PM	0	0	10	9	3	3
5 PM-6 PM	0	0	5	3	1	1
6 PM-7 PM	0	0	1	1	0	0
7 PM-8 PM	0	0	0	0	0	0
8 PM-9 PM	0	0	0	0	0	0
9 PM-10 PM	0	0	0	0	0	0
10 PM-11 PM	0	0	0	0	0	0
11 PM-12 AM	0	0	0	0	0	0
Mean Daily Visitation	613	299	925	692	439	416

Figure 4. Mean Hourly Half Dome Hiker Visitation at the Happy Isles Trailhead, by Time of Day and Day of Week Category

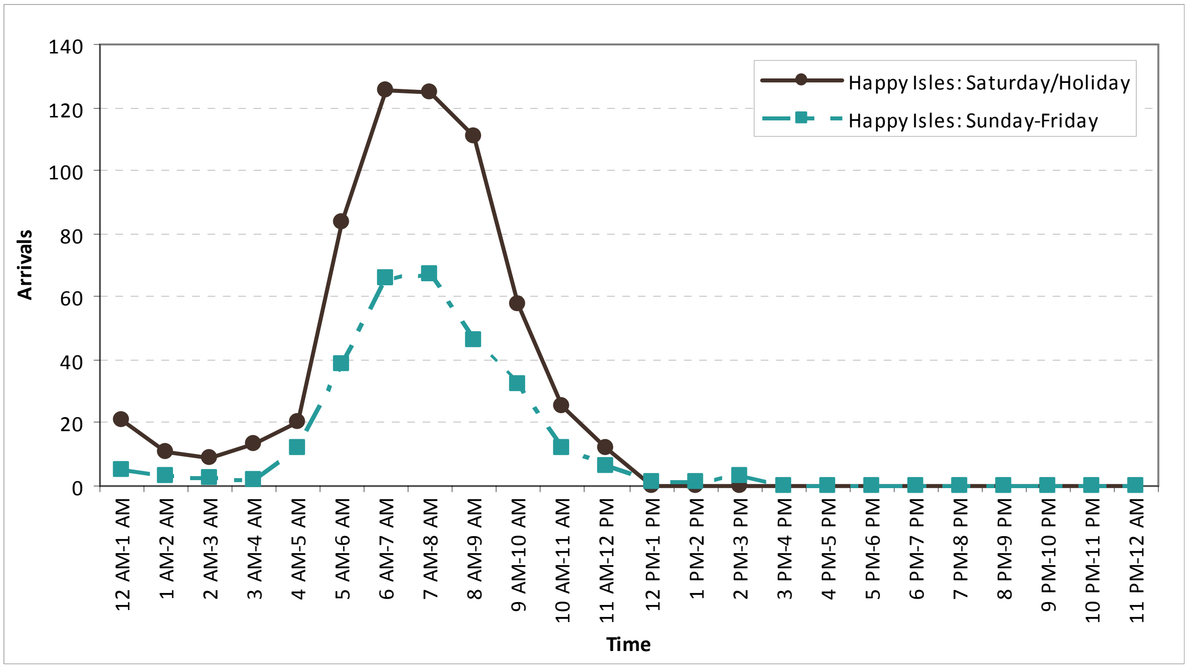


Figure 5. Mean Hourly Visitation on the Half Dome Trail, by Time of Day and Day of Week Category

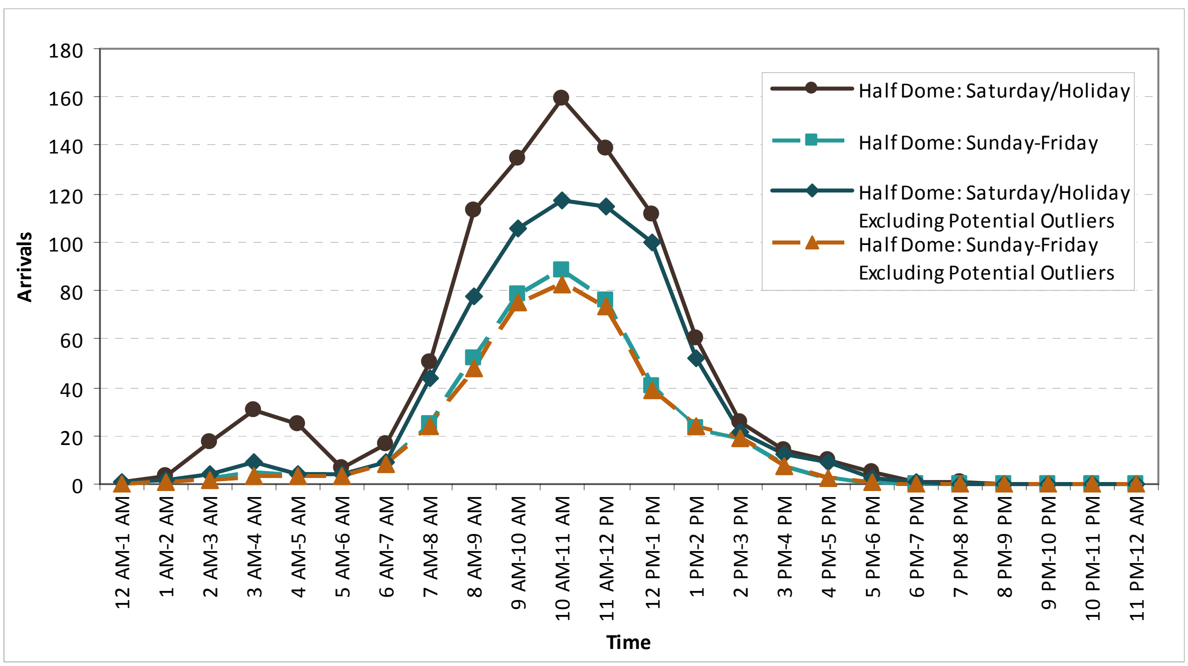


Figure 6. Mean Daily Half Dome Hiker Visitation, by Day of Week – Happy Isles Trailhead

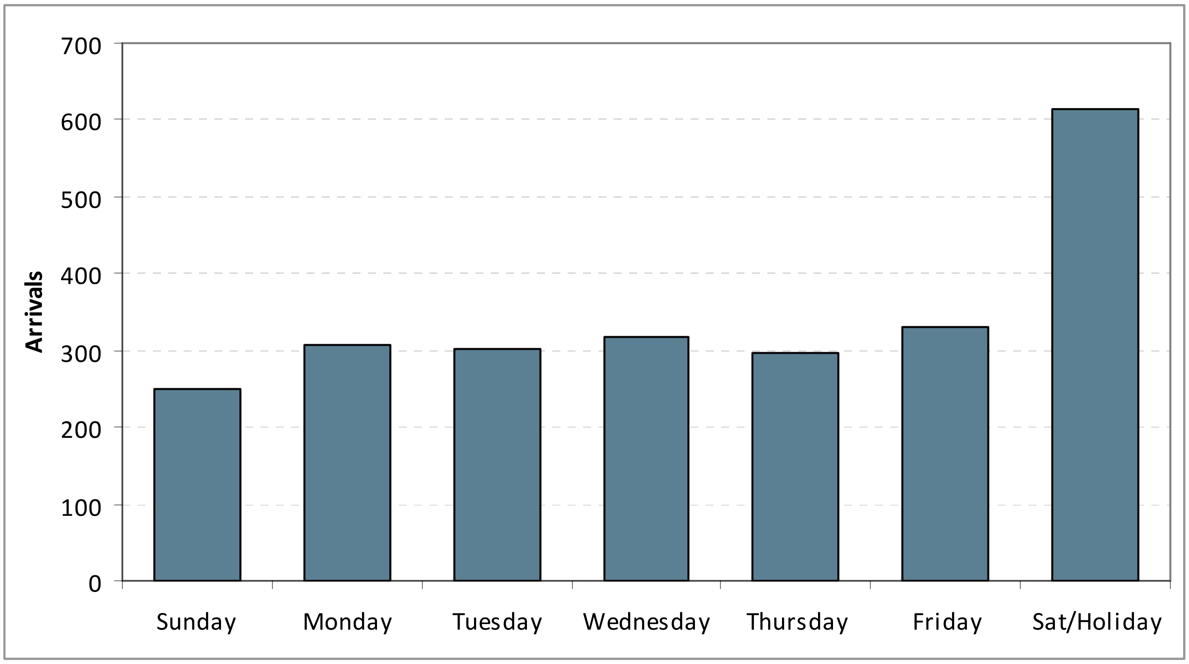


Figure 7. Mean Daily Visitation, by Day of Week – Half Dome Trail at John Muir Trail

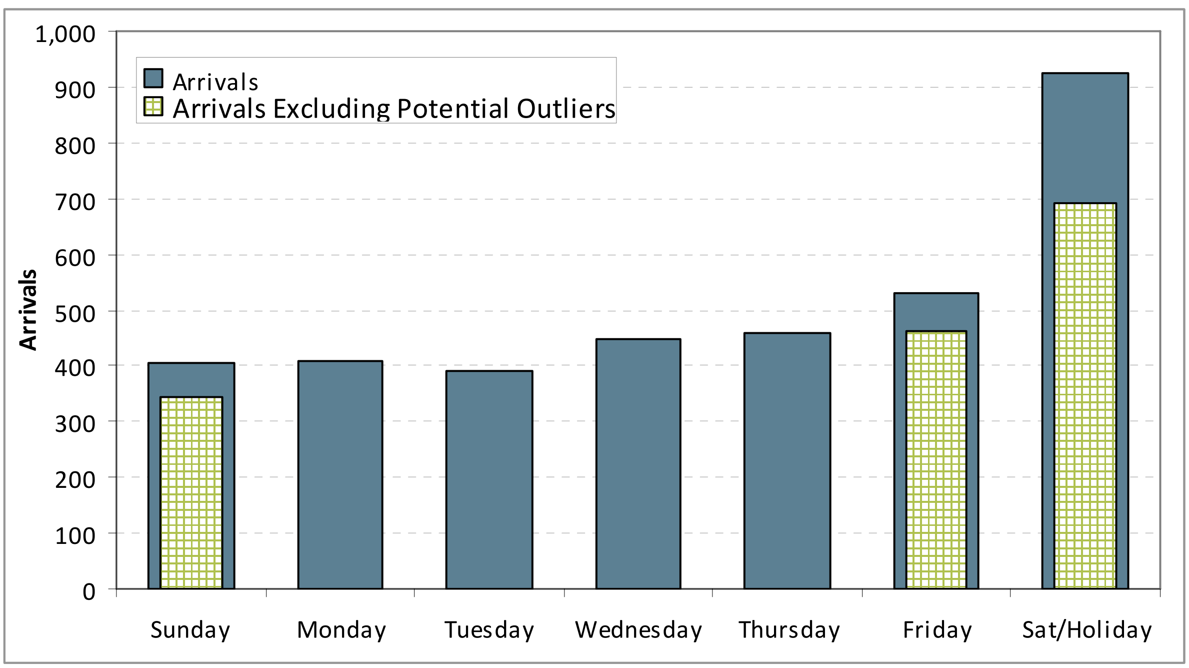


Figure 8 and Figure 9 summarize results of the visitor counts conducted at the Happy Isles trailhead and photographic observations of the number of people at one time (PAOT) on the Half Dome Cables. In particular, Figure 8 presents mean hourly arrivals of Half Dome hikers at the Happy Isles Trailhead and mean PAOT on the Half Dome Cables, by time of day, for Saturdays during the sampling period and July 4,

2008. Figure 9 presents mean hourly arrivals of Half Dome hikers at the Happy Isles Trailhead and mean PAOT on the Half Dome Cables, by time of day, for Sundays through Fridays during the sampling period.

Figure 8. Mean Hourly Half Dome Hiker Visitation at Happy Isles and PAOT on Cables, Saturday/Holiday

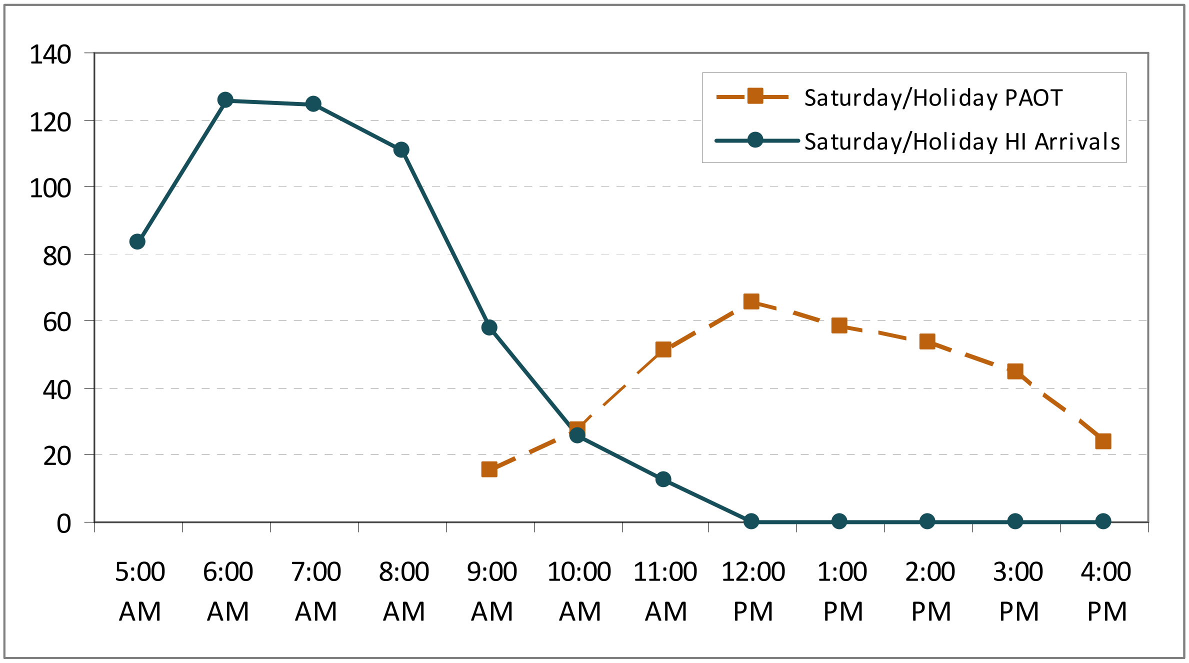
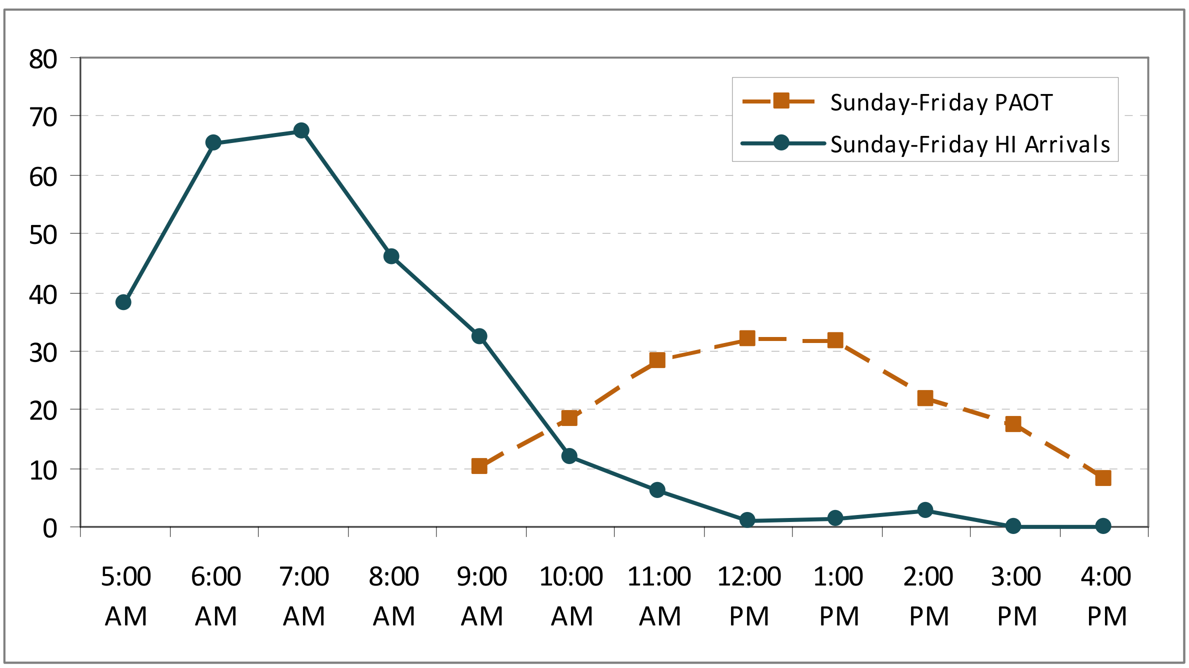


Figure 9. Mean Hourly Half Dome Hiker Visitation at Happy Isles and PAOT on Cables, Sunday-Friday



3.2 Happy Isles and Half Dome Trail Hiking Route Surveys

This section of the report presents descriptive results of the hiking route surveys administered at the Happy Isles trailhead and on the Half Dome Trail. Results of simulation and statistical modeling of the hiking route survey data are reported in Chapter 4 and Chapter 5.

The majority of visitors hike to the summit of Half Dome in groups of 2 or 3 people (Table 10). Furthermore, Half Dome hiking groups of 5 or more are very uncommon.

Table 10. Group Size, by Hiking Route Survey Location

	Happy Isles		Half Dome Trail	
Group Size	Count	Percent	Count	Percent
1	18	12%	226	24%
2	65	44%	449	47%
3	27	18%	134	14%
4	18	12%	90	9%
5	4	3%	35	4%
6	7	5%	17	2%
7	1	1%	0	0%
8	1	1%	0	0%
9	3	2%	0	0%
10	3	2%	0	0%
Mean	3		2	

The vast majority of visitor groups hiking to the summit of Half Dome are day-hikers who begin their hikes at the Happy Isles trailhead (Table 11). However, about one-fifth of early morning Half Dome Trail arrivals are groups who did not start their Half Dome hike at the Happy Isles trailhead that day.

Table 11. Proportion of Half Dome Hikers Who Started at Happy Isles that Day

	n = 398 Started at Happy Isles That Day	n = 42 Did Not Start at Happy Isles That Day
Time	Percent	Percent
8 AM-9 AM	81%	19%
9 AM-10 AM	89%	11%
10 AM-11 AM	94%	6%
11 AM-12 PM	95%	5%
12 PM-1 PM	95%	5%

Most visitor groups that hike to the Half Dome Trail do reach the summit of Half Dome (Table 12). The proportion of visitors who climb part-way up the cables and then decide to turn around before reaching the summit is quite small. Similarly, relatively small proportions of visitors on the Half Dome Trail hike no further than the subdome or base of the cables.

Table 12. Half Dome Hikers' Farthest Destination

	n = 943	
Furthest Point Reached	Count	Percent
Half-Dome summit	792	84%
Part-way up cables	25	3%
Base of cables	7	1%
Subdome	66	7%
Half Dome Trail, below Subdome	53	6%

Relatively few visitors reported going outside the cables during their ascent and/or descent of the cables (Table 13). Of those who did report going outside the cables, the most common reason reported, by far, for doing so was to avoid being delayed by crowds (Table 14).

Table 13. Half Dome Hikers' Self-Report of Going Outside Cables

	n = 785	
Outside Cables	Count	Percent
Did not go outside cables	543	69%
Yes, went outside on ascent	30	4%
Yes, went outside on descent	125	16%
Yes, went outside on both ascent and descent	87	11%

Table 14. Half Dome Hikers' Self-Reported Reasons for Going Outside Cables

	n = 352	
Outside Cables Reason	Count	Percent
Went outside the cables to avoid being delayed by crowds	173	49%
Went outside the cables because I thought it would be safer	50	14%
Went outside the cables because I thought it would be more fun	48	14%
Went outside the cables to let others pass	69	20%
Went outside the cables for other reasons	12	3%

Nearly all visitors who participated in the Half Dome Trail hiking route survey reported they did not have to wait in a queue at the base of the cables, prior to ascending the cables route (Table 15). Of those visitors who did report waiting in queue, most reported having to wait 15 minutes or less (Table 16).

