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Pilot Timed Entry System at Arches National Park in 2022

Comparing visitor use data before and during a pilot managed access system

Natural Resource Data Series NPS/NRSS/NRDS—2023/2297386

ON THIS PAGE
The Windows, Arches National Park
Caleb Meyer, NPS

ON THE COVER
Delicate Arch Viewscape, Arches National Park
Caleb Meyer, NPS

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Table of Contents

Key findings

The Entrance Station

- Visitor access to the park improved during the pilot timed entry system. ARCH never closed the gate due to full parking lots during the pilot timed entry system.

- Vehicle wait times to enter the park increased during the pilot timed entry system. The time to process a vehicle at the entrance station during timed entry was 49 seconds; a 48% increase from 2019.

- Average wait times to enter the park during the busiest times of the pilot timed entry system (10:00-15:00) were 25-30 minutes on average, but never exceeded one hour for even the busiest conditions recorded.

- Daily visitation patterns were more evenly distributed across the hours of the day during the pilot timed entry system. More visitors arrived earlier and later at the park during the pilot timed entry system.

- Visitors arriving to the entrance gate during the pilot timed entry system without a valid reservation was about 18% during the first month of the pilot then decreased to a consistent 14% of all vehicles.

Parking areas at key destinations

- Visitor access to parking was improved during the pilot timed entry system. Collectively, no parking lots exceeded practical parking capacity (defined as 90% of striped capacity) more than 5% of the time during the pilot timed entry system sampling periods, and no parking lot ever exceeded 100% of striped parking spaces.

Visitor experience quality at key destinations

- Visitor experience quality as measured by people per viewscape (PPV) was improved in all locations measured (Windows, Delicate Arch, Devils Garden) during the pilot timed entry system.

- PPV was more frequently below conditions that indicate that park management needs to take action to deal with the density of people, as well as conditions that indicate that people would no longer visit the area due to the density of people during the pilot timed entry system.

- Throughout the entire pilot timed entry system duration, less than 3% of hours at all studied locations (Windows, Delicate Arch, Devils Garden) demonstrated conditions where visitors would want the NPS to take action to address the density of people at key locations.

- Throughout the entire pilot timed entry system duration, less than 1% of hours at all studied locations (Windows, Delicate Arch, Devils Garden) demonstrated conditions where people would no longer visit the area due to the density of people.

Figures

Page

Tables

Format of report

This report is formatted to concisely answer key questions about the pilot timed entry system that was implemented in 2022 at Arches National Park. After a brief overview and introduction, results are presented to address each question. All methods and supplementary data are contained in the Appendices of this report.

List of Acronyms and Abbreviations

NPS – National Park Service

ARCH – Arches National Park

SEUG – Southeast Utah Group, National Park Service

IMRO – Intermountain Regional Office

VERP – Visitor Experience and Resource Protection Implementation Plan (published 1995 – data collected through 2001)

VUM – visitor use management

PPV – people-per-viewscape

VAOT – vehicles-at-one-time

PTES – pilot timed entry system

Introduction

Visitation to Arches National Park (ARCH) increased by 74% between 2011 and 2021, with record high visitation in 2021 of 1.8 million visits (IRMA, 2023). Nearly all visitors arrive by vehicle, with daily vehicle arrivals during the busiest months averaging 2,500 vehicles and peak days seeing more than 3,000 vehicles enter the park. Over 96% of visitors enter the park through the main entrance accessed via U.S. Route 191, four miles north of Moab, Utah. Once inside the park, 96% of visitors in private vehicles visit at least one of the primary attraction sites: Delicate Arch, The Windows, or Devils Garden (Resource Systems Group [RSG], 2020).

ARCH experiences several issues related to sustained high levels of visitation in concentrated locations, including:

- Roadway congestion, strained facilities (i.e. bathrooms, roadways, parking), and associated safety hazards
- Diminished predictability of visitor access to the park
- High levels of use at extraordinary geologic features and along trails that diminishes visitor experience
- Need for additional staffing to address increased visitation, combined with limited housing availability and funding for these additional staff

ARCH applied several management strategies to address the issues above over the past decade. This includes increasing parking availability and adding new restroom facilities, providing increased traveler information and communications, and implementing temporary entrance delays and gate closures. Increasing visitation exacerbates these issues and the associated responses. In recent years, entrance delays are more frequent and have become almost daily during high visitation periods.