Table 15. Number and Proportion of Visitors Forced to Wait in Queue at the Base of the Cables

	n = 778	
Queue Present?	Count	Percent
Yes	12	2%
No	766	98%

Table 16. Wait Time in Queue

	n = 12	
Wait for Queue?	Count	Percent
2 Minutes	1	8%
5 Minutes	1	8%
10 Minutes	2	17%
12 Minutes	1	8%
15 Minutes	6	50%
30 Minutes	1	8%
Mean	13	

Table 17 reports mean travel time derived from the Half Dome Trail hiking route survey, by location and group size. The table also reports the results of ANOVA tests conducted to compare mean travel times, by group size.

Table 17. Mean Travel Times, by Location and Group Size (hh:mm:ss)

Trail Segment	Group Size = 1	Group Size = 2	Group Size = 3+	ANOVA
Happy Isles to Half Dome Trailhead	02:37:19	03:19:21	03:42:35	F = 16.303, p , 0.001
Half Dome Trailhead to Subdome	01:19:47	01:23:37	01:24:34	F = 2.609, p = 0.074
Lingering Time at Subdome*	00:09:21[a]	00:10:12[a]	00:12:05[b]	F = 7.412, p = 0.001
Cables on Ascent	00:25:24	00:25:44	00:25:08	F = 0.330, p = 0.719
Lingering Time at Summit	00:48:06[a]	00:51:01[a, b]	00:54:51[b]	F = 3.143, p = 0.044
Cables on Descent	00:19:45	00:21:14	00:20:34	F = 1.766, p = 0.172
Lingering Time at Subdome	00:06:35[a]	00:07:18[a]	00:08:47[b]	F = 8.096, p < 0.001
Subdome to Half Dome Trailhead	00:54:28[a]	00:59:36[b]	01:00:02[b]	F = 4.672, p = 0.010

Note: Within each row, means with different superscripts are statistically different at α = 0.05.

* Includes time spent waiting in queue.

Figure 10 summarizes visitors' travel times to ascend the Half Dome cables route, by time of day and day of week category. Results suggest that on Saturdays and holidays, there are two peaks in travel times - one occurring at around noon and the second at about 2:00 PM. The line graph of ascent times on weekdays and Sundays has less slope, suggesting that mean ascent times are relatively constant around 24 to 30 minutes, across the hours of the day.

Figure 10. Mean Travel Time to Ascend the Cables Route, by Time of Day and Day of Week Category

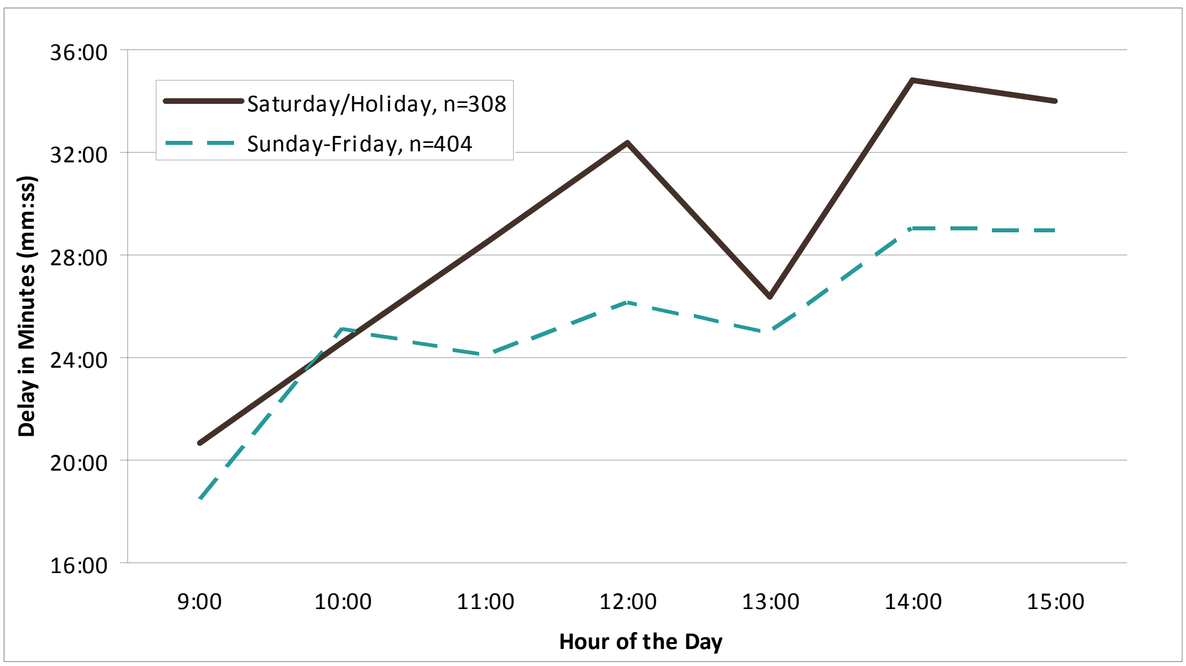
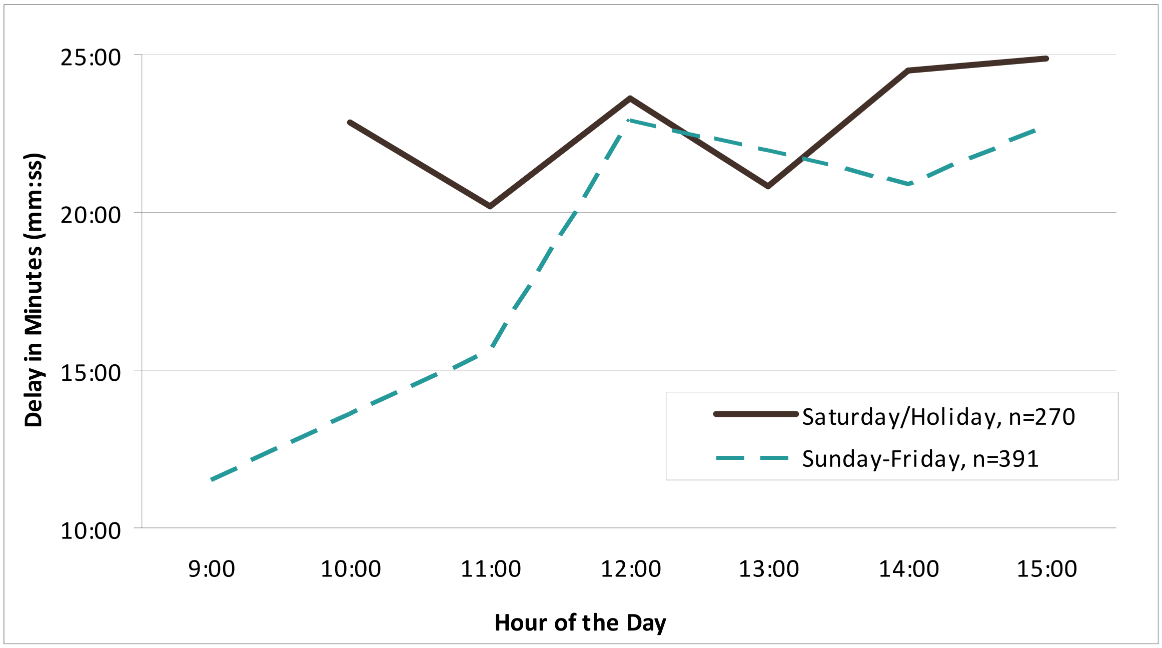


Figure 11 summarizes visitors' travel times to descend the Half Dome cables route, by time of day and day of week category. Results suggest that on Saturdays and holidays, descent times do not vary much beyond the 20 to 25 minute range, regardless of time of day. In contrast, during weekdays and Sundays, descent times appear to peak around noon at about 22 minutes.

Figure 11. Mean Travel Time to Descend the Cables Route, by Time of Day and Day of Week Category



3.3 Photographic Observations

Figure 12 summarizes results of photographic observations of the number of people at one time (PAOT) on the Half Dome cables route, by time of day and day of week category. Results suggest that on Saturdays and holidays, PAOT on the cables peaks at about noon, while it peaks at about 1:00 PM on weekdays and Sundays.

Figure 12. Mean PAOT on the Cables Route, by Time of Day and Day of Week Category

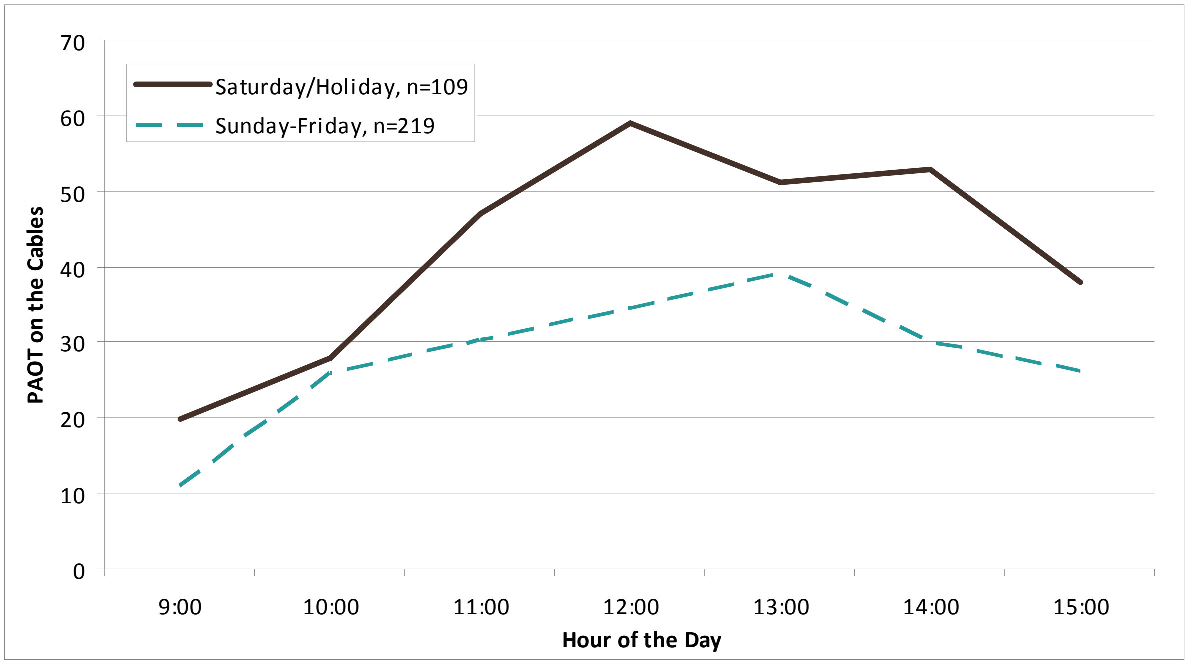


Figure 13 summarizes results of photographic observations of the number of people at one time (PAOT) ascending or descending the Half Dome cables route outside of the two parallel cables. Results suggest that, regardless of the day of the week, mean PAOT traveling outside the cables peaks at about noon and declines relatively sharply during the afternoon hours.

Figure 13. Mean PAOT Traveling Outside the Cables, by Time of Day and Day of Week Category

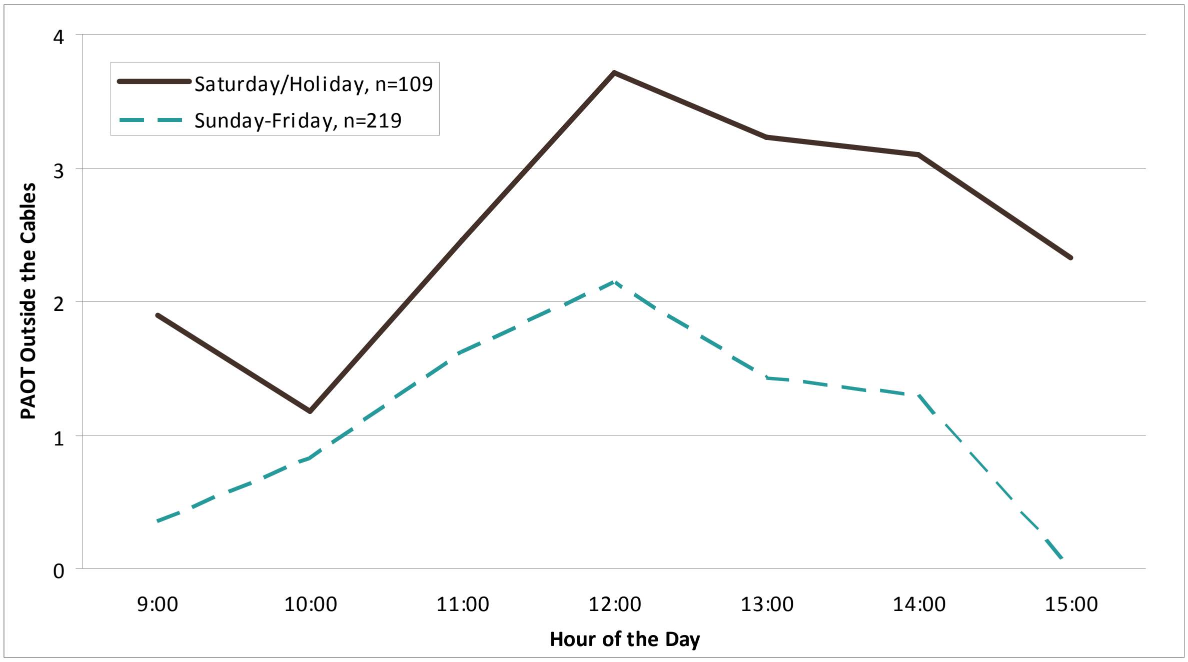
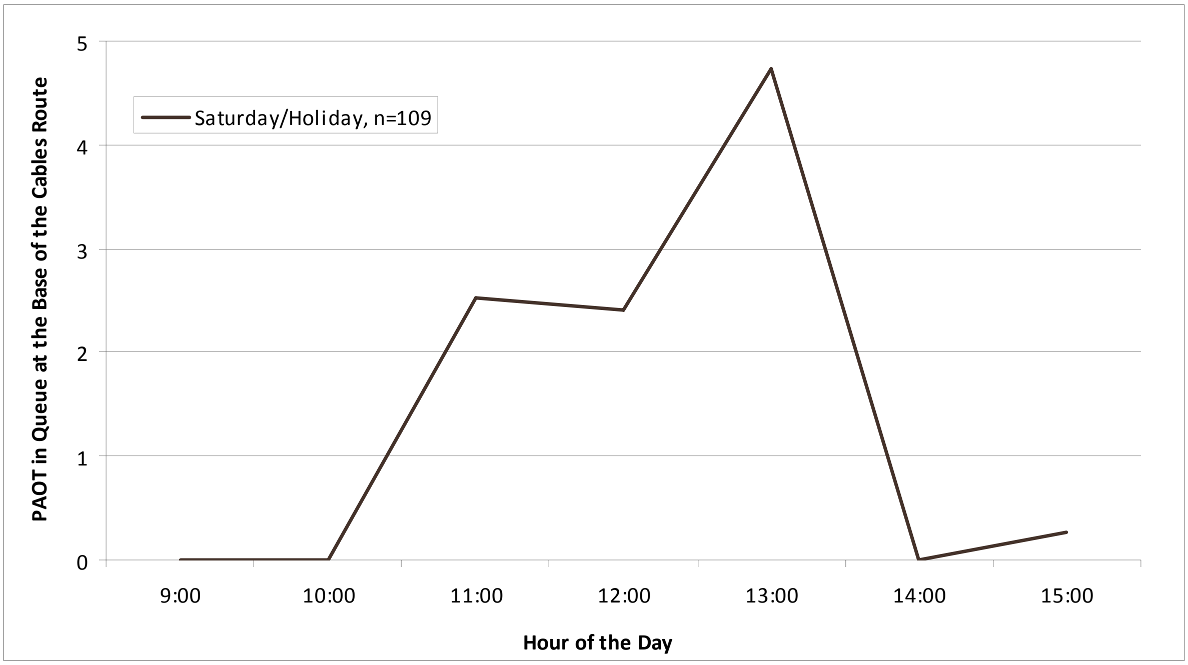


Figure 14 summarizes results of photographic observations of the number of people waiting in queue at the base of the Half Dome cables to ascend the cables route. Results suggest that on Saturdays and holidays, queue length peaks at about 1:00 PM, while queue formation is a rare event on weekdays and Sundays.

Figure 14. Mean Cables Queue Length, by Time of Day and Day of Week



Note: No queues were observed on any weekday or Sunday sampling day.

3.4 Visitor Survey Concerning Perceptions of Safety and Crowding – Summary of Findings

This section of the report begins with a narrative summary of major findings from the normative survey concerning visitors' perceptions of safety and crowding on the Half Dome Trail and cables route. Following the narrative summary, quantitative results of the survey are presented in tabular format.

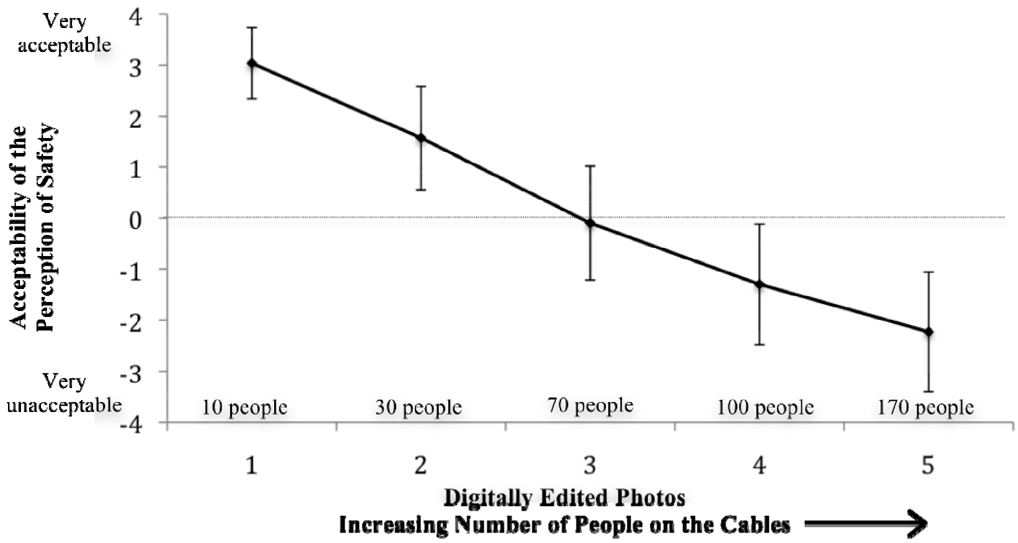
3.4.1 General Characteristics of Half Dome Trail and Cables Route Visitors

A substantial majority of visitors to the Half Dome Trail and cables route have a college degree or more formal education (Table 40); are male (Table 41); are between 18 and 35 years of age (Table 45); and identify themselves as White (Table 48). On average, visitors to the Half Dome Trail and cables route have completed about three hikes in Yosemite National Park within the last 12 months, 14 hikes in the park during their lifetime, and 12 hikes in other parks or wilderness areas in their lifetime (Table 22). Furthermore, the majority of visitors to the Half Dome Trail and cables route are day hikers (Table 21) and started their hikes at Happy Isles (Table 20).

3.4.2 Visitors' Perceptions of Risk and Safety on the Half Dome Cables

The curve derived from plotting visitors' mean acceptability ratings of perceived safety for each of the computer-edited photos of Half Dome cables use density is depicted in Figure 15. The x-axis of the graph corresponds to the number of people at one time on the Half Dome cables, as depicted in the study photographs. The y-axis corresponds to visitors' mean ratings of perceived safety associated with the photographs. The downward slope of the curve suggests a general negative linear relationship between the number of people at one time on the cables route and visitors' perceptions of safety. This result suggests that, in general, as the number of people on the cables route at one time increases, people perceive the cables route to be less safe.

Figure 15. Respondents' Mean Acceptability Ratings of Perceived Safety of Each Photograph.



Note: Error bars represent 95% confidence intervals.

A series of independent samples t-tests was performed to assess whether acceptability ratings of perceived safety for the study photographs were significantly different for visitors contacted on Saturdays compared to those who completed the questionnaire on other days of the week. Results of these tests are summarized in Table 18 and suggest that visitors contacted on Saturdays generally rated the study photographs more acceptable, with respect to perceived safety, than those contacted on other days of the week. However, it should be noted that comparisons among the two sub-populations of visitors are tenuous, given the imbalanced sample sizes for the two groups and the fact that only one Saturday was included in the sampling schedule. More robust comparisons of this nature would require additional sampling on Saturdays.