Arches National Park Timed Entry System Overview

ARCH is considering management strategies to address the issues presented by sustained high levels of visitation. As part of this, ARCH implemented a temporary pilot timed entry system (PTES) from April 3 to October 3, 2022. Visitors arriving by private vehicle needed a reservation to enter the park between 06:00 and 17:00 daily. Timed entry reservations were allotted in hourly entry time blocks. Visitors could book these reservations up to three months in advance or the day before their intended visit through www.recreation.gov. If tickets were available, visitors could reserve a timed entry ticket on the day of their intended visit. Additionally, visitors could enter the park before 06:00 and after 17:00 daily without a timed entry reservation. The PTES was designed based on a “typically busy day” in 2019 of private vehicles arriving through the Moab entrance to ARCH (RSG, 2020), and the primary goal of PTES was to spread visitation more evenly throughout the day. Comprehensive data collection and modeling completed in 2019 was used to design the PTES (RSG, 2020).

The administration of the PTES occurred in the entrance area of the park. Two entrance booths are situated roughly 0.6 miles into the park boundary from U.S. Route 191. Under the pilot, visitors with reservations were “checked in” by scanning a unique QR code prior to fee payment at the entrance booths. During abnormally long wait times at the entrance, visitors arriving early or late for their reservation windows were provided a grace period for entrance. Visitors without reservations were directed to use the roundabout after the booths to exit the park and return outside of PTES hours or after procuring a timed entry reservation. Reservations were verified at the roundabout using a unique sticker method. Staff were stationed in the roundabout to direct visitors with a reservation into the park or to turn visitors around if they did not have a reservation. Additionally, these staff members monitored the number of vehicles turned around.

For the first month of the pilot, two additional staff members were stationed along the two inbound entrance lanes several hundred feet before the booths to check that visitors had a timed entry reservation and to share information with those that did not.

During the busiest times of day when the entrance queue backed up with more than approximately 75 cars in line, two additional staff members were stationed on the service road to operate a type of Fast Pass Lane (Figure 1). Here, staff used phone scanners to validate timed entry reservations, and checked to see that visitors had a pre-paid pass (Interagency Annual Pass, Military Pass, etc.) and a valid form of identification. Staffing challenges only allowed ARCH to use this service road operation for the first two months of the PTES.