Table 18. Mean Acceptability Ratings of Perception of Safety, by Day of Week Category

Photo	Mean Acceptability Saturday	Mean Acceptability Non-Saturday	P-Value
1	3.19 (n = 67)	3.00 (n = 219)	0.348
2	2.18 (n = 66)	1.38 (n = 213)	0.003
3	0.47 (n = 66)	-0.28 (n = 214)	0.022
4	-0.69 (n = 64)	-1.48 (n = 213)	0.028
5	-1.65 (n = 65)	-2.41 (n = 213)	0.035

While only 18% of respondents reported they believe the cables are extremely dangerous, 80% indicated hiking Half Dome requires special caution, and 67% indicated hiking the Half Dome Trail and cables route is more dangerous than hiking other trails in Yosemite National Park (Table 33). Furthermore, while only 12% of respondents believe the likelihood of them having an accident is high, 23% think the likelihood of others having an accident is high, and 47% indicated they believe the likelihood of a serious injury occurring from an accident is high (Table 33).

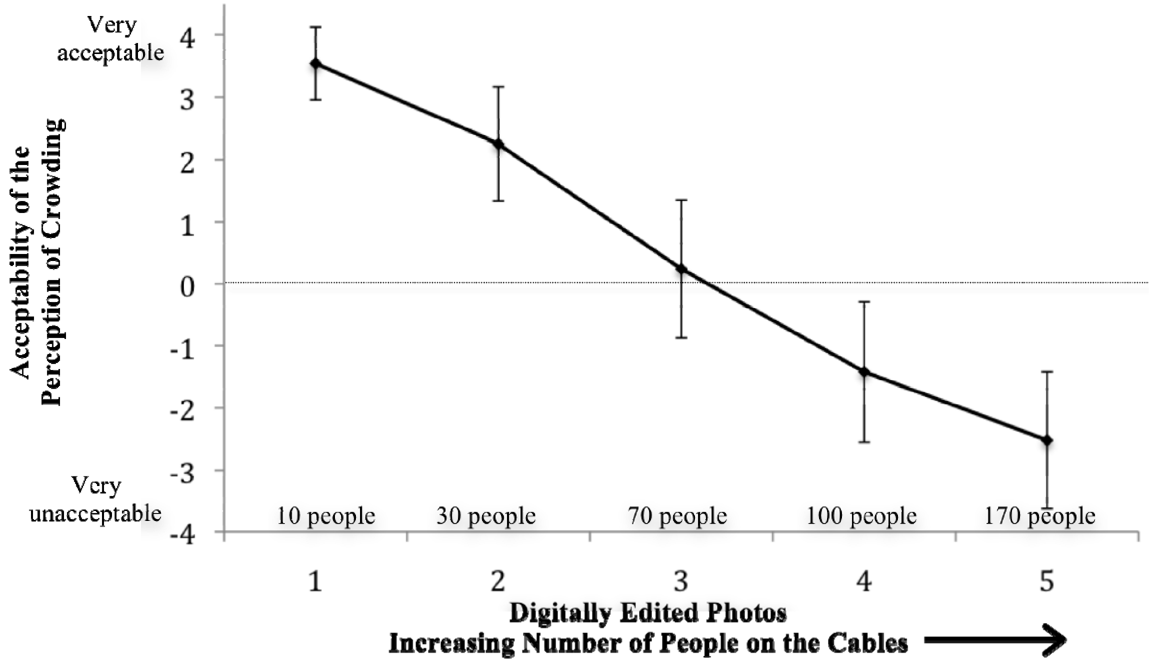
When asked about their actual experience on the Half Dome cables route, 79% of respondents reported seeing other people passing outside the cables while holding onto the cables, and 24% reported seeing other people passing outside the cables while not holding onto the cables (Table 38). Furthermore, 50% of respondents reported seeing visitors engaged in some other type of dangerous behavior, 51% saw items, such as water bottles, dropped from the cables, and 11% reported seeing falling rocks while traveling on the cables route. In addition, 53% of respondents reported seeing one or more other visitors "frozen" on the cables route due to fear, 78% indicated that they saw other visitors they considered to be unprepared for the hike, and 22% of respondents reported seeing other individuals they considered to be unfit for the hike. Despite the frequency with which respondents reported seeing unsafe visitor behaviors, only 20% of respondents characterized the cables as either poor or very poor, with regards to safety and security. Furthermore, 87% of respondents reported that they were satisfied or very satisfied with their experience on the Half Dome cables route (Table 35).

3.4.3 Visitors' Perceptions of Crowding on the Hike to the Summit of Half Dome

Respondents were asked to indicate how crowded they felt during several stages of their hike to the summit of Half Dome. About one-quarter (27%) of respondents reported feeling some degree of crowding while hiking on trails; 40% reported feeling crowded at the subdome; 39% reported feeling crowded at the base of the cables; 60% reported feeling crowded on the cables route; and 38% reported feeling crowded on the summit (Table 31). It is noteworthy that visitors generally felt substantially more crowded on the Half Dome cables than during any other portion of their hike to the Half Dome summit. However, just 5% of respondents reported that they perceived crowding and the number of people on the cables to be a safety issue that needs to be addressed (Table 39).

The curve derived from plotting visitors' mean crowding-related acceptability ratings for each of the computer-edited photos of Half Dome cables use density is depicted in Figure 16. The x-axis of the graph corresponds to the number of people at one time on the Half Dome cables, as depicted in the study photographs. The y-axis corresponds to visitors' mean crowding-related acceptability ratings associated with the photographs. The downward slope of the curve suggests a general negative linear relationship between the number of people at one time on the cables route and visitors' crowding-related acceptability ratings. This result suggests that, in general, as the number of people on the cables route at one time increases, people perceive the cables route to be increasingly crowded. It should also be noted that 74% of respondents indicated the actual conditions of the cables fell somewhere between photos 2 and 3, which corresponds to between 30-70 people (Table 30).

Figure 16. Respondents' Mean Acceptability Ratings of Perceived Crowding of Each Photograph.



Note: Error bars represent 95% confidence intervals.

A series of independent samples t-tests was performed to assess whether acceptability ratings of perceived crowding for the study photographs were significantly different for visitors contacted on Saturdays compared to those who completed the questionnaire on other days of the week. Results of these tests are summarized in Table 19 and suggest that visitors contacted on Saturdays generally rated the study photographs more acceptable, with respect to perceived crowding, than those contacted on other days of the week. However, it should be noted that comparisons among the two sub-populations of visitors are tenuous, given the imbalanced sample sizes for the two groups and the fact that only one Saturday was included in the sampling schedule. More robust comparisons of this nature would require additional sampling on Saturdays.

Table 19. Mean Acceptability Ratings of Perception of Crowding, by Day of Week Category

Photo	Mean Acceptability Saturday	Mean Acceptability Non-Saturday	P-Value
1	3.67 (n = 66)	3.51 (n = 217)	0.230
2	2.82 (n = 65)	2.08 (n = 213)	0.001
3	0.84 (n = 64)	0.05 (n = 211)	0.017
4	-0.86 (n = 64)	-1.58 (n = 214)	0.032
5	-1.91 (n = 65)	-2.71 (n = 214)	0.022

Respondents were asked to choose the photograph that depicted the maximum number of people at one time on the cables: 1) they preferred to see; 2) the NPS should allow before limiting use; and 3) beyond which they would no longer hike the Half Dome Trail and cables route. The vast majority (80%) of respondents indicated that they would prefer to see no more than 10 to 30 people at one time on the Half Dome cables (Table 28). More than half (59%) of respondents indicated that use should be limited at the point where no more than 70 to 100 people are on the cables at one time (Table 27). About half (47%) of respondents reported that they would not return to hike the Half Dome cables route if use was allowed to reach a point where 100 or more people would be on the cables at one time (Table 29).

3.4.4 Visitors' Attitudes Toward Potential Management Actions

Of the 10 potential management actions respondents were asked to evaluate, increased signage received the greatest level of support from visitors (Table 34). In particular, 57% of respondents reported that they support increasing the amount of signage concerning hazards of the Half Dome hike, and 59% support increasing the amount of signage concerning mileage. No other management actions were supported by a majority of visitors, and only a few received support from 25% or more respondents: 1) providing rangers to enforce Leave No Trace principles (42% support and 29% oppose); 2) implementing a visitor education program concerning the Half Dome hike (35% support and 36% oppose); and 3) implementing a permit system to limit use of the Half Dome Trail and cables route (27% support and 46% oppose). Management actions that received the least support from respondents included: 1) requiring visitors to start their hike to Half Dome before 7:00 AM (23% support and 53% oppose); 2) requiring visitors to undergo an orientation emphasizing safety considerations associated with the Half Dome hike (21% support and 55% oppose); 3) limiting the extent to which the NPS promotes the Half Dome hike (18% support and 49% oppose); 4) requiring visitors to use safety equipment on the Half Dome hike (15% support and 64% oppose); and 5) charging a fee to pay for visitor education and safety related to the Half Dome hike (15% support and 65% oppose).

In addition to asking respondents to indicate their support or opposition for a list of potential management actions on the Half Dome Trail and cables route, respondents were asked, in an open-ended format, if there were safety issues that needed to be addressed through management. The most common response from those who gave an answer to the question was that the cables needed to be improved or replaced (e.g., adding a third cable to the system).

3.4.5 Tabular Results of the Visitor Survey Concerning Perceptions of Safety and Crowding

Table 20. Half Dome Hike Starting Location

Where did you start your hike to Half Dome?

	(n= 279)	
Origin	Count	Percent
Happy Isles	235	84%
Little Yosemite Valley	18	6%
Cloud's Rest	10	3%
Tuolumne Meadows	8	3%
Glacier Point	7	3%
Other	1	1%

Table 21. Proportion of Day Versus Overnight Hikers on Half Dome Trail

On this trip, are you a day hiker or overnight backpacker?

	(n= 290)	
Hiker Type	Count	Percent
Day hiker	224	77%
Overnight hiker	66	23%

Table 22. Number of Previous Hikes in Yosemite National Park and Other Parks

Including this hike, approximately how many hikes (day and overnight) have you taken…

Question	n	Median	25th Pctl	75th Pctl	Mean	Std Dev.
In YNP in last 12 months?	289	2	1	3	3.43	8.25
In YNP in your lifetime?	288	3	2	12	14.44	61.17
In other parks in last 12 months?	288	5.5	2	12	11.59	17.96

Table 23. Photo-Based Crowding Responses - Distribution

We would like to know how many people you think you could see at one time on the cables without feeling too crowded. To help us judge this, please rate each of the photographs by indicating how acceptable you find it based on the number of people in the photo.

	Very Unacceptable						Very Acceptable						
Photo	-4	-3	-2	-1	0	1	2	3	4	Median	25th Pctl	75th Pctl	n
1	<1%	<1%	1%	3%	2%	4%	10%	77%	97%	4	4	4	283
2	2%	1%	2%	3%	6%	10%	19%	27%	27%	3	2	4	278
3	4%	10%	9%	10%	17%	11%	15%	12%	5%	0	-2	2	275
4	22%	17%	16%	11%	10%	9%	7%	3%	3%	-2	-3	0	278
5	54%	10%	9%	6%	6%	5%	3%	1%	3%	-4	-4	-2	279

Table 24. Photo-Based Crowding Responses - Means and Standard Deviations

We would like to know how many people you think you could see at one time on the cables without feeling too crowded. To help us judge this, please rate each of the photographs by indicating how acceptable you find it based on the number of people in the photo.

Photo	n	Mean	Std. Dev.
1	283	3.54	1.17
2	278	2.25	1.83
3	275	0.24	2.22
4	278	-1.42	2.26
5	279	-2.52	2.20

Table 25. Photo-Based Safety Responses - Distribution

We would like to know how many other people you could see at one time on the cables without feeling too unsafe. Please rate each of the photographs by indicating how safe or unsafe you find it based on the number of people in the photo.

	Very Unacceptable						Very Acceptable						
Photo	-4	-3	-2	-1	0	1	2	3	4	Median	25th Pctl	75th Pctl	n
1	<1%	<1%	1%	1%	2%	5%	14%	23%	52%	4	3	4	286
2	2%	3%	7%	6%	8%	14%	24%	21%	17%	2	1	3	279
3	6%	11%	14%	13%	18%	12%	13%	8%	6%	0	-2	2	280
4	23%	16%	16%	12%	11%	9%	7%	3%	5%	-2	-3	0	277
5	48%	14%	9%	8%	7%	4%	3%	3%	4%	-3	-4	-1	278

Table 26. Photo-Based Safety Responses - Means and Standard Deviations

We would like to know how many other people you could see at one time on the cables without feeling too unsafe. Please rate each of the photographs by indicating how safe or unsafe you find it based on the number of people in the photo.

Photo	n	Mean	Std. Dev.
1	286	3.04	1.39
2	279	1.57	2.03
3	280	-0.10	2.23
4	277	-1.30	2.36
5	278	-2.23	2.34

Table 27. Photo-Based Responses - Visitor Use Limit

Which photograph shows the maximum number of people the National Park Service should allow on the cables at one time? In other words, at what point should visitor use of the cables be limited?

	(n = 233)	
Response	Count	Percent
Photo 1	9	3%
Photo 2	71	25%
Photo 3	97	34%
Photo 4	39	14%
Photo 5	17	6%
No photo represents the limit point	10	4%
Visitors should not be limited at all	40	14%
Mean	3	

Table 28. Photo-Based Responses - Preference

Which photograph shows the number of people on the cables that you would prefer to see?

	(n = 270)	
Response	Count	Percent
Photo 1	134	47%
Photo 2	96	33%
Photo 3	36	13%
Photo 4	3	1%
Photo 5	1	<1%
I Don’t Know	18	6%
Mean	2	

Table 29. Photo-Based Responses - Displacement

Which photograph shows the maximum number of people on the cables that would cause you to never return?

Response	Count (n = 286)	Percent
Photo 1	2	1%
Photo 2	4	1%
Photo 3	23	8%
Photo 4	59	21%
Photo 5	74	26%
I Don't Know	20	7%
The number of people does not matter to me	104	36%
Mean	4	

Table 30. Photo-Based Responses - Most Similar to Today

Which photograph looks most like the number of people on the cables you saw today?

Response	Count (n = 279)	Percent
Photo 1	61	21%
Photo 2	136	48%
Photo 3	74	26%
Photo 4	8	3%
Photo 5	0	0%
I Don't Know	6	2%
Mean	2	

Table 31. Perceived Crowding, by Location - Distribution

How crowded did you feel at each of the following locations?

	Not at all crowded						Extremely Crowded				25th	75th	
Location	1	2	3	4	5	6	7	8	9	Median	Pctl	Pctl	n
On the trail	53%	20%	14%	4%	7%	1%	<1%	<1%	0%	1	1	3	289
At the subdome	37%	23%	17%	11%	8%	2%	2%	0%	0%	2	1	3	286
Base of the cables	37%	24%	15%	10%	9%	2%	1%	1%	<1%	2	1	3	280
On the cables	24%	16%	13%	10%	14%	6%	7%	5%	1%	3	1	5	278
At the summit	41%	21%	16%	10%	6%	3%	2%	1%	<1%	1	0	1	273

Table 32. Perceived Crowding, by Location - Mean and Standard Deviation

How crowded did you feel at each of the following locations?

Location	n	Mean	Std. Dev.
On the trail	289	2.00	1.38
At the subdome	286	2.43	1.53
Base of the cables	280	2.52	1.69
On the cables	278	3.48	2.19
At the summit	273	2.43	1.70

Table 33. Agree/Disagree with Safety Issues Statements

To what extent do you agree or disagree with each of the following statements?

	Highly Disagree			Highly Agree			25th	75th			
Statement	-2	-1	0	1	2	Median	Pctl	Pctl	n	Mean	Std Dev.
The cables are extremely dangerous.	31%	26%	25%	13%	5%	-1	-2	0	287	-0.66	1.18
The likelihood of me having a serious accident is high.	43%	28%	18%	9%	3%	-1	-2	0	284	-0.98	1.12
The likelihood of someone else having a serious accident is high.	15%	28%	29%	19%	9%	0	-1	1	286	-0.21	1.18
The likelihood of serious injury from an accident is high.	14%	21%	18%	24%	23%	0	-1	1	285	0.20	1.37
Rangers will advise when the cables are not safe.	8%	9%	25%	23%	35%	1	0	2	278	0.68	1.26
Passing outside the cables is a safe way to pass.	38%	17%	19%	14%	11%	-1	-2	1	285	-0.56	1.41
Hiking Half Dome requires special conditioning.	5%	11%	21%	43%	20%	1	0	1	286	0.62	1.07
Hiking Half Dome requires special equipment.	27%	23%	26%	21%	3%	-1	-2	0	286	-0.51	1.17
Hiking Half Dome requires special caution.	3%	8%	10%	36%	44%	1	1	2	285	1.10	1.05
Half Dome is more dangerous than other trails.	5%	9%	20%	40%	27%	1	0	2	285	0.76	1.08
If an accident happens, rangers will help me to safety.	13%	19%	40%	18%	10%	0	-1	1	284	-0.08	1.14
Half Dome is depicted as being more dangerous than it is.	14%	19%	40%	16%	9%	0	-1	1	286	-0.14	1.13

Table 34. Support/Oppose Potential Management Actions

To what extent do you support or oppose each of the following potential management actions concerning the Half Dome cables hike?

Management Action	Strongly Oppose -2	-1	0	1	Strongly Support 2	Median	25th Pctl	75th Pctl	n	Mean	Std Dev.
Increase signage concerning hazards of the hike.	9%	9%	26%	40%	17%	1	0	1	283	0.48	1.14
Increase signage concerning mileage.	9%	7%	25%	30%	29%	1	0	2	284	0.62	1.23
Require an orientation emphasizing safety.	38%	17%	24%	15%	6%	-1	-2	0	284	-0.65	1.29
Implementation of education program on etiquette.	21%	15%	30%	25%	10%	0	-1	1	281	-0.13	1.27
Limit the number of hikers each day (permits).	32%	14%	26%	16%	11%	0	-2	1	281	-0.40	1.38
Require hikers to use safety equipment.	40%	24%	22%	9%	6%	-1	-2	0	280	-0.83	1.21
Charge a fee to pay for education and safety.	54%	11%	20%	9%	6%	-2	-2	0	284	-0.98	1.27
Provide more rangers to enforce Leave No Trace principles.	17%	12%	30%	29%	13%	0	-1	1	281	0.07	1.27
Require hikers to start before 7am.	37%	16%	25%	16%	7%	-1	-2	0	284	-0.60	1.30
Limit promotion of the cables trail.	32%	17%	33%	12%	6%	0	-2	0	283	-0.57	1.22

Table 35. Satisfaction Ratings for Half Dome Cables Route Management

Please rate the Half Dome Cables Route on the following.

Management Action	Very Poor -2	-1	0	1	Very Good 2	Median	25th Pctl	75th Pctl	n	Mean	Std Dev.
Information availability	6%	11%	42%	31%	11%	0	0	1	281	0.29	1
Safety and security	5%	15%	36%	35%	10%	0	0	1	283	0.31	1
Overall satisfaction	1%	3%	10%	31%	56%	2	1	2	281	1.36	0.87
Signs about conditions	12%	16%	42%	16%	13%	0	-1	1	280	0.02	1.16
Mileage signs	6%	19%	34%	26%	16%	0	0	1	281	0.27	1.11
Presence of rangers	20%	24%	41%	11%	5%	0	-1	0	280	-0.41	1.08

Table 36. Presence of Rangers During Half Dome Hike

Did you encounter a ranger on the hike today?

Response	Count (n= 284)	Percent
Yes	73	26%
No	211	74%

Table 37. Information Obtained from Rangers Encountered During Half Dome Hike

If Yes, did you gain information regarding the Half Dome cables hike from them?

Response	Count (n= 73)	Percent
Yes	16	22%
No	57	78%

Table 38. Half Dome Hikers' Observations of Safety Issues

Please indicate how often you observed each of the following.

Management Action	Never 0	1	Sometimes 2	3	Often 4	Median	25th Pctl	75th Pctl	n	Mean	Std Dev.
Passing outside the cables while holding onto them	19%	15%	38%	10%	17%	2	1	3	274	1.91	1.31
Passing outside the cables while NOT holding on	76%	13%	8%	2%	2%	0	0	0	273	0.41	0.85
Dangerous behavior	50%	32%	13%	3%	3%	1	0	1	272	0.77	0.96
Dropping items (water bottles)	49%	22%	18%	8%	4%	1	0	2	274	0.97	1.16
Falling rocks	89%	8%	3%	0%	0%	0	0	0	270	0.14	0.42
Individuals frozen on the cables from fear	47%	22%	23%	5%	4%	1	0	2	270	0.97	1.11
Individuals unprepared for the hike or climb	22%	26%	30%	14%	8%	2	1	2	272	1.60	1.96
Individuals unfit for the hike or climb	26%	23%	31%	14%	8%	2	0	2	275	1.55	1.22

Table 39.Visitors' Perceptions of Safety Issues That Need to be Addressed

Are there any safety issues that need to be addressed concerning the Half Dome hike, and if so, what are they? (Open-ended question)

Comment Category	(n= 95) Count	Percent
Improve/change the cables	19	20%
Enforcement of rules	17	18%
Maintenance of the cables	15	16%
Increased signage	11	12%
Require equipment	8	8%
More availability of water	6	6%
Crowding and the number of people	5	5%
Educate	5	5%
More rangers	5	5%
Passing	4	4%

Table 40. Education Level

What is the highest level of formal education you have completed?

Education Level	Count (n= 278)	Percent
Some high school	6	2%
High school graduate or GED	15	5%
Some college, business or trade school	46	17%
College, business or trade school graduate	78	28%
Some graduate school	29	10%
Master's, doctoral or professional degree	104	37%

Table 41. Gender

Please indicate your gender.

Gender	Count (n= 274)	Percent
Male	209	76%
Female	65	24%

Table 42. Most Frequently Reported Zip Code of Residence

What is your zip code (if you live in the United States)?

Zip Codes	(n= 22) Count
93117	5
94025	4
95008	4
24060	3
93720	3
94558	3

Note: 15 zip codes had 2 counts

Table 43. State of Residence

Frequency distribution of respondents organized by state.

State	(n= 228) Count	Percent
California	159	70%
Virginia	7	3%
Georgia	6	3%
Utah	6	3%
Nevada	6	3%
Washington	6	3%
Michigan	5	2%
Texas	5	2%
Colorado	4	2%
Oregon	4	2%
North Carolina	3	1%
Wisconsin	3	1%
Maryland	2	1%
Florida	2	1%
Ohio	2	1%
Illinois	2	1%
Missouri	2	1%
Alabama	1	<1%
Minnesota	1	<1%
New Mexico	1	<1%
Hawaii	1	1%

Table 44. Country of Residence (if not USA)

What country do you live in (if not in the United States)?

Country	(n= 34) Count	Percent
UK	9	26%
Netherlands	6	18%
Germany	5	15%
Sweden	4	12%
France	3	9%
Switzerland	3	9%
Canada	2	6%
Japan	1	3%
Spain	1	3%

Table 45. Age

What is your age?

Age Group	Count (n= 276)	Percent
18 to 24 years old	70	25%
25 to 34 years old	91	33%
35 to 44 years old	35	13%
45 to 54 years old	61	22%
55 to 64 years old	17	6%
65 years old and older	2	1%
Mean Age	34.76	

Table 46. Ethnicity - Hispanic/Latino

Are you Hispanic or Latino?

Response	Count (n= 268)	Percent
Yes	19	7%
No	249	93%

Table 47. Ethnicity - Middle Eastern/Arabian

Are you of Middle Eastern/ Arabian ancestry/ descent?

Response	Count (n= 269)	Percent
Yes	6	2%
No	263	98%

Table 48. Race

What is your race? (Mark all that apply)

Response	Count (n= 279)	Percent
Indian	7	3%
Asian	28	10%
Black	6	2%
Hawaiian	5	2%
Pacific	5	2%
White	242	87%

Chapter 4: Half Dome Visitor Use Model

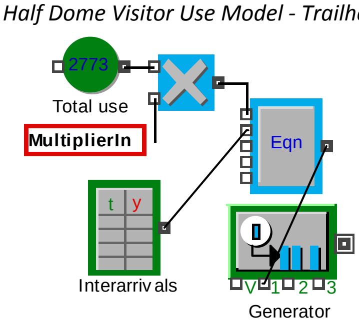
This chapter of the report presents the methods used to develop a computer simulation model of visitor use on the Half Dome Trail and cables route, and associated descriptive results. The chapter begins by describing the model algorithm and programming, and concludes with descriptive results of baseline simulations, assuming summer 2008 visitor use levels.

4.1 Model Algorithm and Programming

The computer simulation model of visitor use on the Half Dome Trail and cables route was developed using Extend v.7 (2007) discrete-event systems simulation software. The structure of the model consists of hierarchical blocks (H-blocks) that: 1) simulate visitor use and behavior on the John Muir and Half Dome trails, at the subdome, on the Half Dome cables, and on the Half Dome Summit; and 2) monitor people at one time (PAOT) at points of interest (i.e., on the cables route, at the subdome, on the Half Dome summit). Each type of hierarchical block contained within the study model is described in the following paragraphs.

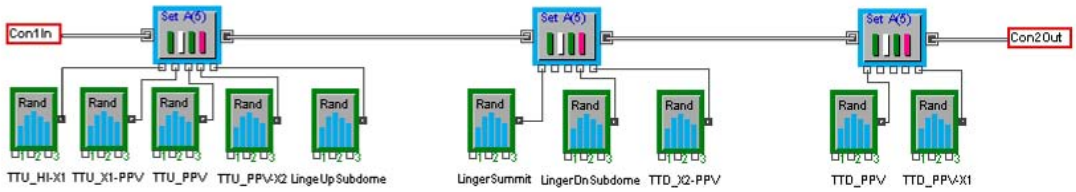
The Trailhead H-block is used within the study model to generate simulated visitor groups embarking on hikes from the Happy Isles trailhead to the Half Dome Trail and cables route (Figure 17). Visitor group arrival rates within the model vary by time of day and day of week, and are based on the visitor counts and calibrations conducted at Happy Isles during summer 2008. The arrival rates specified within the model can be “ramped up” or “ramped down” to model changes in visitation from that measured during summer 2008.

Figure 17. Half Dome Visitor Use Model - Trailhead H-Block.



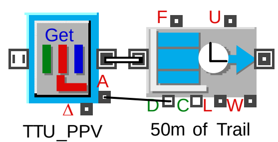
After leaving the Trailhead H-block, simulated visitor groups are routed within the model to an Attribute H-block (Figure 18). The Attribute H-block is designed to assign attribute values to simulated visitor groups, including values that define each simulated group’s size, and the amount of time they spend hiking on trails, traveling on the cables route, and lingering at the subdome and on the Half Dome summit. The distributions of group sizes, travel times, and lingering times assigned to simulated visitors are based on results of the Happy Isles and Half Dome Trail hiking route surveys.

Figure 18. Half Dome Visitor Use Model - Attribute H-Block.



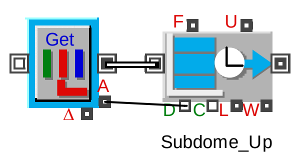
After being assigned attribute values, simulated visitor groups are routed to hike from Happy Isles to the Half Dome Trail, and from there to the subdome. Trail Section H-blocks simulate visitor use and travel along the hiking trails (Figure 19), based on the distributions of hiking times recorded in the Happy Isles and Half Dome Trail hiking route surveys.

Figure 19. Half Dome Visitor Use Model - Sample Trail Section H-Block.



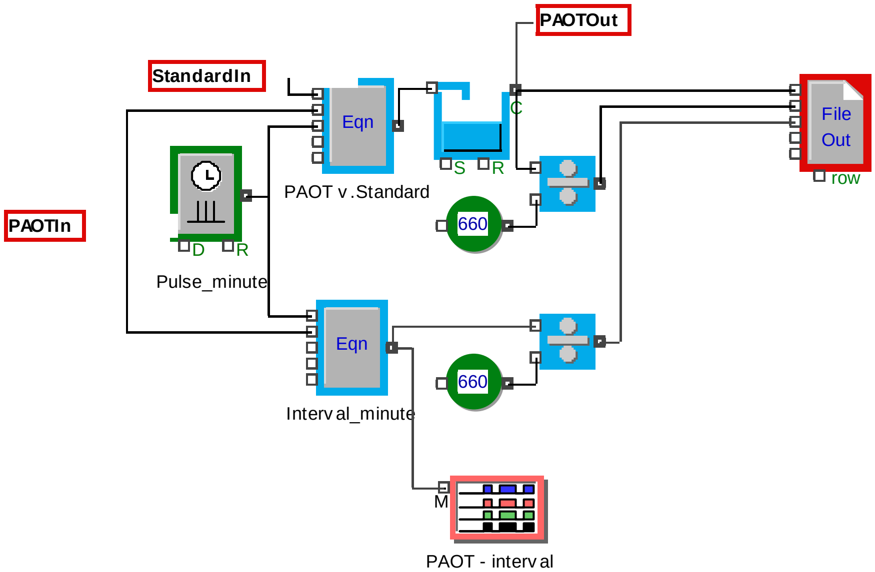
Next, simulated visitor groups are routed to the Subdome Area H-block where they "linger" for periods of time based on the distribution of subdome lingering times recorded in the Half Dome Trail hiking route survey (Figure 20). It should be noted that simulated visitor groups are routed back to the Subdome Area H-block after descending the Half Dome cables route and that the distribution of lingering times used within the model for these groups returning from the cables is different than the distribution of subdome lingering times used for visitor groups on their way to the cables.

Figure 20. Half Dome Visitor Use Model - Subdome Area H-Block.



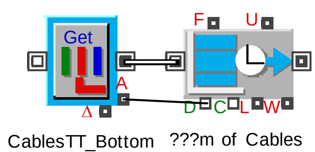
A PAOT Calculator H-block (Figure 21) is connected to the Subdome Area H-block to monitor the number of people in the subdome area at one time, at one minute intervals throughout the course of each simulated visitor use day. The PAOT Calculator H-block contains File Output blocks that report to an ASCII text file the percentage of time within a simulated visitor use day user-specified standards of quality for PAOT in the subdome area are exceeded. Thus, the PAOT Calculator H-block could be used as a key component of simulation analyses designed to estimate user capacities for the Half Dome Trail.

Figure 21. Half Dome Visitor Use Model - PAOT Calculator H-Block.



After lingering at the subdome, simulated visitor groups are routed to the base of the Half Dome cables route, represented within the model by the Cables Route H-block (Figure 22). Within the Cables Route H-block, visitors are assigned a travel time to ascend the cables, based on the total number of people on the cables route at that time. Queue formation is modeled within the Cables Route H-block, based on the number of people on the cables route each time a visitor arrives at the base of the cables to begin ascending the route. It should be noted that simulated visitor groups are routed back to the Cables Route H-block after lingering on the Half Dome summit and that visitor groups are assigned a travel time for descending the cables based on the total number of people on the cables route at the time they begin their descent.

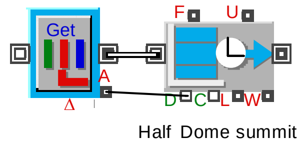
Figure 22. Half Dome Visitor Use Model - Cables Route H-Block



A PAOT Calculator H-block (Figure 20) is connected to the Cables Route H-block to monitor the total number of people on the Half Dome cables at one time, at one minute intervals throughout the course of each simulated visitor use day. The PAOT Calculator H-block contains File Output blocks that report to an ASCII text file the percentage of time within a simulated visitor use day user-specified standards of quality for PAOT on the Half Dome cables are exceeded. Thus, the PAOT Calculator H-block could be used as a key component of simulation analyses designed to estimate user capacities for the Half Dome Trail.

Upon ascending the Half Dome cables route, simulated visitor groups are routed to the Half Dome Summit H-Block (Figure 23) where they “linger” for periods of time based on the distribution of Half Dome summit lingering times recorded in the Half Dome Trail hiking route survey. After lingering on the Half Dome summit, simulated visitor groups are routed back to the Half Dome Cables H-block to descend the cables route. From there, simulated visitor groups are routed to the subdome and the Half Dome Trail junction with the John Muir Trail, where they exit the model.

Figure 23. Half Dome Visitor Use Model - Half Dome Summit H-Block.



In summary, the computer model simulates Half Dome hikers' behavior as they: 1) arrive at the Happy Isles trailhead to begin their hike; 2) hike from Happy Isles to the Half Dome Trail, and from there, to the subdome; 3) linger at the subdome before ascending the cables route; 4) wait in queue at the base of the cables, if a queue is present; 5) ascend the cables route; 6) linger on the Half Dome summit; 7) descend the cables route; 8) linger at the subdome after descending the cables route; and 9) hike from the subdome to the junction of the Half Dome Trail and John Muir Trail. The modeling processes described above are stochastic, meaning the outcomes vary with each replication of the model. For example, the specific hiking and lingering times assigned to simulated groups vary around means and standard deviations of lognormal distributions with each replication of the model. This is similar to the way actual visitor behavior within the study site can be generalized in terms of central tendencies derived from multiple days of observations, yet varies from one day to the next. Thus, estimates of outcome variables of interest (e.g., number of people at one time on the Half Dome cables route) vary from one replication to the next, and consequently, are computed as means derived from the results of multiple replications of the model. The method of independent replications was used to determine the number of replications needed to generate reliable model estimates and the results of these replications analyses are presented in Appendix M.

4.2 Descriptive Results of the Half Dome Visitor Use Model

Descriptive results from simulation of baseline visitor use on the Half Dome Trail and cables route, as measured during summer 2008, are reported in Table 49 and Table 50. In particular, Table 49 reports the average number of people at one time: 1) in the subdome area; 2) on the Half Dome cables route; and 3) on the Half Dome summit. It should be noted that separate results were generated for Saturdays/holidays and Sundays/weekdays, as presented in Table 49. Table 50 reports model estimates of mean travel times to ascend and descend the cables route, by day of week category.

Table 49. Baseline Simulation Results - Mean and Maximum PAOT, by Location

	Saturday/Holiday		Sunday-Friday	
	Mean	Max	Mean	Max
Subdome	13	65	7	41
Cables	37	145	16	72
Summit	35	126	19	77

Table 50. Baseline Simulation Results - Mean and Maximum Cables Ascent and Descent Times

	Saturday/Holiday (minutes)		Sunday-Friday (minutes)	
	Mean	Max	Mean	Max
Ascent	32	72	25	49
Descent	23	59	20	44

Chapter 5: Briefing Documents

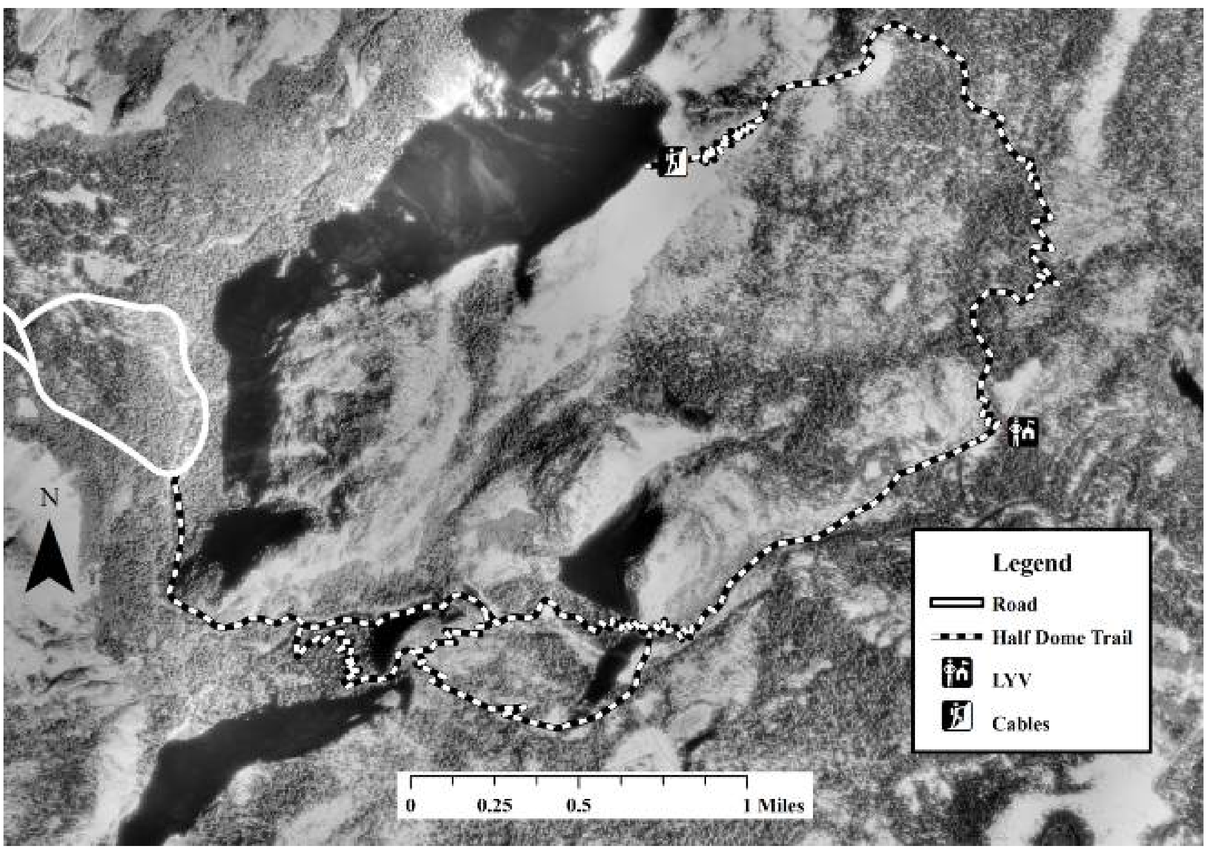
This chapter of the report presents a series of briefing documents that summarize and highlight results of statistical and simulation modeling of relationships among visitor use on the Half Dome cables, the amount of time it takes visitors to ascend and descend the cables, and the prevalence of visitors ascending or descending the route outside the parallel cables. The briefing documents are designed to be used as either "stand-alone" documents or as a set. Further, the briefing documents are written in concise format, with limited use of technical language, in order to facilitate their use with a broad range of audiences. Each briefing document includes a statement of the purpose of the analyses presented, the results, and implications for visitor use on the Half Dome cables route. The briefing documents address, in order, the following topics: 1) relationships among the total number of visitors on the Half Dome cables route at one time and the number of visitors who choose or are forced to travel outside of the parallel cables; 2) relationships among the total number of visitors on the Half Dome cables route at one time and the formation and length of a queue at the base of the cables; 3) relationships among the total number of visitors on the Half Dome cables route at one time and the amount of time it takes visitors to ascend and descend the cables route; 4) relationships among the amount of time it takes visitors to ascend and descend the Half Dome cables route and the number of visitors who choose or are forced to travel outside of the parallel cables; and 5) relationships among the total number of visitors on the Half Dome cables route at one time and visitors' perceptions of safety and crowding.

5.1 Relationships between Half Dome Cables Use Density and Incidence of Visitors Traveling Outside the Cables

5.1.1 Issue

The hike to the summit of Half Dome (Figure 24) is perhaps the most iconic and popular backcountry excursion for visitors to Yosemite National Park. The culmination of the hike involves ascending the last 400 vertical feet of Half Dome via a cable system. Most visitors ascend, and subsequently descend, the Half Dome summit between its two parallel cables. However, some visitors travel outside of the cables, incurring increased exposure to unarrested falls from the granite dome. The occurrence of this behavior, coupled with recent accidents involving falls from the cables, have made risk management on Half Dome a priority at the park. However, current information about visitor use of the cables is primarily anecdotal; scientifically defensible data are needed from which to develop management options that better address visitor safety on the Half Dome cables. The purpose of the research presented in this briefing is to statistically model the relationship between the total number of people ascending and descending the Half Dome cables at one time and the number of visitors who are forced or choose to go outside the cables.