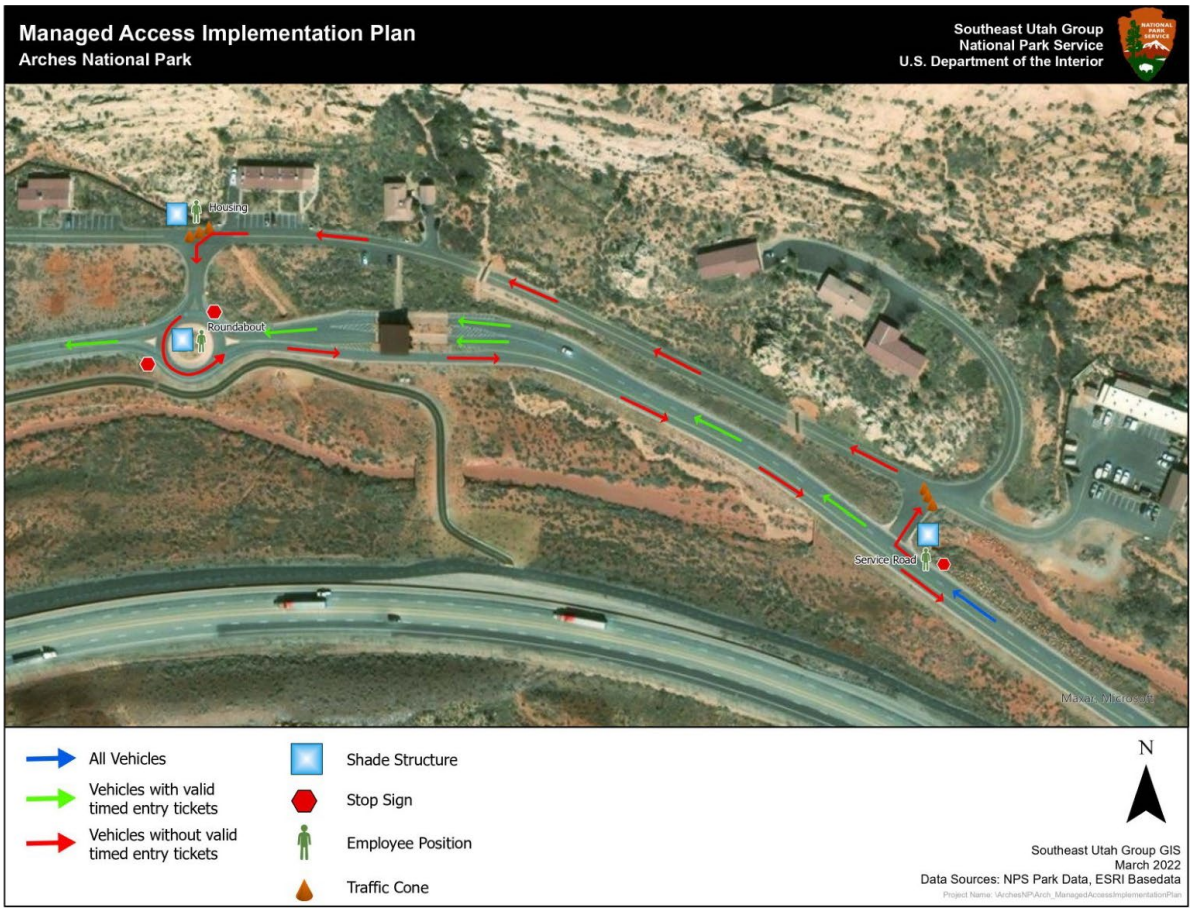

Figure 1: Entrance Road Operations for Pilot Timed Entry System

Methods overview

The methods developed for the data collection that informed this report are designed to identify changes in visitor use before and after the PTES. Extensive details regarding the methodological approaches used are provided in Appendix B. Where possible and relevant, data is compared from the PTES to previous data. In 2019, ARCH completed comprehensive collections of visitor use data (RSG, 2020). Due to data quantity, quality, and recency, data between the PTES is most often compared to 2019. In some instances, other data sources are used if 2019 data is unavailable or insufficient. To describe visitor use aspects that are only relevant to PTES, no comparisons are made and data for 2022 is simply presented.

Most data collection completed during the pilot involved passive visitor use monitoring equipment, like observations (visitors at one time counts, etc.), automated counters, and other low-impact techniques. Monitoring is a key component to evaluate management actions in VUM (IVUMC, 2016).

How did timed entry change visitor use at the entrance station?

This section describes changes at the entrance station during the pilot timed entry system.

How were daily vehicle arrivals different before versus during the pilot timed entry system?

Daily average vehicle arrivals were lower during PTES when compared to the same period in 2019 (Figure 2). The daily average vehicle arrivals in 2019 was 2378 vehicles, and the daily average vehicle arrivals during PTES was 1865. This is a decrease of 27%. This change is likely the result of numerous factors which are described in the discussion section below. A busy day during PTES was similar to an average day in 2019.

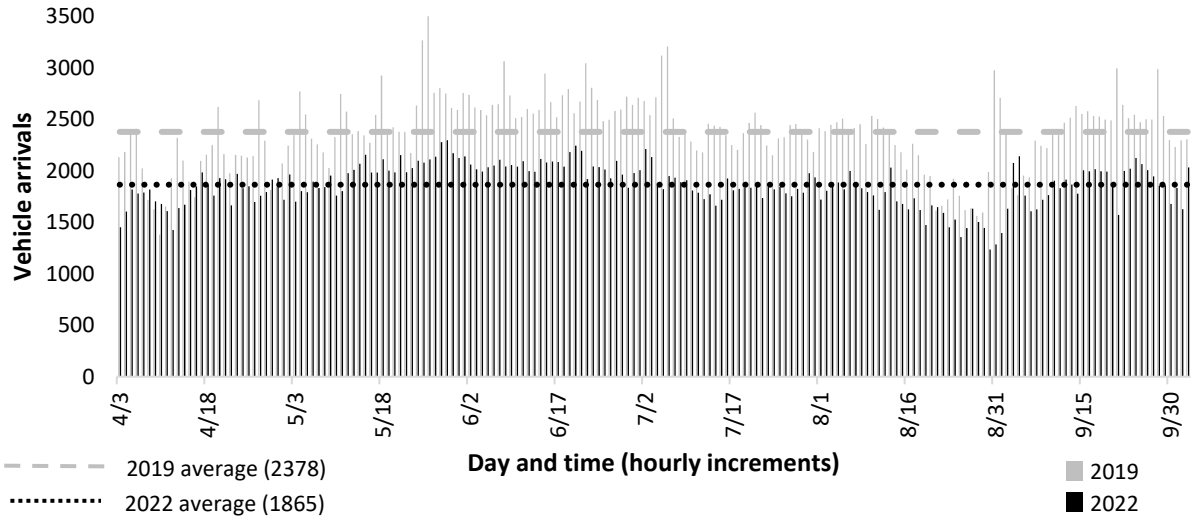

Figure 2: Daily Vehicle Arrivals at the Arches Main Entrance (2019 and 2022)