Figure 24. Half Dome Study Area from Happy Isles to Half Dome Summit



5.1.2 Data Collection & Coding

Three hundred twenty-eight photographic observations of visitor use on the Half Dome cables were taken on nine weekdays and seven weekend days in July and August, 2008 (Figure 25). Visitors ascending or descending the Half Dome cables within each photo were coded based on their location relative to the two parallel cables (Figure 26). In particular, those visitors whose abdominal midpoints were observed to be between the cables were coded as inside the cables, and marked in green. Those visitors whose abdominal midpoints were outside of the cables were coded as being outside the cables, and marked in red. Each color coded photo was used to compute the total number of visitors ascending and descending the cables at the time the photo was taken, and the number of visitors inside and outside the cables.

Figure 25. Half Dome Cables Photographic Observation

Figure 26. Photographic Observation Coding; Green = Inside, Red = Outside

5.1.3 Data Analysis

Linear and quadratic regression models were estimated using the total number of visitors on the cables at one time as the independent (i.e., explanatory) variable and the total number of visitors outside the cables at one time as the dependent variable. The linear and quadratic models were specified as noted in Equations 1 and 2, respectively.

Equation 1: $OC = b_1 * TC$ ***Equation 2:*** $OC = b_1 * TC + b_2 * TC^2$

OC = Total number of visitors outside the cables at one time
TC = Total number of visitors ascending and descending the cables at one time
b_1 and b_2 = Regression model parameter estimates

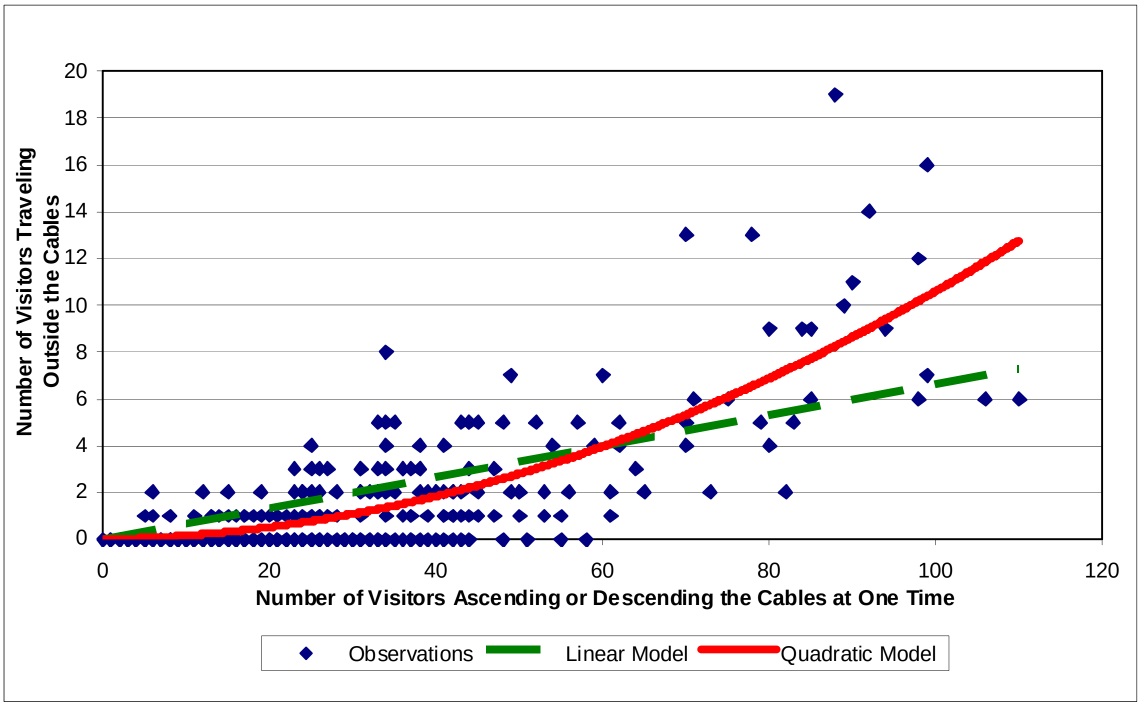
Based on statistical (Table 51) and graphical results (Figure 27) of the regression analyses, the quadratic model was found to fit the photo-based data observations best. Results of the regression analyses suggest that there is a statistically significant, positive relationship between the total number of people on the cables at one time and the incidence of visitors going outside the cables. That is, as the number of people on the cables at one time increases, the number of visitors who are forced or choose to go outside the cables increases to a statistically significant degree. The quadratic model can be further interpreted as suggesting that the relationship between the total number of people on the cables and the number that go outside the cables is increasingly pronounced as use density on the cables increases.

Table 51. Total PAOT on the Cables and PAOT Outside the Cables - Linear and Quadratic Regression Models (Standard Errors in Parentheses)

	Linear	***Quadratic***
Constant	--	--
Parameter 1	0.066* (0.003)	0.006 (0.006)
Parameter 2	--	0.001* (0.000)
Model R^2	0.618	0.716

*Statistically significant at α = 0.001

Figure 27. Photo-Based Observation Data and Regression Model Plots – Total PAOT on the Cables and PAOT Outside the Cables



The quadratic regression model was used to estimate the number of people who are forced or choose to go outside the cables, given varying numbers of people ascending and descending the cables at one time (Table 52). For example, results of these computations suggest that visitors generally do not go outside the cables when there are fewer than 30 visitors ascending or descending the cables at one time; when use density on the cables exceeds roughly 30 people at one time, one or more visitors can be expected to go outside the cables. It should be noted, however, that these estimates represent general expectations with respect to visitor behavior on the Half Dome cables. Factors not explained by the statistical model presented in this briefing may cause some visitors to go outside the cables, even when there are very few or no other visitors on the cables (e.g., "thrill-seeking"). That being said, the results provide a reliable empirical basis for generalizing about the relationship between use density on the Half Dome cables and the incidence of visitors traveling outside the cables as they ascend and descend the granite dome.

Table 52. Estimated Number of Visitors Outside the Half Dome Cables as a Function of Total Number of Visitors on the Cables Route at One Time

Total On Cables Route	Outside Cables	Total on Cables Route	Outside Cables	Total on Cables Route	Outside Cables
1 – 28	0	75 – 80	6	107 – 111	12
29 – 41	1	81 – 86	7	112 - 115	13
42 – 51	2	87 – 91	8	116 – 119	14
52 – 60	3	92 – 97	9	120 – 123	15
61 – 67	4	98 – 101	10	124 – 127	16
68 – 74	5	102 – 106	11	128 – 131	17

5.2 Relationship between Half Dome Cables Use Density and Queuing at the Base of the Cables Route

5.2.1 Issue

At times of particularly high visitor use on the Half Dome cables route, a queue forms at the base of the cables, as arriving visitors wait for an opportunity to enter and ascend the cable system. The purpose of the research presented in this briefing is to examine relationships between visitor use density on the Half Dome cables and queuing at the base of the cables route. Results are expected to help inform judgments concerning the appropriate level of use on the Half Dome cables. Further, findings from this component of the Half Dome study provide an empirical basis to model queue formation and length in the computer simulation model of visitor use on the Half Dome cables developed as part of the larger Half Dome visitor use study.

5.2.2 Data Collection & Coding

Three hundred twenty-eight photographic observations of visitor use on the Half Dome cables were collected on nine weekdays and seven weekend days in July and August, 2008. Visitors within each of the photographs were color-coded into one of three groups: 1) visitors queuing to ascend the cables were coded with yellow dots; 2) visitors traveling within the cables were coded with green dots; and 3) visitors traveling outside the cables were coded with red dots (Figure 28). Each color-coded photo was used to compute the number of visitors: 1) in queue for the cables; 2) on the entire observable length of the cables; and 3) on the lower portion of the cables as delineated in Figure 28. The lower portion of the cables is approximately 100 feet in length, constituting roughly one-sixth of the observable extent of the cables. Differentiation of use density on the lower portion of the cables was included in the analysis to optimize modeling of the relationship between cables use density and queue formation. In particular, visual inspection of the photographic observations suggests that visitor congestion in the lower portion of the cables potentially contributes more substantively to queue formation and length than congestion higher on the cables.

Figure 28. Coded Cables Photograph Depicting the Lower Section of the Cables and Queue at its Base

5.2.3 Data Analysis and Results

Queues of visitors waiting to ascend the cables route were observed in only 12 of the 328 photographic observations made during the study period, representing just 4.0% of all photographic observations. This finding, coupled with the fact that data collection occurred during the busiest period of the visitor use season, suggests that queue formation at the base of the cables is a relatively rare event. In photographs with a queue, observed queue lengths ranged from 1 to 33 visitors, with a mean of 12 visitors in queue. All 12 photographic observations of a queue were recorded on Saturdays. Further, all photographic observations of a queue were captured between the hours of 11:20 AM and 3:40 PM, and on days when daily visitor use of the Half Dome Trail exceeded 557 people.

Four regression models were estimated using all 328 photographic observations to examine relationships between visitor use density on the cables and queue formation at the base of the cables. In particular, linear and quadratic regression models were estimated with the number of visitors on the entire observable length of the cables at one time specified as the independent (i.e., explanatory) variable, and the number of visitors in queue at the base of the cables specified as the dependent variable. Similarly, linear and quadratic regression models were estimated with the number of visitors on the lower portion of the cables modeled as the independent variable, and the number of visitors in queue at the base of the cables modeled as the dependent variable. The linear and quadratic models were specified as noted in Equations 1 through 4.

Equation 1: $Q = b_1{*}TC$ ***Equation 2:*** $Q = b_1{*}TC + b_2{*}TC^2$

Equation 3: $Q = b_1{*}BC$ ***Equation 4:*** $Q = b_1{*}BC + b_2{*}BC^2$

Q = Number of visitors in queue at the base of the cables at one time
TC = Number of visitors on the entire observable length of the cables at one time
BC = Number of visitors on the lower portion of the cables at one time
b_1 and b_2 = Regression model parameter estimates

Results of the regression analyses suggest that there is a statistically significant, positive relationship between the total number of people on the cables, whether it be the entire observable length of the cables or just the bottom section of the cables, and queue length at the base of the cables (Table 53). However, the relationships observed in the regression results are not particularly strong, with the best fitting model accounting for only 21% of variation in queue length. The lack of statistically robust relationships may be due to the fact that less than 5% of the observations used to estimate the regression models contained queues of 1 or more people, or it may be that relationships between queue formation and cables use density are in fact not strong. In either case, the findings described in this briefing suggest that queue formation at the base of the cables is a relatively rare event, observed only during mid-day hours on the busiest Saturdays during the summer.

Table 53. PAOT on the Cables and PAOT in Queue - Linear and Quadratic Regression Models (Standard Errors in Parentheses)

	Total on Entire Observable Length of Cables		Total on Bottom Section of Cables	
	Linear	Quadratic	Linear	Quadratic
Parameter 1	0.024* (0.004)	-0.010 (0.010)	0.193* (0.023)	0.025 (0.052)
Parameter 2	--	0.001* (<0.000)	--	0.010* (0.003)
Model R^2	0.092	0.127	0.179	0.210

*Statistically significant at α = 0.001

As stated, one purpose of the analyses presented in this briefing document was to derive an empirical basis for modeling queue formation in the computer model of visitor use on the Half Dome cables developed as part of the larger study. Given the relatively limited predictive power of the regression models presented in Table 53, an alternative approach was developed as the basis for modeling queue formation in the computer model. In particular, a physical capacity of the bottom portion of the cables was defined based on the Highway Capacity Manual's (HCM) Pedestrian Level of Service (LOS) concept. The HCM's Pedestrian LOS E for a walkway area (e.g., the Half Dome cables route) is described as "approaching the limit of capacity with stoppages and interruptions to flow." The HCM's Pedestrian LOS E is reached when walkway space is less than or equal to 15 square feet per person. Using this value, Pedestrian LOS E of the lower section of the Half Dome cables route (which is roughly 300 square feet in area) is estimated to be reached when there are 20 visitors in this area of the cables. To illustrate the use density associated with a Pedestrian LOS E on the lower portion of the cables, Figure 29 depicts a queue formed at the base of the cables with 21 visitors on the lower portion of the cables. Based on these results, the computer model of Half Dome visitor use was programmed to queue simulated visitors at the base of the cables when there are 20 simulated visitors in the bottom portion of the cables, and to clear visitors from the queue when this number falls below 20 visitors.

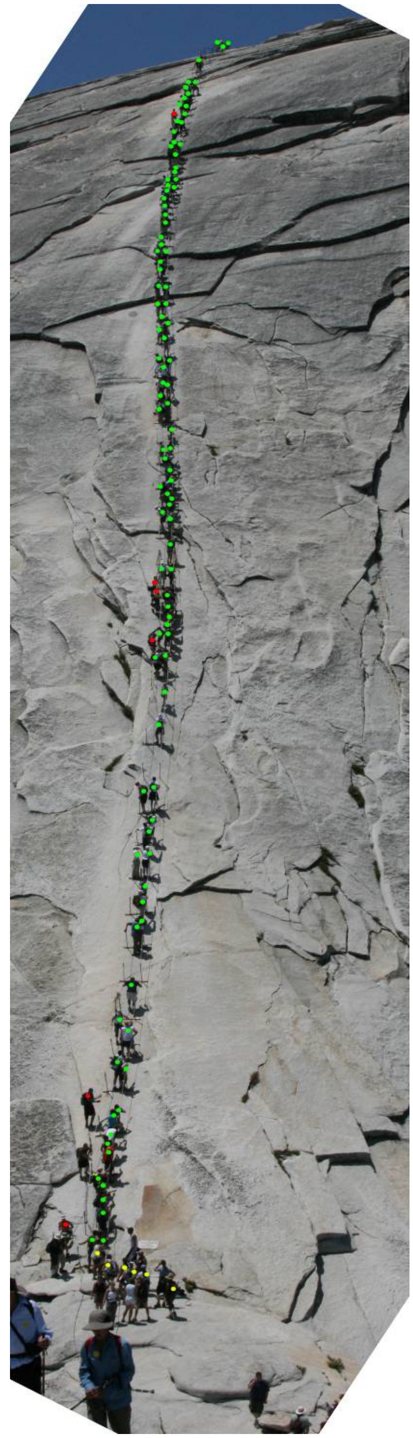
Figure 29. Photographic Observation Depicting Twenty-One Visitors in the Lower Section of the Cables Visitors.

5.3 Relationships Between Half Dome Cables Use Density and Travel Times Ascending and Descending the Cables Route

5.3.1 Issue

Prior to this study, the National Park Service lacked empirical information about the extent to which congestion on the Half Dome cables during periods of high use affects the length of time it takes visitors to ascend and descend the cables. This issue is an important safety concern to the NPS, as visitors whose progress on the cables is impeded by congestion are exposed to the risk of accidents on the cables for longer periods of time. The purpose of the research presented in this briefing is to assess the extent to which visitor use density on the Half Dome cables affects the amount of time it takes visitors to ascend and descend the cables route. A subsequent briefing document presents research designed to examine whether there is a significant relationship between the amount of time it takes to ascend or descend the cables route and the number of visitors who are forced or choose to go outside the cables.

Figure 30. Coded Cables Photograph



5.3.2 Data Collection

Data used in the analysis presented in this briefing are drawn from two sources: 1) photographic observations of visitor use on the Half Dome cables; and 2) the Half Dome Trail hiking route survey. Data used to measure Half Dome cables use density, including the number of visitors ascending or descending the route outside the cables, were collected through 328 photographic observations of the cables route. Visitors ascending or descending the cables within each of the photographs were color-coded into one of two groups: 1) visitors ascending or descending Half Dome within the cables were coded with green dots; 2) visitors ascending or descending outside the cables were coded with red dots (Figure 30). Each color-coded photo was used to compute the number of visitors on the entire observable length of the cables (PAOT) and the number of visitors observable outside the cables (PAOT outside the cables). The Half Dome Trail hiking route survey was administered to collect a total of 660 observations of travel times for visitors ascending and descending the Half Dome cables route. The hiking route survey observations included information about the length of time it took each study participant to ascend and descend the cables, as well as the time at which each participant started ascending and descending the cables. Photographic observations were collected on 21 days during July and August, 2008 and the hiking route survey was administered on a subset of 11 of the days during which photographic observations were recorded. Photographic observations were recorded at twenty minute intervals beginning at 9:00 AM and ending at 4:00 PM. The hiking route survey was administered from 8:00 AM to 4:00 PM.

5.3.3 Analytical Methods

Estimating "Free-flow" Travel Times for Ascending and Descending the Cables

Average travel times to ascend and descend the Half Dome cables under "free flow" conditions (i.e., times when congestion on the cables does not typically impede visitors' progress) were calculated from hiking route survey data collected during periods of relatively low cables use. In particular, the ascent free-flow time was calculated as the mean travel time for all hiking route survey observations in which visitors began ascending the cables between the hours of 9:00 AM and 10:00 AM and stayed within the cables during their ascent. The descent free-flow time was calculated as the mean travel time for all hiking route survey observations in which visitors started descending the cables between the hours of 9:00 AM and 11:00 AM and stayed within the cables during their descent.

Relationship between Cables Use Density and Travel Times on the Cables

Analysis of variance (ANOVA) was used to statistically model relationships between Half Dome cables use density and visitors' travel times ascending and descending the cables. The purpose of these analyses was to test whether it takes visitors more time to ascend and descend the cables as the number of visitors on the cables at one time increases beyond that associated with "free-flow" conditions. For the analyses, two categorical variables were created: 1) PAOT on the cables at the time each hiking route survey participant started to ascend the cables, based on the photographic observation recorded closest in time to each participant's ascent start time; and 2) PAOT on the cables at the time each hiking route survey participant started to descend the cables, based on the photographic observation recorded closest in time to each participant's descent start time. These variables were coded into eight use density categories, ranging from 0-10 PAOT to 90+ PAOT. ANOVA's were conducted with the categorical use density variables as the independent (i.e., explanatory) variables and travel times for visitors *who stayed within the cables* to ascend and descend the cables as the dependent variables. The results of the ANOVA's provide statistical comparisons of mean travel times to ascend and descend the cables, as a function of the number of people on the cables.

5.3.4 Results

"Free-flow" Travel Times for Ascending and Descending the Cables

Visitor use levels during the early hours of the day are relatively low, allowing visitors to ascend and descend the cables route without being impeded by the presence of other people on the cables. Under such conditions, visitors take an average of approximately 20 minutes (N=79) to ascend the cables and about 15 minutes (N=60) to descend the cables route.

Relationship between Cables Use Density and Travel Times on the Cables

Results of the ANOVA relating visitor use density on the cables and visitors' travel times ascending the cables suggest that as the number of people on the cables at one time increases, the amount of time it takes visitors to ascend the cables to the Half Dome summit also increases (Table 54). Further, the ANOVA results in Table 54 suggest that a statistically significant change in the time it takes visitors to ascend the cables occurs when there are 30 or more people on the cables at one time. That is, as the number of people on the cables increases from the lowest category of use density (i.e., 0-9 PAOT) up to as many as 20-29 PAOT, mean travel times for ascending the cables increase, but not significantly. The first statistically significant increase in mean travel times to ascend the cables, as denoted by the superscripts in the Mean Travel Times column in Table 54, occurs once the number of people on the cables at one time increases to 30 or more.

Table 54. Mean Travel Times for Visitors Ascending the Half Dome Cables, by Cables Use Density Categories

PAOT on the Cables	N	Mean Travel Time (mm:ss)
0-9 people	48	20:19[a]
10-19 people	110	21:25[a]
20-29 people	136	22:58[a,b]
30-39 people	149	24:49[b,c]
40-49 people	108	26:21[c,d]
50-79 people	100	28:56[d]
80-89 people	31	38:54[e]
90+ people	25	38:01[e]

Note: Superscripts denote statistically similar mean travel times at α=0.05.

Results of the ANOVA relating visitor use density on the cables and visitors' travel times descending the cables suggest that, generally, as the number of people on the cables at one time increases, the amount of time it takes visitors to descend the cables route also increases (Table 55). Further, the ANOVA results in Table 55 suggest that a statistically significant change in the time it takes visitors to descend the cables occurs when there are 30 or more people on the cables at one time. That is, as the number of people on the cables increases from the lowest category of use density (i.e., 0-9 PAOT) up to as many as 20-29 PAOT, mean travel times for descending the cables increase, but not significantly. The first statistically significant increase in mean travel times to descend the cables, as denoted by the superscripts in the Mean Travel Times column in Table 55, occurs once the number of people on the cables at one time increases to 30 or more.

Table 55. Mean Travel Times for Visitors Descending the Half Come Cables, by Cable Use Density Categories

PAOT on the Cables	N	Mean Travel Time (mm:ss)
0-9 people	13	16:55[a, b, c, d, e, f]
10-19 people	78	16:04[a]
20-29 people	118	18:43[a, b, d, e]
30-39 people	147	21:22[b, d, e, f, h, j]
40-49 people	120	20:39[b, e, f, k]
50-79 people	113	23:00[c, f, g, h, j]
80-89 people	31	26:13[h, i, j]
90+ people	45	24:56[h, j, k]

Note: Superscripts denote statistically similar mean travel times at α=0.05.

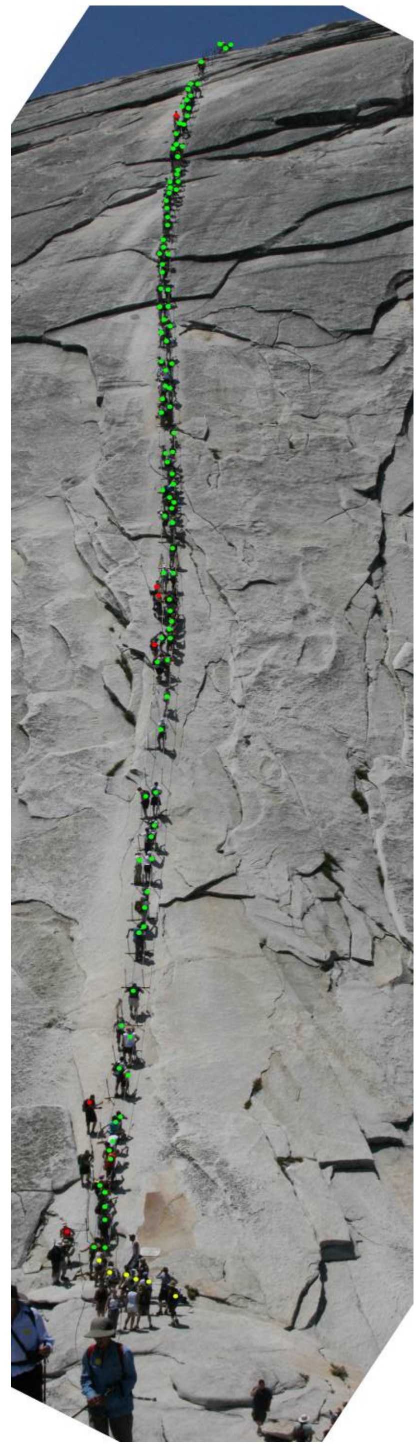
In summary, results of the analyses reported in this briefing suggest that there is a significant and positive relationship between the number of people on the cables at one time and the amount of time it takes visitors to ascend and descend the cables. During periods of low to moderate use (i.e., times when congestion on the cables does not typically impede visitors' progress on the cables), visitors generally ascend the cables in about 20 minutes and descend the cables in about 15 minutes. When the number of people on the cables at one time exceeds a threshold of approximately 30 people, the amount of time it takes visitors to ascend and descend the cables route increases to a statistically significant degree.

5.4 Congestion-Related Delays on the Half Dome Cables and the Prevalence of Visitors Traveling Outside the Cables

5.4.1 Issue

Results of analyses reported in a subsequent briefing suggest that there is a significant and positive relationship between the number of people on the Half Dome cables at one time and the amount of time it takes visitors to ascend and descend the cables. In particular, when cables use density reaches roughly 30 or more people at one time, the amount of time it takes to ascend and descend the cables route increases to a statistically significant degree. Congestion-related delays on the cables route is an important safety concern to the National Park Service, as visitors whose progress on the cables is impeded by the presence of others are exposed to the risk of accidents on the cables for longer periods of time. The purpose of the research presented in this briefing is to examine whether there are statistically significant relationships between the amount of time it takes visitors who stay within the cables to ascend or descend the cables route and the number of visitors who are forced or choose to go outside the cables.

Figure 31. Coded Cables Photograph



5.4.2 Data Collection

Data used in the analysis presented in this briefing are drawn from two sources: 1) photographic observations of visitor use on the Half Dome cables; and 2) a Half Dome Trail hiking route survey. Data used to measure Half Dome cables use density, including the number of visitors ascending or descending the route outside the cables, were collected through 328 photographic observations of the cables route. Visitors ascending or descending the cables within each of the photographs were color-coded into one of two groups: 1) visitors ascending or descending Half Dome within the cables were coded with green dots; 2) visitors ascending or descending outside the cables were coded with red dots (Figure 31). Each color-coded photo was used to compute the number of visitors on the entire observable length of the cables (PAOT) and the number of visitors observable outside the cables (PAOT outside the cables). The Half Dome Trail hiking route survey was administered to collect a total of 660 observations of travel times for visitors ascending and descending the Half Dome cables route. The hiking route survey observations included information about the length of time it took each study participant to ascend and descend the cables, as well as the time at which each participant started ascending and descending the cables. Photographic observations were collected on 21 days during July and August, 2008 and the hiking route survey was administered on a subset of 11 of the days during which photographic observations were recorded. Photographic observations were recorded at twenty minute intervals beginning at 9:00 AM and ending at 4:00 PM. The hiking route survey was administered from 8:00 AM to 4:00 PM.

5.4.3 Analysis

The travel time and photographic observation data were aggregated across all sampling days to compute hourly means for ascent and descent travel times and corresponding hourly means of PAOT outside the cables. To do this, travel time data from the hiking route survey and photographic observations of PAOT outside the cables were matched according to time of day. For example, the hourly mean travel time for visitors beginning their ascent of the cables between 8:50 AM and 9:50 AM was computed and matched with the hourly mean PAOT outside the cables computed based on the 9:00 AM, 9:20 AM, and 9:40 AM photographic observations. It should be noted that mean hourly ascent/descent times were computed based only on delay times of visitors who stayed within the cables during their ascent/descent. This pairing procedure was applied for all data throughout the sampling hours of the study (9:00 AM – 4:00 PM), resulting in 6 pairs of hourly mean ascent times and PAOT outside the cables, and 7 pairs of hourly mean descent times and PAOT outside the cables.

Regression analyses were conducted with the paired travel time and photographic observation data to model statistical relationships between visitors' travel times ascending and descending the cables and PAOT outside the cables. Two linear regression models were estimated, the first with hourly mean travel time to ascend the cables entered as the independent (i.e., explanatory) variable and the second with hourly mean travel time to descend the cables route entered as the independent variable. The hourly mean PAOT outside the cables was specified as the dependent variable in both regression models, as noted in Equations 1 and 2.

Equation 1: $OC = b_1 * \uparrow TT$ ***Equation 2:*** $OC = b_1 * \downarrow TT$

OC = Hourly mean number of visitors outside the cables at one time
TT = Hourly mean visitor travel time on the cables (*arrow denotes direction of travel*)
b_1 = Regression model parameter estimate

5.4.4 Results

Results of the regression analyses suggest that there is a statistically significant, positive relationship between hourly mean travel time to ascend or descend the cables and PAOT outside the cables (Table 56). That is, as the amount of time it takes visitors who stay within the cables to ascend or descend the cables increases, the number of visitors who go outside the cables increases to a statistically significant degree.

Table 56. Travel Time on the Cables and PAOT Outside the Cables - Linear Regression Models (Standard Errors in Parentheses)

	Ascent	Descent
b1	0.065* (0.009)	0.091* (0.012)
Model R^2	0.894	0.901

*Statistically significant at $\alpha = 0.001$

The regression models reported in Table 56 were used to estimate the hourly mean number of people outside the cables at one time, given varying hourly mean travel times for ascending and descending the cables (Table 57). Comparison of the results of these computations with mean ascent (20 minutes) and descent (15 minutes) travel times under "free flow" conditions provides insight into the effects of cables congestion on visitor behavior. In particular, the results suggest that even with relatively minimal congestion-related delays, one or more visitors can be expected to go outside the cables. The results also suggest that factors not explained by the statistical models presented in this briefing (e.g., "thrill-seeking") may cause some visitors to go outside the cables, even when there are no congestion-related delays of their progress. It should be noted that estimates of PAOT outside the cables associated with hourly mean ascent or descent times of greater than 30 minutes should be interpreted with caution, as they require extrapolating beyond the range of observed mean ascent and descent times. That being said, the results provide a reliable empirical basis for generalizing about the relationship between travel times on the Half Dome cables and the incidence of visitors traveling outside the cables as they ascend and descend the granite dome.

Table 57. Estimated Hourly Mean Number of Visitors Outside the Half Dome Cables as a Function of Hourly Mean Travel Times Ascending and Descending the Cables Route

Hourly Mean Ascent Time (minutes)	Hourly Mean # of Visitors Outside Cables	Hourly Mean Descent Time (minutes)	Hourly Mean # of Visitors Outside Cables
1 – 7	0	1 - 5	0
8 – 22	1	6 – 16	1
23 – 38	2	17 – 27	2
39 – 53	3	28 – 38	3
54 – 68	4	39 – 49	4

5.5 Visitors' Perceptions of Risk and Crowding on the Half Dome Cables Route

5.5.1 Issue

This study investigated visitors' perceptions of risk, safety, and crowding on the Half Dome Trail and cables route, including measuring visitor-based standards for crowding and risk on the Half Dome cables. The study also examined visitors' attitudes about the appropriateness and acceptability of management actions designed to address visitor safety and crowding issues on the Half Dome Trail and cables route. Finally, this research assessed visitors' preparedness for the hike to the Half Dome summit and demographic characteristics. The results of the study are expected to support the National Park Service (NPS) in decision-making related to managing visitor safety and crowding issues associated with the hike to the summit of Half Dome.

5.5.2 Data Collection

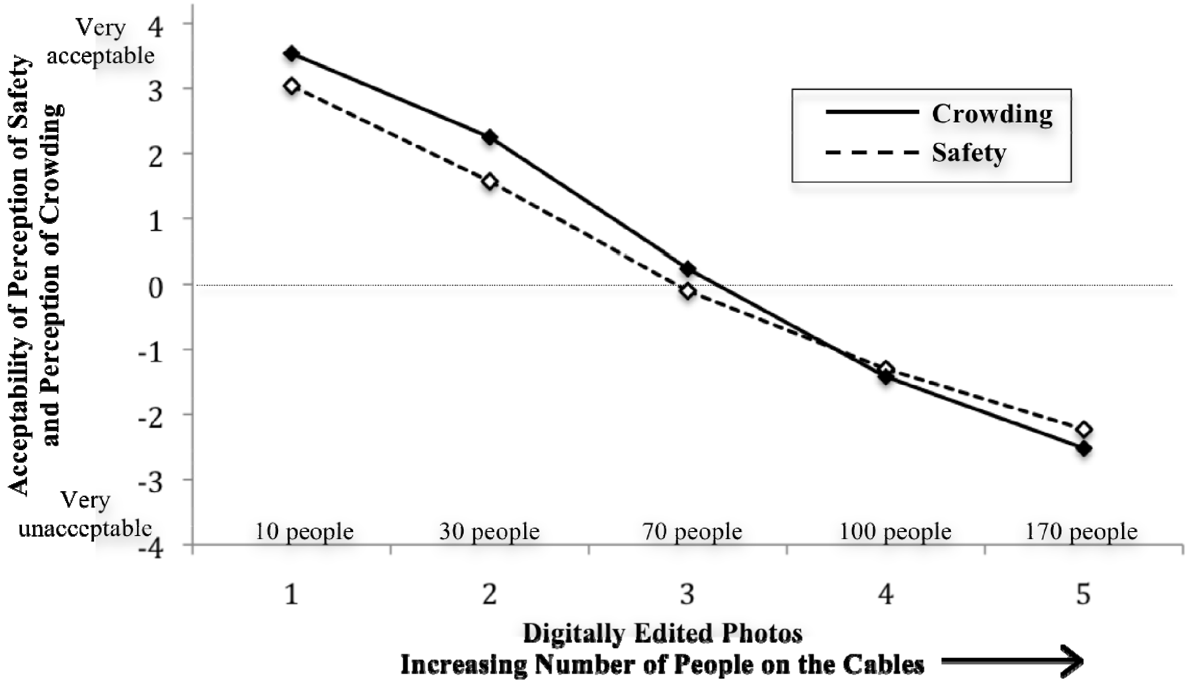
The investigation consisted of an on-site visitor survey administered at the subdome on the Half Dome Trail on five days between August 3, 2008 and August 16, 2008. The survey response rate was 90%, resulting in a total of 291 completed questionnaires. The survey instrument was designed to address several topics related to the Half Dome Trail and cables route, including visitors': 1) perceptions of risk, safety, and crowding; 2) support or opposition for potential visitor use management actions; and 3) demographics. In addition, a series of questions accompanied by digitally-edited photographs was included to measure visitor-based standards for risk and crowding on the Half Dome cables route (Figure 32).

Figure 32. Example of Two of the Five Digitally Edited Photos Used to Measure Visitor-Based Standards for Crowding and Risk

5.5.3 Data Analysis

Data from the survey were analyzed using Statistical Package for Social Sciences (SPSS) version 17.0. Descriptive results suggest that: 1) most Half Dome hikers are day-hikers who start their hikes at Happy Isles; 2) a substantial majority of Half Dome hikers are college educated, white males, between 18 and 35 years of age; 3) when there are 70 or more people on the cables at one time, visitors generally report feeling unsafe and crowded (Figure 33); 4) Half Dome hikers feel more crowded on the cables route than on any other portion of the hike to the summit of Half Dome; 5) visitors commonly witness what they perceive to be unsafe behaviors on the cables route, yet they generally feel safe and enjoy their experience on the cables route; 6) visitors generally prefer to see no more than 10 to 30 people at one time on the cables; 7) visitors generally believe visitor use should be limited, if needed, to prevent the number of people at one time on the cables from exceeding 70 to 100 people; 8) respondents generally reported they would not return if there would be 100 or more people on the cables at one time (Table 29); and 9) visitors' most preferred safety and crowding management actions include increasing signage and enforcing rules, while the least preferred actions include requiring the use of safety equipment and charging use fees to hike to the summit of Half Dome.

Figure 33. Respondents' Mean Acceptability Ratings of their Perceptions of Safety and Crowding for Each Photo



Appendix A HALF DOME TRAIL CALIBRATION COUNT LOG

Half Dome Trail Count Form

Date: ___________________ Weather: _____________________________

Initials: ______________

Time			Inbound	Outbound	Comments
9:00	to	9:15			
9:15	to	9:30			
9:30	to	9:45			
9:45	to	10:00			
10:00	to	10:15			
10:15	to	10:30			
10:30	to	10:45			
10:45	to	11:00			
11:00	to	11:15			
11:15	to	11:30			
11:30	to	11:45			
11:45	to	12:00			
12:00	to	12:15			
12:15	to	12:30			
12:30	to	12:45			
12:45	to	13:00			
13:00	to	13:15			
13:15	to	13:30			
13:30	to	13:45			
13:45	to	14:00			
14:00	to	14:15			
14:15	to	14:30			
14:30	to	14:45			
14:45	to	15:00			
15:00	to	15:15			
15:15	to	15:30			
15:30	to	15:45			
15:45	to	16:00			

Appendix B HAPPY ISLES HIKING ROUTE SURVEY CARD

Happy Isles to Half Dome Trailhead Hiking Times

2008

1. Card no.____________
2. Date:_______________
3. Group size:____________
4. Time depart Happy Isles: __________
5. Time arrive at Half Dome Trailhead (X1): _________

Thank you for your help with this important study!

PRIVACY ACT and PAPERWORK REDUCTION ACT statement: 16 U.S.C. 1a-7 authorizes collection of this information. This information will be used by park managers to better serve the public. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. The permanent data will be anonymous. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. BURDEN ESTIMATE statement: Public reporting burden for this form is estimated to average 5 minutes per response. Direct comments regarding the burden estimate or any other aspect of this form to:
Bret Meldrum
Resources Management and Science
5083 Foresta Rd.
El Portal, CA 95318
bret_meldrum@nps.gov

OMB # 1024-0224 (NPS # 08-013)

Expiration Date: 10/31/2009

Appendix C HALF DOME TRAIL HIKING ROUTE SURVEY CARD

Half Dome Survey 2008 *OMB#:*1024-0224 (NPS #08-013) *Expires:* 10/31/2009

Card #: ___________ Date: ______________ Group Size: __________

1.

Location	**Current Time *Up*** hh:mm:ss	**Location**	**Current Time *Down*** hh:mm:ss
Trailhead	Time : :	**Top Cables *Enter***	Time : :
Sub-dome	Time : :	**Base Cables *Exit***	Time : :
Base Cables *Enter*	Time ___:_____:____ Wait in Queue? ☐ No ☐ Yes: _______ *min*	**Sub-dome**	Time ___:_____:____
Top Cables *Exit*	Time : :	**Trailhead**	Time : :

2. Did you climb the cables to the Half Dome Summit? ☐ No (*go to Q3*) ☐ Yes (*go to Q4*)

3. Which of the following best describes your trip today? (*Check one*)

☐ Hiked to the sub-dome, spent no time before returning (*end survey*)

☐ Hiked to the sub-dome, spent time before returning (*end survey*)

☐ Waited in queue, but decided not to climb cables (*end survey*)

☐ Climbed part-way up cables, but did not summit (*end survey*)

☐ DK/NS or ☐ Other: ________________________________ (*end survey*)

4. While climbing up and down the cables today, did you go outside of the Half Dome Cables? (*Check all that apply*)

☐ Yes, upward ☐ Yes, downward ☐ No (*end survey*)

5. Which of the following best explains why you went outside the cables today? (*Check all that apply*)

☐ To avoid being delayed by crowds inside the cables

☐ I thought it would be safer than being inside the cables

☐ I thought it would be more fun than being inside the cables

☐ Other: ____

Appendix D HAPPY ISLES HIKING ROUTE SURVEY LOG

Happy Isles → Half Dome Delay Card Log

Date: __________ Weather: _____________ Random Start: ________

AM Initials: ____________________ PM Initials: _____________________________

Time			Intercept Time	Refusals	Card Number	Group Size	Comments
5:00	to	5:10					
5:10	to	5:20					
5:20	to	5:30					
5:30	to	5:40					
5:40	to	5:50					
5:50	to	6:00					
6:00	to	6:10					
6:10	to	6:20					
6:20	to	6:30					
6:30	to	6:40					
6:40	to	6:50					
6:50	to	7:00					
7:00	to	7:10					
7:10	to	7:20					
7:20	to	7:30					
7:30	to	7:40					
7:40	to	7:50					
7:50	to	8:00					
8:00	to	8:10					
8:10	to	8:20					
8:20	to	8:30					
8:30	to	8:40					
8:40	to	8:50					

Time			Intercept Time	Refusals	Card Number	Group Size	Comments
8:50	to	9:00					
9:00	to	9:10					
9:10	to	9:20					
9:20	to	9:30					
9:30	to	9:40					
9:40	to	9:50					
9:50	to	10:00					
10:00	to	10:10					
10:10	to	10:20					
10:20	to	10:30					
10:30	to	10:40					
10:40	to	10:50					
10:50	to	11:00					
11:00	to	11:10					
11:10	to	11:20					
11:20	to	11:30					
11:30	to	11:40					
11:40	to	11:50					
11:50	to	12:00					
12:00	to	12:10					
12:10	to	12:20					
12:20	to	12:30					
12:30	to	12:40					
12:40	to	12:50					
12:50	to	13:00					

Appendix E HALF DOME TRAIL HIKING ROUTE SURVEY LOG

Half Dome Cables Delay Card Log   Page _____ of ______

Date: __________________   Initials: ___________________________

Time	**Group Size**	**Accept/Refuse**	**Card #**	**Comments**
hh-mm	*#*	*A/R*		

Comment Codes: LB – refusal due to language barrier

NOTE: From 9:00 to 13:00 recruitments are to occur as minimal 5 minute intervals.