The variation in daily vehicle arrivals was more stable during PTES than in 2019. The standard deviation of the average daily vehicle arrivals in 2019 was 348 and reflects about 15% of the daily average vehicle arrivals. The standard deviation of daily vehicle arrivals during PTES was 199 and reflects about 11% in daily average vehicle arrivals.

How were hourly vehicle arrivals at the entrance different before versus during the pilot timed entry system?

During PTES, average and maximum daily vehicle arrivals increased in the early morning hours (pre-07:00) and late afternoon hours (after 17:00) compared to average and maximum daily vehicle arrivals in 2019 (Figure 3). Prior to PTES, visitation surged in ARCH between the hours of 08:00 and 12:00. Surges in maximum hourly vehicle arrives were eliminated under PTES with no large pulses in visitation between 08:00 and 12:00, as seen in 2019.

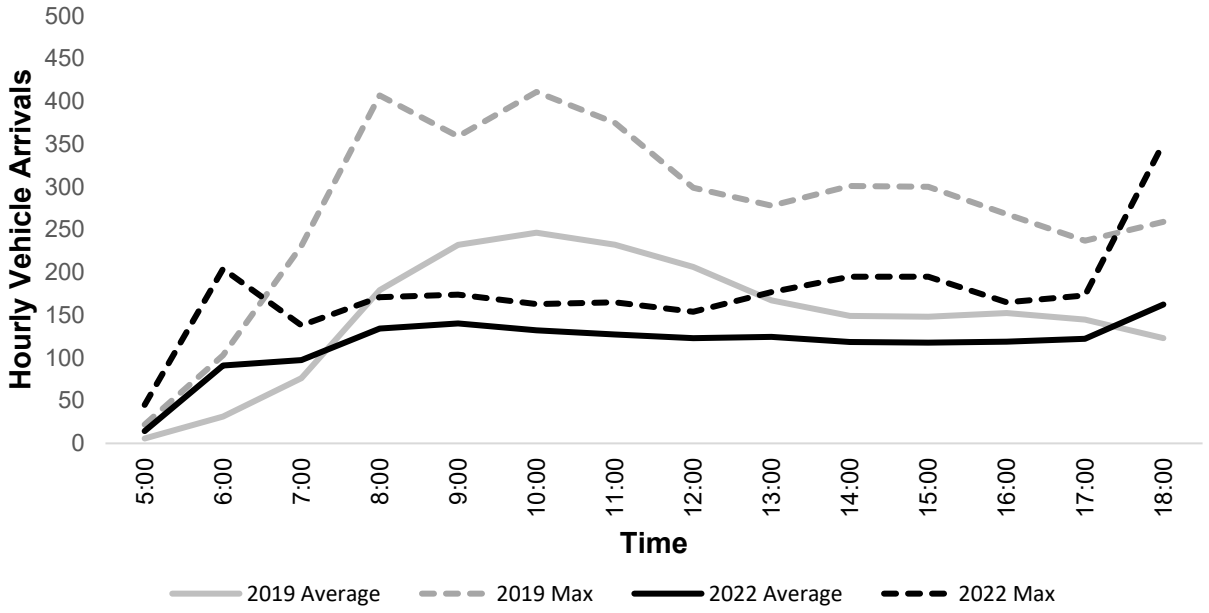

Figure 3: Hourly Average and Hourly Maximum Vehicle Arrivals at the Arches Main Entrance (2019 and 2022)

How often did reservations sell out?

Figure 4 summarizes timed entry ticket sales across the 2022 pilot season. Ticket sales were between 95% and 100% for the majority of the first three months of PTES (April through June); however, tickets sales dropped off in July and August, dropping to nearly 50% by the end of August before surging for Labor Day weekend. Nearly every day in July and every day in August had ticket availability, as well as half of the days in September. Spring months had more limited ticket availability and those limited surpluses generally occurred in the early morning (06:00-07:00 time block) or at the end of the daily timed entry period (16:00-17:00 time block).