Appendix F HAPPY ISLES HIKING ROUTE SURVEY CODEBOOK

Refers to *Hiking Route Survey Data and Analysis\Delay Data Analysis - Happy Isles to Half Dome.xls*

Variable	Description	Origin	Values
Card_Num	Card number	Card Front	#
Date	Date	Card Front	dd-mm-yyyy
Group_Size	Group size	Card Front	#
Group_Size_Extreme	Group size excluding extreme outliers	Calculated	#
Group_Size_Grouped_Extreme	Group size excluding extreme outliers grouped	Calculated	1, 2, and 3+
HI_Time_0700	Whether group arrived at Happy Isles before 7:00 AM	Calculated	1=yes, 2=no
HI_Time_0730	Whether group arrived at Happy Isles before 7:30 AM	Calculated	1=yes, 2=no
HI_Time_0800	Whether group arrived at Happy Isles before 8:00 AM	Calculated	1=yes, 2=no
HI_Time	Time group reached Happy Isles Trailhead	Card Front	hh:mm:ss
HD_Time	Time group reached Half Dome Trailhead/X1	Card Front	hh:mm:ss
TT_HI_to_HD	Travel time from Happy Isles to Half Dome (minutes)	Calculated	minutes
TT_HI_to_HD_Extreme	Travel time from Happy Isles to Half Dome excluding extreme outliers (minutes)	Calculated	minutes

Appendix G HALF DOME TRAIL HIKING ROUTE SURVEY CODEBOOK

Refers to *Hiking Route Survey Data and Analysis\Delay Data Analysis - Half Dome.xls*

Variable	Description	Origin	Values
Card Number	Unique response ID	Card Front	# (1-1142)
Date	Date of data collection	Card Front	dd-mm-yyyy
GroupSize	Reported group size at X1	Card Front	#
GroupSize_Extreme	Reported group size at X1 excluding extreme outliers	Calculated	#
GroupSize_Extreme_Grouped	Reported group size at X1 excluding extreme outliers grouped	Calculated	1 = 1 2 = 2 3 = 3+
HappyIsles	Did the respondent start at the Happy Isles Trailhead?	Card Front (had written on cards 614-1142)	0 = no 1 = yes
X1Up_Time	Time respondent arrives at trailhead (X1) upbound	Card Front	hh:mm:ss
X2Up_Time	Time respondent arrives at subdome (X2) upbound	Card Front	hh:mm:ss
X3Up_Time	Time respondent arrives at base of the cables (X3) upbound	Card Front	hh:mm:ss
X4Up_Time	Time respondent arrives at top of the cables (X4) upbound	Card Front	hh:mm:ss
X4Down_Time	Time respondent arrives at top of the cables (X4) downbound	Card Front	hh:mm:ss
X3Down_Time	Time respondent arrives at base of cables (X3) downbound	Card Front	hh:mm:ss
X2Down_Time	Time respondent arrives at Subdome (X2) downbound	Card Front	hh:mm:ss
X1Down_Time	Time respondent arrives at trailhead (X1) downbound	Card Front	hh:mm:ss
X1Up	Stop number for X1Up	Calculated	# (1 = first stop, 2 = second stop, etc)
X2Up	Stop number for X2Up	Calculated	# (1 = first stop, 2 = second stop, etc)
X3Up	Stop number for X3Up	Calculated	# (1 = first stop, 2 = second stop, etc)
X4Up	Stop number for X4Up	Calculated	# (1 = first stop, 2 = second stop, etc)
X4Down	Stop number for X4Down	Calculated	# (1 = first stop, 2 = second stop, etc)
X3Down	Stop number for X3Down	Calculated	# (1 = first stop, 2 = second stop, etc)
X2Down	Stop number for X2Down	Calculated	# (1 = first stop, 2 = second stop, etc)
X1Down	Stop number for X1Down	Calculated	# (1 = first stop, 2 = second stop, etc)
RouteLoc1	Location of Stop 1	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc2	Location of Stop 2	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down

HALF DOME TRAIL HIKING ROUTE SURVEY CODEBOOK (CONTINUED)

Variable	Description	Origin	Values
RouteLoc3	Location of Stop 3	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc4	Location of Stop 4	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc5	Location of Stop 5	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc6	Location of Stop 6	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc7	Location of Stop 7	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteLoc8	Location of Stop 8	Calculated	X1Up, X2Up, X3Up, X4Up, X4Down, X3Down, X2Down, X1Down
RouteCheck1	Checks whether route stop pairings are logical: RouteLoc1 and RouteLoc2	Calculated	0 = Logical 1 = Error
RouteCheck2	Checks whether route stop pairings are logical: RouteLoc2 and RouteLoc3	Calculated	0 = Logical 1 = Error
RouteCheck3	Checks whether route stop pairings are logical: RouteLoc3 and RouteLoc4	Calculated	0 = Logical 1 = Error
RouteCheck4	Checks whether route stop pairings are logical: RouteLoc4 and RouteLoc5	Calculated	0 = Logical 1 = Error
RouteCheck5	Checks whether route stop pairings are logical: RouteLoc5 and RouteLoc6	Calculated	0 = Logical 1 = Error
RouteCheck6	Checks whether route stop pairings are logical: RouteLoc6 and RouteLoc7	Calculated	0 = Logical 1 = Error
RouteCheck7	Checks whether route stop pairings are logical: RouteLoc7 and RouteLoc8	Calculated	0 = Logical 1 = Error
RouteCheckSum	Sum of route errors	Calculated	#
TT_X1UpX1Down	Travel time between X1Up and X1Down (NOT USED)	Calculated	hh:mm:ss
TT_X1UpPPVUp	Travel time between X1Up and PPVUp	Calculated	hh:mm:ss
TT_PPVUp	Travel time for PPVUp	Calculated	hh:mm:ss
TT_PPVUpX2Up	Travel time between PPVUp and X2Up	Calculated	hh:mm:ss

Variable	Description	Origin	Values
TT_X2UpX2Down	Travel time between X2Up and X2Down (NOT USED)	Calculated	hh:mm:ss
TT_X2UpX3Up	Travel time between X2Up and X3Up	Calculated	hh:mm:ss
TT_X3UpX3Down	Travel time between X3Up and X3Down (NOT USED)	Calculated	hh:mm:ss
TT_X3UpX4Up	Travel time between X3Up and X4Up	Calculated	hh:mm:ss
TT_X4UpX4Down	Travel time between X4Up and X4Down	Calculated	hh:mm:ss
TT_X4DownX3Down	Travel time between X4Down and X3Down	Calculated	hh:mm:ss
TT_X3DownX2Down	Travel time between X3Down and X2Down	Calculated	hh:mm:ss
TT_X2DownPPVDown	Travel time between X2Down and PPVDown	Calculated	hh:mm:ss
TT_PPVDown	Travel time for PPVDown	Calculated	hh:mm:ss
TT_PPVDownX1Down	Travel time between PPVDown and X1Down	Calculated	hh:mm:ss
TT_X1UpPPVUp_Extreme	Travel time between X1Up and PPVUp, excluding extreme outliers	Calculated	hh:mm:ss
TT_PPVUp_Extreme	Travel time for PPVUp, excluding extreme outliers	Calculated	hh:mm:ss
TT_PPVUpX2Up_Extreme	Travel time between PPVUp and X2Up, excluding extreme outliers	Calculated	hh:mm:ss
TT_X2UpX3Up_Extreme	Travel time between X2Up and X3Up, excluding extreme outliers	Calculated	hh:mm:ss
TT_X3UpX4Up_Extreme	Travel time between X3Up and X4Up, excluding extreme outliers	Calculated	hh:mm:ss
TT_X4UpX4Down_Extreme	Travel time between X4Up and X4Down, excluding extreme outliers	Calculated	hh:mm:ss
TT_X4DownX3Down_Extreme	Travel time between X4Down and X3Down, excluding extreme outliers	Calculated	hh:mm:ss
TT_X3DownX2Down_Extreme	Travel time between X3Down and X2Down, excluding extreme outliers	Calculated	hh:mm:ss
TT_X2DownPPVDown_Extreme	Travel time between X2Down and PPVDown, excluding extreme outliers	Calculated	hh:mm:ss
TT_PPVDown_Extreme	Travel time for PPVDown, excluding extreme outliers	Calculated	hh:mm:ss
TT_PPVDownX1Down_Extreme	Travel time between PPVDown and X1Down, excluding extreme outliers	Calculated	hh:mm:ss

HALF DOME TRAIL HIKING ROUTE SURVEY CODEBOOK (CONTINUED)

Variable	Description	Origin	Values
UpPhotoTime	Cable photo observation to be paired with upbound cable delay data	Photo time assigned to all BaseCablesEnterUp times +/- 10 min of cable photo observation times.	hh:mm:ss (9:00-16:00)
UpPhotoTimeGroup	Hourly grouping of up photo observations	UpPhotoTime grouped by hour	1 = 9:00, 9:20, 9:40 2 = 10:00, 10:20, 10:40 3 = 11:00, 11:20, 11:40 4 = 12:00, 12:20, 12:40 5 = 13:00, 13:20, 13:40 6 = 14:00, 14:20, 14:40 7 = 15:00, 15:20, 15:40
UpOutsideCables	PAOT outside the cables	Count from UpPhotoTime observation	#
UpOutsideCables_PhotoGroup	Hourly mean PAOT outside the cables by UpPhotoTimeGroup	UpOutsideCables mean by UpPhotoTimeGroup	#
UpTotalOnCables	PAOT on cable route (inside + outside)	Count from UpPhotoTime observation	#
UpTotalOnCablesGroup	Grouped UpTotalonCables	Calculated from UpTotalonCables	1=1-9 2=10-19 3=20-29 4=30-39 5=40-49 6=50-79 7=80-89 8=90+
Queue	Was a queue present upon upbound arrival at X3	Card Front	0=no 1=yes
QueueLength	Reported waiting time from the visitor route survey	Card Front	minutes
TT_X3X4Up_Extreme_PhotoGroup	Mean X3 to X4 travel time by photo groups (UpPhotoTimeGroup)		
TT_X3X4Up_Extreme_CablesGroup	Mean X3 to X4 travel time by cable groups (UpTotalOnCablesGroup)	Calculated	minutes
DownPhotoTime	Cable photo observation to be paired with downbound cable delay data	Photo time assigned to all TopCablesEnterUp times +/- 10 min of cable photo observation times.	hh:mm:ss (9:00-16:00)
DownPhotoTimeGroup	Hourly grouping of down photo observations	DownPhotoTime grouped by hour	1 = 9:00, 9:20, 9:40 2 = 10:00, 10:20, 10:40 3 = 11:00, 11:20, 11:40 4 = 12:00, 12:20, 12:40 5 = 13:00, 13:20, 13:40 6 = 14:00, 14:20, 14:40 7 = 15:00, 15:20, 15:40 8 = 16:00

Variable	Description	Origin	Values
DownOutsideCables	PAOT outside the cables	Count from DownPhotoTime observation	#
DownOutsideCables_PhotoGroup	Hourly mean PAOT outside the cables by DownPhotoTimeGroup	DownOutsideCables mean by DownPhotoTimeGroup	#
DownTotalOnCables	PAOT on cable route (inside + outside)	Count from DownPhotoTime observation	#
DownTotalOnCablesGroup	Grouped DownTotalonCables	Calculated from DownTotalonCables	1=1-9 2=10-19 3=20-29 4=30-39 5=40-49 6=50-79 7=80-89 8=90+
TT_X4X3Down_Extreme_PhotoGroup	Mean X4 to X3 travel time by photo groups (DownPhotoTimeGroup)		
TT_X4X3Down_Extreme_CablesGroup	Mean down delay time for PAOT on cable groups	Calculated	minutes
MeanUpDownTotalOnCables	Mean of UpTotalOnCables and DownTotalOnCables	Mean of UpTotalOnCables and DownTotalOnCables	#
MeanUpDownOutsideCables	Mean of UpOutsideCables and DownOutsideCables	Mean of UpOutsideCables and DownOutsideCables	#
Summit	Q2	Did you climb the cables to the summit of Half Dome today?	0 = No 1 = Yes

HALF DOME TRAIL HIKING ROUTE SURVEY CODEBOOK (CONTINUED)

Variable	Description	Origin	Values
TripType	Q3	Which of the following best describes your trip today?	1 = Hiked to the sub-dome, spent no time before returning 2 = Hiked to the sub-dome, spent time before returning 3 = Waited in queue, but decided not to climb the cables 4 = Climbed part way up the cables, but did not summit 5 = Other *code all "other" responses describing a trip turning around on the Half Dome Trail between the trailhead (X1) and arrival at the sub-dome (X2)* 6 = Other *code all "other" responses describing trip turnarounds not included in code 5* 99 = Don't Know / Not Sure
TripTypeOtherText	Q3	Text entered in other line associated with Q3 codes 5 &6	Text
OutsideCables	Q4	While climbing up and down the cables today, did you go outside the Half Dome Cables?	0 = No 1 = Yes, *upward* 2 = Yes, *downward* 3 = Yes, *both up & down*
OutsideCablesAvoidDelay	Q5	Went outside the cables to avoid being delayed by crowds.	0 = No 1 = Yes
OutsideCablesSafer	Q5	Went outside the cables because I thought it would be safer.	0 = No 1 = Yes
OutsideCablesFun	Q5	Went outside the cables because I thought it would be more fun.	0 = No 1 = Yes
OutsideCablesPass	Q5	Went outside the cables to let others pass.	0 = No 1 = Yes

Variable	Description	Origin	Values
OutsideCablesOther	Q5	Went outside the cables for other reasons. *Code all other responses describing going outside the cables "to let others pass" as Q5pass.*	0 = No 1 = Yes
OutsideCablesOtherText	Q5	Record text of Q5 other response coded as 1.	Text
OutsideCablesGroup	Groups why people went outside cables		1 = did not go out 2 = went out to avoid delay 3 = went out for all other reasons.

Appendix H HALF DOME CABLES ROUTE PHOTOGRAPHIC OBSERVATION LOG

Half Dome Cable Photo Log

Date: ____________________ Weather: ______________________________

Initials: _______________ Card #: _______________________________

Time	File #	Comments
8:00		
8:20		
8:40		
9:00		
9:20		
9:40		
10:00		
10:20		
10:40		
11:00		
11:20		
11:40		
12:00		
12:20		
12:40		
13:00		
13:20		
13:40		
14:00		
14:20		
14:40		
15:00		
15:20		
15:40		
16:00		

Appendix I HALF DOME CABLES ROUTE PHOTOGRAPHIC OBSERVATION CODEBOOK

Refers to *Hiking Route Survey Data and Analysis\ HD Cables Route Photo Data.sav*

Variable	Description	Origin	Values
Date	Date of data collection	Card Front	dd-mm-yyyy (7-24-08 to 7-28-08)
Weekend	Groups Weekdays & Sundays and Saturdays & July 4th	*Date*	0 = Weekdays & Sundays 1 = Saturdays & July 4th
Time	Time of Photographic Observation	Photographic Observation Log	hh:mm (09:00 to 16:00; hh::00, hh:20, or hh:40)
Hour	Hour of photographic observation	*Time*	hh:00 (9:00 to 16:00)
OutsideCables	PAOT outside the cables	Sum of red codes in each photographic observation	#
TotalonCables	PAOT using on the cables route, including those outside the cables	Sum of green and red codes in each photographic observation	#
Queue	PAOT in queue at the base of the cables route	Sum of yellow codes in each photographic observation	#
BottomCablesOutside	PAOT outside the lower 1/6th of the cables	Sum of red codes in each photographic observation below the 10th stanchion above the base of the cables	#
Bottom TotalonCables	PAOT using the lower 1/6th of the cables route, including those outside the cables	Sum of green and red codes in each photographic observation below the 10th stanchion above the base of the cables	#

Appendix J VISITOR CROWDING AND SAFETY SURVEY QUESTIONNAIRE

Half Dome Survey

2008

Date:_____________ Time:____________ AM/PM ID:______________

QuickTime™ and a decompressor are needed to see this picture.

Thank you for agreeing to take this survey. Your input is very important to protect Yosemite National Park.

1. Where did you start your hike to Half Dome?

   ____

2. We are interested in learning about your experience with hiking on trails in Yosemite and other national parks and wilderness areas. We are defining a day hike as a hike of at least one mile round-trip on an established trail in a park or wilderness area without staying overnight along the trail.

   a. On this trip, are you a day hiker or an overnight backpacker? (Check one)

   ❒ Day hiker

   ❒ Overnight backpacker

   b. Including this hike, approximately how many hikes (day and overnight) have you taken in Yosemite National Park in the past 12 months?

   NUMBER OF HIKES: _______________

   c. Including the hike you're on now, approximately how many hikes (day and overnight) have you taken in Yosemite National Park in your lifetime?

   NUMBER OF HIKES: _______________

   d. Approximately how many hikes (day and overnight) have you taken in the past 12 months in other parks or Wilderness areas?

   NUMBER OF HIKES: _______________

3. **We would like to know how many other people you think you could see at one time on the cables without feeling too crowded. To help judge this, please rate each of the photographs by indicating how acceptable you find it based on the number of people in the photo. (Circle <u>one</u> number for each photo.)**

	Very Unacceptable							Very Acceptable
Photo 1…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 2…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 3 …	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 4…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 5…	-4	-3	-2	-1	0	+1	+2	+3	+4

4. **We would also like to know how many other people you could see at one time on the cables without feeling too unsafe. Please rate each of the photographs by indicating how safe or unsafe you find it based on the number of people in the photo. (Circle <u>one</u> number for each photo.)**

	Very Unsafe							Very Safe	
Photo 1…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 2…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 3 …	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 4…	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 5…	-4	-3	-2	-1	0	+1	+2	+3	+4

5. **Which photograph shows the maximum number of people <u>the National Park Service should allow on the cables at one time</u>? In other words, at what point should visitor use of the cables be limited? (Record photo number or check one of the boxes.)**

__________ Photo Number **<u>OR</u>** ❒ Visitor use should not be limited at any point represented in the photos **<u>OR</u>** ❒ Visitor use should not be limited at all

6. **Which photograph shows the number of people on the cables that you would prefer to see? (Record photo number or check one of the boxes.)**

__________ Photo Number **<u>OR</u>** ❒ Don't Know

7. **Which photograph shows the number of people on the cables that would cause you to never want to return? (Record photo number or check one of the boxes.)**

__________ Photo Number **<u>OR</u>** ❒ Don't Know **<u>OR</u>** ❒ The number of people on the cables does not matter to me

8. **Which photograph looks most like the number of people on the cables you saw today? (Record photo number or check one of the boxes.)**

________________ Photo Number

OR

❒ Don't Know

9. **How crowded did you feel at each of the following locations?**

		Not at all Crowded				Moderately Crowded				Extremely Crowded
a.	On the trail while hiking	1	2	3	4	5	6	7	8	9
b.	At the sub-dome	1	2	3	4	5	6	7	8	9
b.	At the base of the cables	1	2	3	4	5	6	7	8	9
c.	On the cables	1	2	3	4	5	6	7	8	9
d.	On the Half Dome summit	1	2	3	4	5	6	7	8	9

10. **To what extent do you agree or disagree with each of the following statements?**

		Highly Disagree		Neither Agree or Disagree		Highly Agree
a.	The Half Dome cables are extremely dangerous.	-2	-1	0	+1	+2
b.	The likelihood of me having an accident on the cables is high.	-2	-1	0	+1	+2
c.	The likelihood of the average person having an accident on the cables is high.	-2	-1	0	+1	+2
d.	The likelihood of a serious injury occurring from an accident on the cables is high.	-2	-1	0	+1	+2
e.	Rangers will advise visitors when it is NOT safe to climb the cables.	-2	-1	0	+1	+2
f.	Passing outside the cables is a safe way to get by slower climbers.	-2	-1	0	+1	+2
g.	Hiking Half Dome requires special physical conditioning.	-2	-1	0	+1	+2
h.	Hiking Half Dome requires special equipment.	-2	-1	0	+1	+2
i.	Hiking Half Dome requires special caution.	-2	-1	0	+1	+2
j.	Hiking Half Dome is more dangerous than hiking trails in most other parks and wilderness areas.	-2	-1	0	+1	+2
k.	If an accident happens to me on the Half Dome hike, rangers will be able to help me back to safety.	-2	-1	0	+1	+2
l.	Hiking Half Dome is depicted as being more difficult than it really is.	-2	-1	0	+1	+2

11. **To what extent do you support or oppose each of the following potential management practices concerning the Half Dome Cables hike?**

		Strongly Oppose		Neutral		Strongly Support
a.	Increase informational signs regarding potential safety/natural hazards at the cables	-2	-1	0	+1	+2
b.	Provide mileage signs along the hike	-2	-1	0	+1	+2
c.	Require an orientation (e.g., a short video) that emphasizes visitor safety and Leave No Trace principles	-2	-1	0	+1	+2
d.	Implement a use etiquette education program regarding us on the cables	-2	-1	0	+1	+2
e.	Limit the number of hikers allowed to hike the Half Dome Cables each day by means of a permit system (ie. day-use reservation system)	-2	-1	0	+1	+2
f.	Require all hikers on this trail to use climbing specific equipment (harnesses, cordage, and carabiners) to ascend the cables	-2	-1	0	+1	+2
g.	Charge a hiking fee for use of the Half Dome Cables to help pay for hiker education and safety	-2	-1	0	+1	+2
h.	Provide more rangers along this trail to enforce Leave No Trace principles, rules, and regulations	-2	-1	0	+1	+2
i.	Require visitors to start the hike before 7:00am	-2	-1	0	+1	+2
j.	Limit promotion of the cables trail (remove interpretive photos, work with the concessionaire to minimize related souvenir sales, etc) to reduce use of the Half Dome Cables	-2	-1	0	+1	+2

12. **Please rate the Half Dome cables route on the following.**

		Extremely Poor		Neutral		Extremely Good
a.	Availability of information	-2	-1	0	+1	+2
b.	Safety and security	-2	-1	0	+1	+2
c.	Your overall satisfaction	-2	-1	0	+1	+2
d.	Signs about the conditions of the cables	-2	-1	0	+1	+2
e.	Mileage signs	-2	-1	0	+1	+2
f.	Presence of rangers	-2	-1	0	+1	+2

13. **Did you encounter a ranger on the hike today?**

- ❒ Yes
- ❒ No

If Yes, did you gain information regarding the Half Dome cables hike from them?

- ❒ Yes
- ❒ No

14. **Please indicate how often you observed each of the following.**

		Not at All		Sometimes		Very Often
a.	Passing on the outside of the cables while holding onto the cables	0	1	2	3	4
b.	Passing on the outside of the cables while NOT holding onto the cables	0	1	2	3	4
c.	Dangerous behavior	0	1	2	3	4
d.	Dropping items such as water bottles	0	1	2	3	4
e.	Falling rocks	0	1	2	3	4
f.	Individuals frozen on the cables due to fear	0	1	2	3	4
g.	Individuals you believe were unprepared for the hike or climb	0	1	2	3	4
h.	Individuals you believe were not fit enough for the hike or climb	0	1	2	3	4

15. Are there any safety issues that need to be addressed with concerning the Half Dome hike, and if so, what are they?

____

____

____

____

16. **What is the highest level of formal education you have completed? (Check one)**
- ❒ Some high school
- ❒ High school or GED
- ❒ Some college, business or trade school
- ❒ College, business or trade school graduate
- ❒ Some graduate school
- ❒ Master's, doctoral or professional degree

17. **Are you:** ❒ Male ❒ Female

18. **What is the zip code of your permanent residence? (*Enter the name of the country if you reside outside the United States.)***

ZIP CODE: __________________________

19. **What is your age?** _______ years

20. **Are you Hispanic or Latino? (Check one)**
- ❒ Yes
- ❒ No

21. **Are you of Middle Eastern/Arabian ancestry/ descent? (Check one)**

- ☐ Yes
- ☐ No

22. **What is your race? (Check all that apply)**

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian
- ☐ Pacific Islander other than Native Hawaiian
- ☐ White

Thank you for your help with this survey. Your input is very important. Please return this completed questionnaire to the survey attendant. You can obtain further information about this and other studies later this year at: www.nps.gov/goga.

PRIVACY ACT and PAPERWORK REDUCTION ACT statement:
16 U.S.C. 1a-7 authorizes collection of this information. This information will be used by park managers to better serve the public. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. Your name is requested for follow-up mailing purposes only. When analysis of the questionnaire is completed, all name and address files will be destroyed. Thus the permanent data will be anonymous. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

OMB control number: 1024-0224 (NPS#08-013)
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BURDEN ESTIMATE STATEMENT: Public reporting burden for this form is estimated to average 15 minutes per response. Direct comments regarding the burden estimate or any other aspect of this form to:

Bret Meldrum
Yosemite National Park
Resources Management and Science Division

Phone: 209-379-1216
bret_meldrum@nps.gov

Appendix K VISITOR CROWDING AND SAFETY SURVEY PHOTOGRAPHS

Photo 1
(11 People)

Photo 2
(34 People)

Photo 3
(70 People)

Photo 4
(105 People)

Photo 5
(170 People)

Appendix L VISITOR CROWDING AND SAFETY SURVEY REFUSAL LOG

Yosemite National Park Survey Log

Date___________ Day of Week____________

Time Arrive________ Time Leave_________ Name____________

Time	Refusal (Y/N)	Summit (Y/N)	Survey #	Group Size	Comments

Appendix M METHOD OF INDEPENDENT REPLICATIONS ANALYSIS RESULTS

The method of independent replications was used to determine the number of simulation replications of the visitor use model needed to generate estimates of the number of people at one time on the Half Dome cables and on the Half Dome Summit, with 95% confidence and within +/- 5 people. Because the computer simulation model developed in this study was used to generate estimates of multiple outputs simultaneously, the alpha levels for the confidence intervals specified within each of the reliability analyses conducted in this study were adjusted using a Bonferroni Correction. In particular, the specified alpha level was adjusted by dividing it by the number of outputs estimated together (Law & Kelton, 2000). In the case of this study, the computer simulation model was used to estimate, simultaneously, the number of people at one time, on the Half Dome cables, and on the Half Dome Summit. Thus, the Bonferroni Corrected alpha level for the reliability analyses is equal to 0.0125 (alpha = 0.025, divided by 2).

The first step within the method of independent replications was to run the visitor use model for a relatively small number of replications, commonly referred to as the "short run." The method of independent replications requires that the short run simulation involves a sufficient number of replications to ensure that the variances of the outputs of interest have stabilized. Thus, an iterative, graphical analysis process was used to select the number of short run replications needed to achieve variance stability. In particular, the visitor use model was run for 500 replications and the variances of each of the outputs were graphically analyzed to determine the number of replications at which the variances of the outputs stabilized (Figure 34 through Figure 37). In addition, the percentage change in variance of each output associated with each additional replication (from 1 to 500 replications) was computed to assess the marginal benefit of each additional replication in terms of variance stabilization. The number of short run replications was selected as the point at which the marginal reduction in variance associated with an additional replication of the model was less than or equal to 5% (these "thresholds" of variance stabilization are marked in Figure 34 through Figure 37 with vertical dashed lines).

Figure 34. Half Dome Visitor Use Model - PAOT on Cables Variance for 500 Replications, Saturday/Holiday

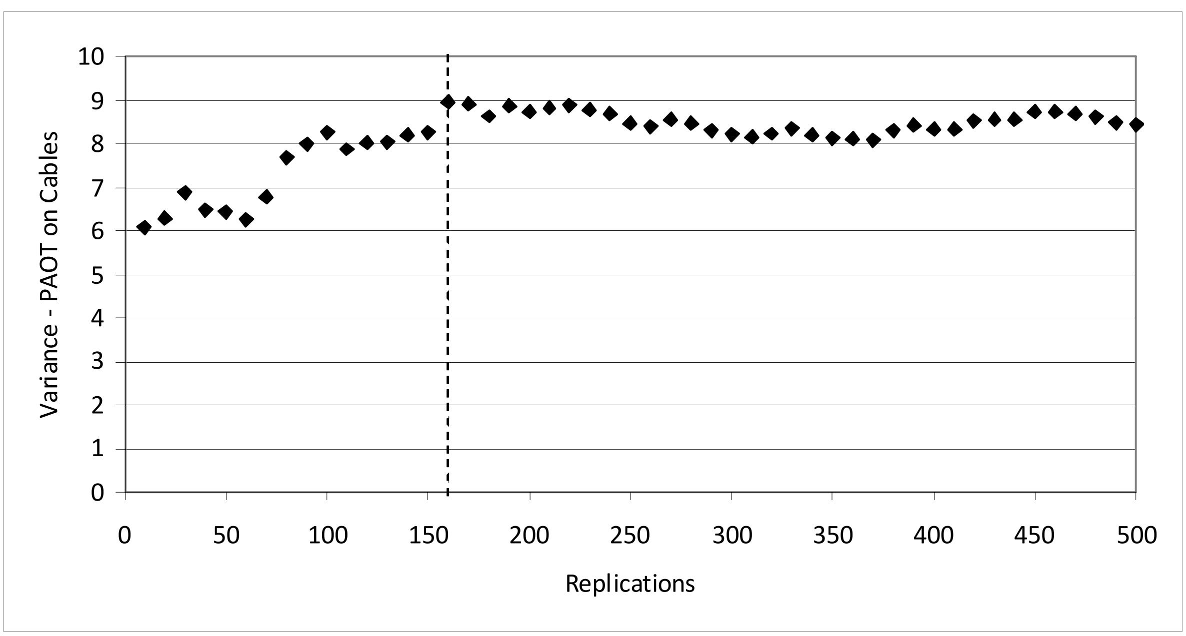


Figure 35. Half Dome Visitor Use Model - PAOT on Summit Variance for 500 Replications, Saturday/Holiday

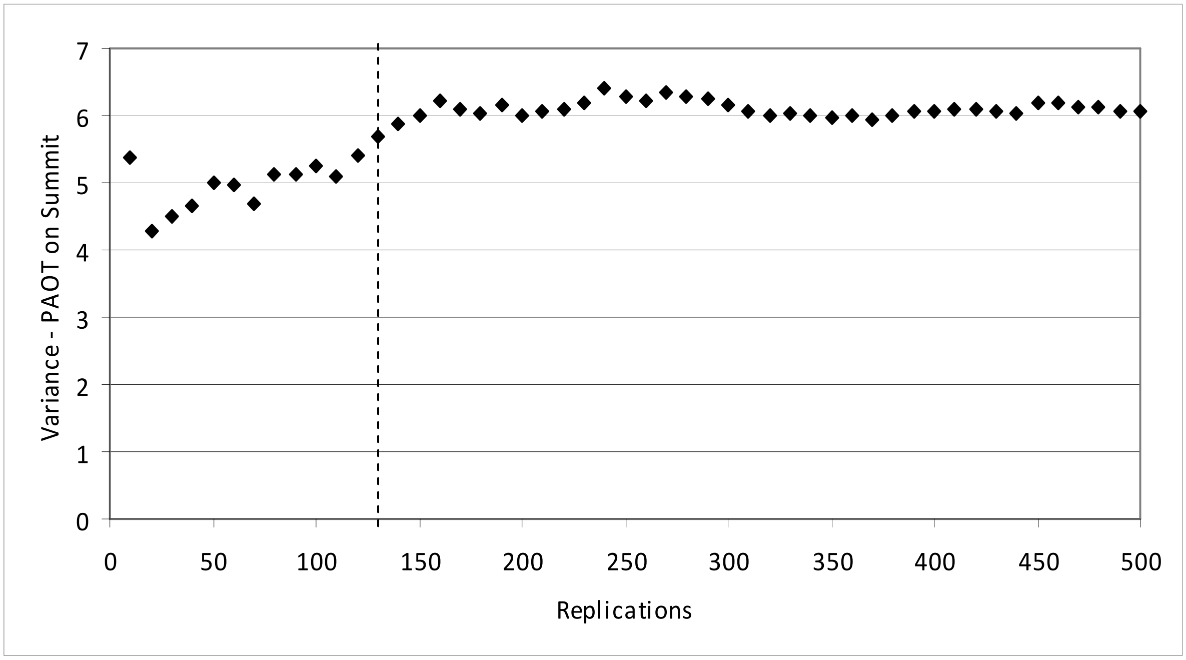


Figure 36. Half Dome Visitor Use Model - PAOT on Cables Variance for 500 Replications, Sunday-Friday

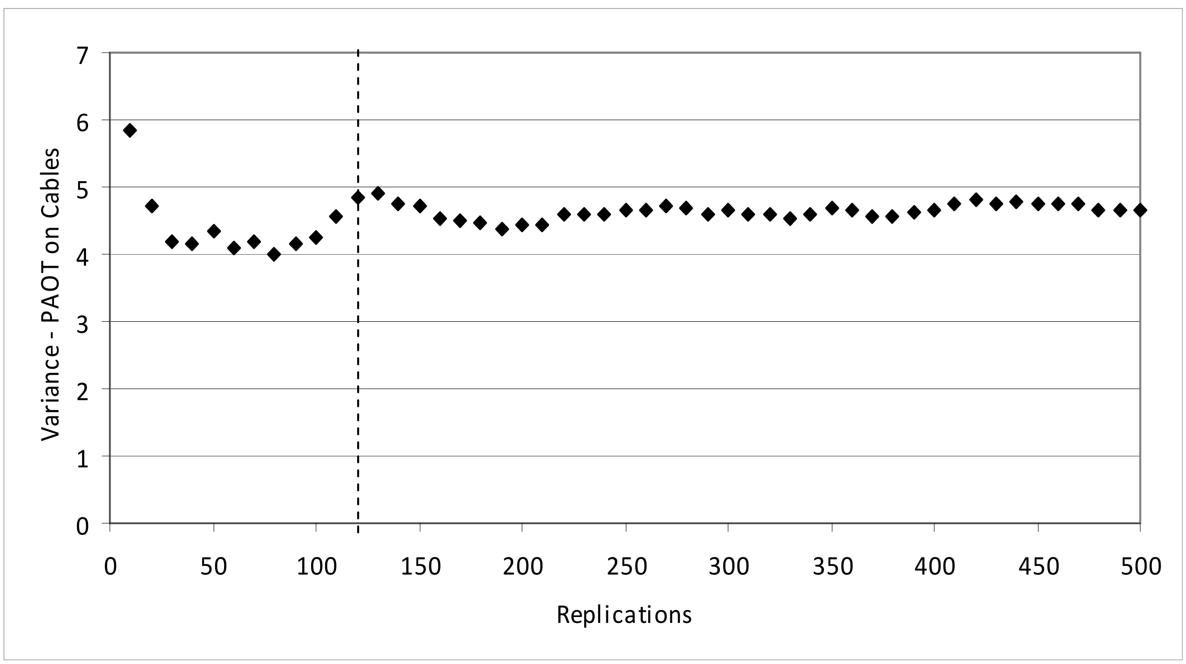
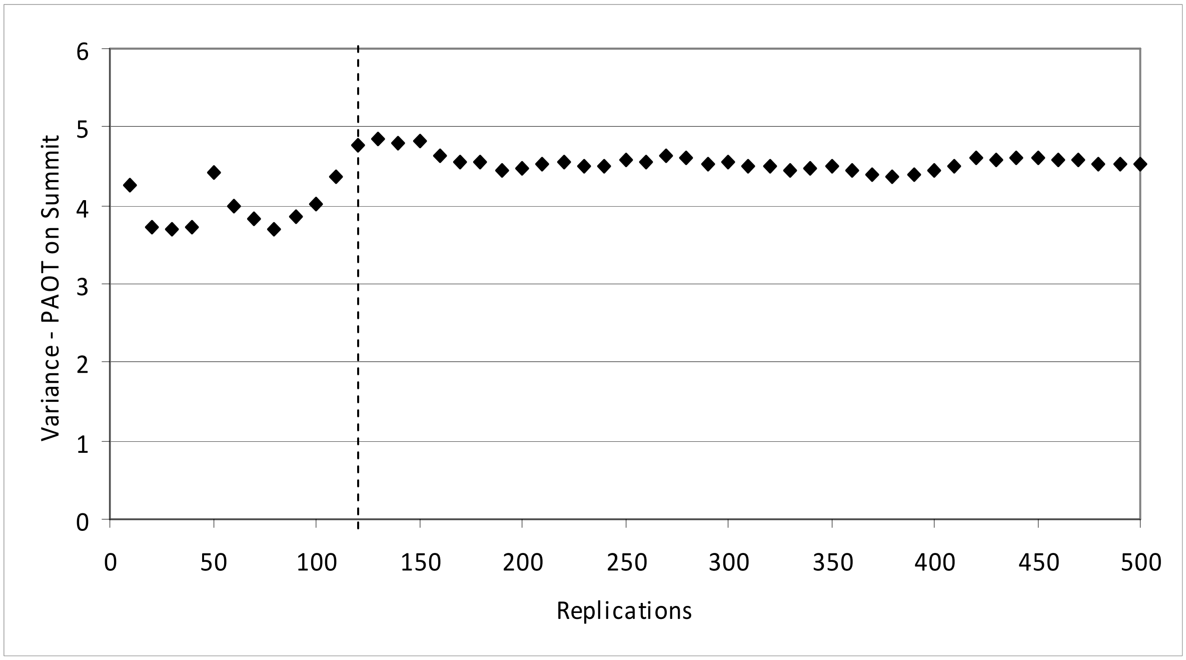


Figure 37. Half Dome Visitor Use Model - PAOT on Summit Variance for 500 Replications, Sunday-Friday



The visitor use model was run for the short run number of replications identified through the process described above, and the following equation was used to compute the confidence interval half-width around the mean of each output of interest resulting from the short run simulations:

$$\pm t_{n-1,1-\alpha/2}\sqrt{[S^2(n)]/n} \qquad (4)$$

Where:

n = number of replications conducted for the short run simulation
tn-1, 1 - α / 2 = (1 - α / 2) percentile of the t-student distribution with n-1 degrees of freedom
S^2 (n) = sample variance of the output variable from the short run simulation

In the case of this study, the confidence interval half-widths associated with the short run were less than the user-specified values in all cases, thus no further replications were needed. Had the confidence intervals associated with the short run replications not been sufficiently precise, the following equation would have been used to compute the number of replications needed to achieve the desired level of precision for the output:

n* = Round [n x (h / h*)2] (5)

Where:

n* = estimated number of replications needed to achieve user-specified level of precision
n = number of replications from short run simulation
h = interval half-width computed using short run results and Equation 4
h* = user specified confidence interval half-width

In such a case (i.e., the number of replications within the short run simulation does not result in the desired level of precision for model outputs), the model is then run for n* replications and the computation process using Equations 4 and 5 is repeated until the desired level of precision for the corresponding model output is obtained. At each iteration of the method, n^* and $S^2(n^*)$ are substituted into Equation 4.

Table 58 and Table 59 report the results of the method of independent replications for the visitor use model, based on Saturday/holiday and Sunday/weekday visitor use levels during summer 2008, respectively. Results reported in the tables include: 1) the number of replications performed for the short run simulations; 2) the mean, variance, and 95% confidence interval half-widths of the outputs resulting from the short run simulations; 3) the "target" confidence interval half-width for each model output, representing the minimum level of precision specified for the study; and 4) an indication of whether the number of replications conducted in the short run simulation is satisfactory for achieving the minimum level of precision specified for the corresponding output .

Table 58. Half Dome Visitor Use Model - Method of Independent Replications Result – Saturday/Holiday

Model Output	Short Run Replications	Mean	Variance	95% CI Half-width[a]	95% CI Half-width Needed	Short Run Satisfactory?
PAOT – Half Dome Summit	130	33	6.3	0.5	≤ 5	Yes
PAOT – Half Dome Cables	160	35	8.9	0.6	≤ 5	Yes

[a]Alpha = 0.05; Bonferroni Corrected alpha = 0.0125.

Table 59. Half Dome Visitor Use Model - Method of Independent Replications Result – Sunday-Friday

Model Output	Short Run Replications	Mean	Variance	95% CI Half-width[a]	95% CI Half-width Needed	Short Run Satisfactory?
PAOT – Half Dome Summit	120	21	4.6	0.3	≤ 5	Yes
PAOT – Half Dome Cables	120	19	4.7	0.3	≤ 5	Yes

[a]Alpha = 0.05; Bonferroni Corrected alpha = 0.0125.