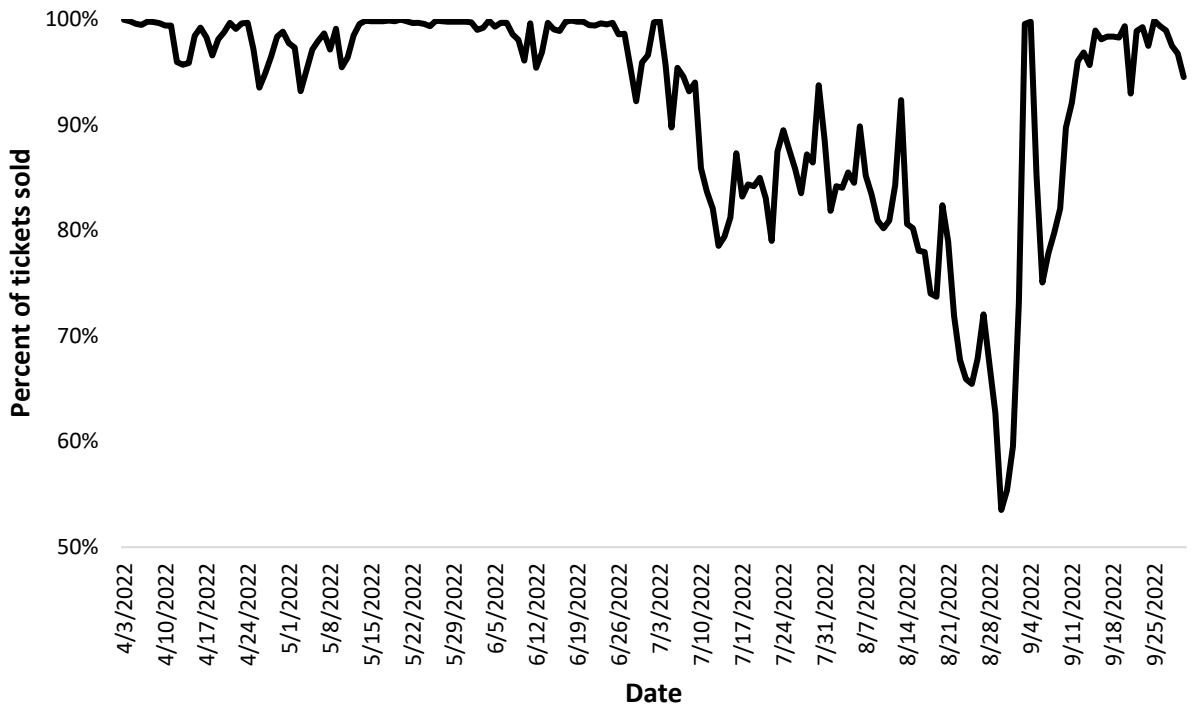

Figure 4: Timed Entry Ticket Sales for 2022 Pilot Period (4/3/2022-9/30/2022)

How did wait time change at the entrance station?

Knowing processing times provides insight into the associated visitor experiences with wait times to enter the park. Processing time is the amount of time it takes for a vehicle to be processed at the entrance booth. This includes ticket scanning, entrance fee payment processing, and park orientation. In 2019, processing time averaged 33 seconds between 09:00 and 14:00 in June. During PTES, processing time increased to about 49 seconds in June between 09:00 and 14:00. With the increases in processing time during PTES, vehicles would likely experience a 48% longer wait time on average.

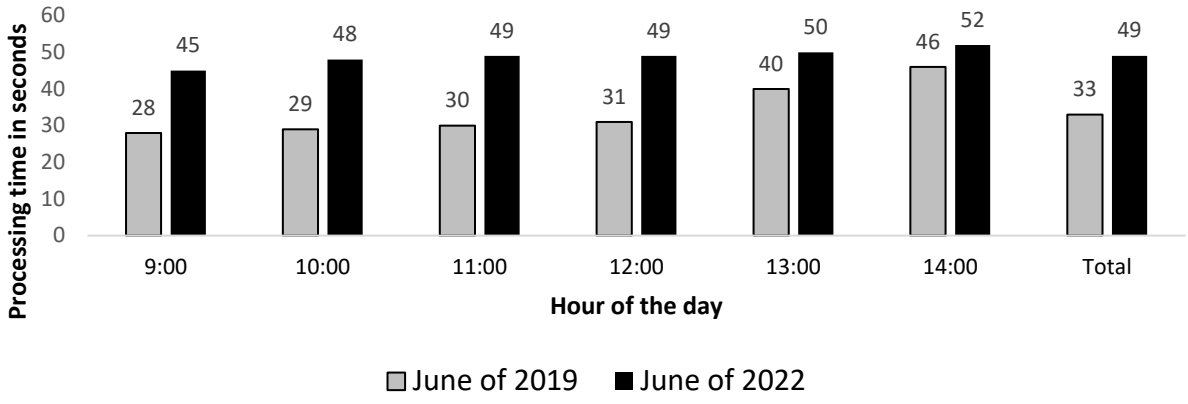

Figure 5: Processing Time in Seconds (June 2019 and June 2022)

Queue length on the entrance road was also collected during PTES (Figure 6). The service road (see Figure 1) is referenced on Figure 6 as it informed changes in vehicle processing (see Figure 1) and is a commonly referenced point for visitors. When the queue reaches the service road, there are approximately 50 vehicles waiting in line (25 per lane). The queue length during PTES was past the service road approximately 41% of the time during the sampling period (05/26/2022-06/25/2022; 09/01/2022-09/30/2022; 06:00-17:59). Queue length during PTES sampling period was lowest in the morning and highest at 11:00. The queue length remained past the service road until approximately 16:00.

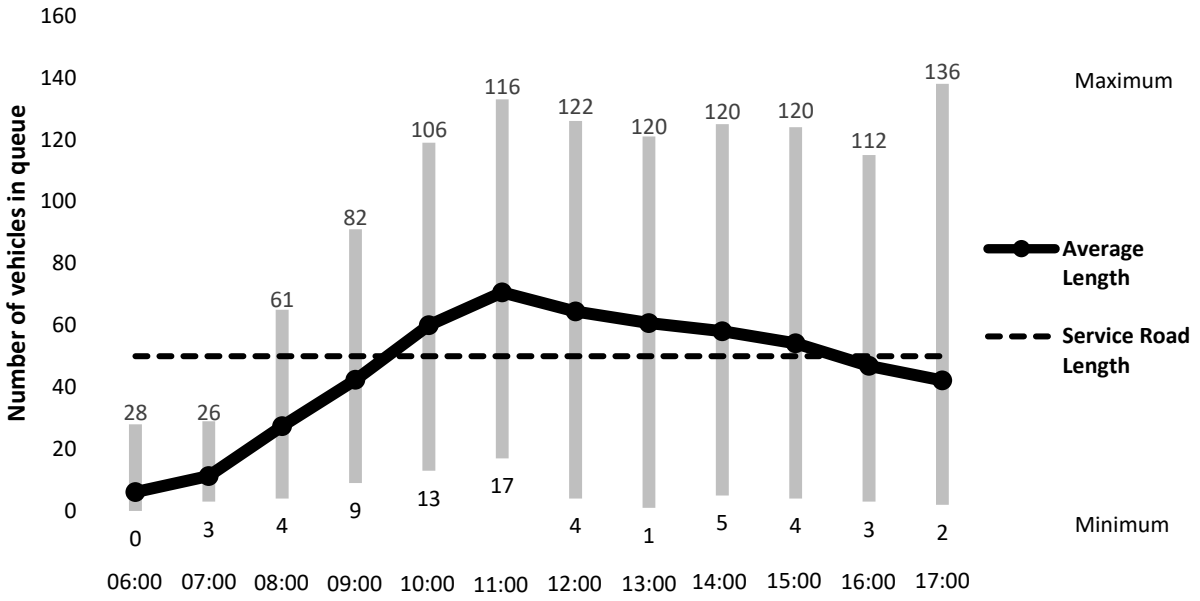

Figure 6. Queue length during the pilot timed entry system

Wait time can be calculated by multiplying the number of vehicles per lane in the queue by the average processing time (Table 1). During the PTES sampling period, average wait times ranged from 2 minutes to nearly a half an hour (29 minutes). From 10:00 to 15:00, visitors could expect an approximately 20-30-minute wait during PTES. At the maximum recorded queue length during the PTES sampling period, the wait time would be approximately one hour (56 minutes). Wait time when the queue reached the service road would be about 20 minutes. Calculated using the same PTES average queue length during the sampling period, comparable 2019 wait times would average from 2 minutes to approximately 20 minutes. From 10:00 to 15:00, the comparable approximate wait time would be 15–20-minute wait. At the maximum recorded queue length during the PTES sampling period, the comparable 2019 wait time would be about 37 minutes. Comparable 2019 wait time when the queue reached the service road would be about 14 minutes.

Table 1. Average wait times to enter the park

Hour of day	PTES average queue length (in vehicles)	PTES wait times	Comparable 2019 wait times*
06:00	6	2 minutes	2 minutes
07:00	11	5 minutes	3 minutes
08:00	27	11 minutes	8 minutes
09:00	42	17 minutes	12 minutes
10:00	60	25 minutes	17 minutes
11:00	71	29 minutes	19 minutes
12:00	64	26 minutes	18 minutes
13:00	61	25 minutes	17 minutes
14:00	58	24 minutes	16 minutes
15:00	54	22 minutes	15 minutes
16:00	47	19 minutes	13 minutes
17:00	42	17 minutes	12 minutes

*Wait times are based on length of queue during the pilot timed entry system and processing time during 2019

How did gate closures change under managed access?

Since 2018, ARCH closed the main gate into the park for 2 to 4 hours when primary parking lots in the park were full and there was a long vehicle queue on the entrance road (Figure 7). ARCH utilized gate closures more frequently in the last few years with increasing visitation. Under PTES, there were no gate closures between April 3 and October 3, 2022 (the duration of PTES).

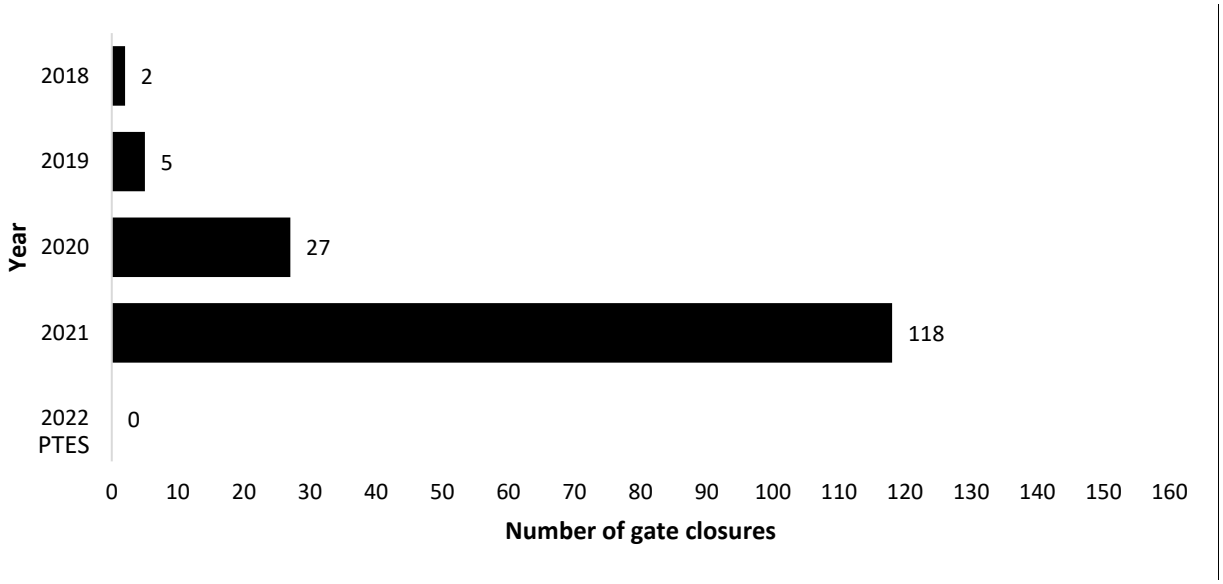

Figure 7. Entrance Gate Closures April 3-October 3 (2018-2022)

How many visitors booked a reservation and did not arrive at their scheduled day and time?

No-shows are defined as reservations that were made but never used. No-show rates were consistently lower in the morning hours and higher in the afternoon hours (Table 2). No-shows were highest in April on average (36% daily) and lowest in August (26% daily). For all months, the highest rates of no-shows occurred in the 16:00 reservation hour. ARCH adjusted timed entry ticket allocations to account for no-shows by overselling reservations.

Table 2. No-show summary for non-used reservations.

Month	Average	Range	Lowest Hour	Highest Hour
April	35.8%	17-63%	08:00	16:00
May	31.4%	15-65%	07:00	16:00
June	32.7%	15-62%	09:00	16:00
July	28.6%	14-62%	09:00	16:00
August	26.4%	10-58%	08:00	16:00
September	30.3%	25-37%	08:00	16:00
Total	**30.86%**	**10-65%**	**08:00**	**16:00**

How many vehicles arrived without a valid timed entry ticket?

The number of visitors arriving at the park without a valid timed entry ticket was measured by staff manually counting vehicles that turned around on the entrance road or after the entrance booth during timed entry hours of operation. Turnarounds are used to identify how many potential visitors arrived at the park unaware of the timed entry reservation requirements; however, visitors were also turned around if they arrived too early or late for their reserved entry time window or if they arrived on the wrong day. Turn around rates were relatively stable (average of 15%) across the 6-month pilot season (Figure 8).

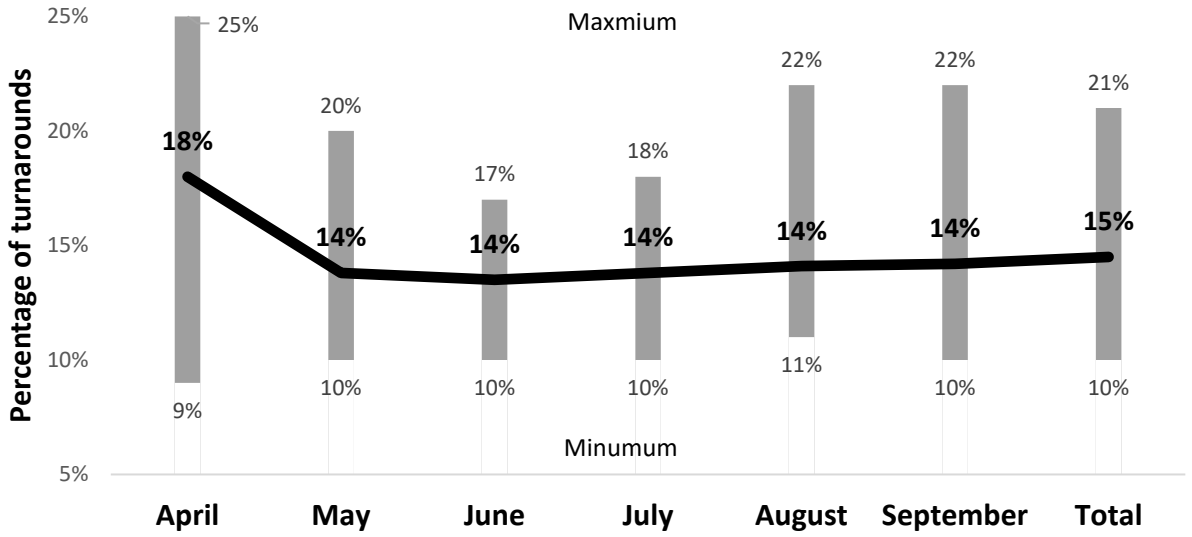

Figure 8. Percent of Total Vehicle Arrivals Turned Around (06:00–16:00, April 3-September 30, 2022)

How did timed entry influence visitor access to parking?

Parking lots in ARCH were identified as at practical parking capacity when 90% of striped parking spaces were occupied, which is above industry standards (80% denotes practical parking lot capacity in most settings; Edwards, 1999). When practical capacity is reached, parking lots generally feel full and arriving vehicles will experience a lack of available parking, congestion in the lot, and other poor parking conditions. When practical capacity is reached, there are sufficient empty spaces to assure parking availability. Beyond that point, arriving vehicles will experience poor parking conditions due to a lack of available parking/congested parking lots. Collectively, no parking lots exceeded practical parking capacity more than 5% of the time during the PTES sampling period (08/22/2022-09/29/2022), and no parking lot ever exceeded 100% of striped parking spaces.

How did visitor access to parking change in the Windows area?

Parking at the Windows areas was below practical capacity about 99% of the time during the PTES observation periods (08/23/2022-09/10/2022; 09:00-15:59; 188 observations; Figure 9). Striped capacity was never exceeded during the PTES observation periods. In 2019, parking at the Windows area was below practical capacity about 85% of the time during observation periods (08/31/2019-09/10/2019; 09:00-15:59; 418 observations total). Striped capacity was exceeded about 6% of the time.

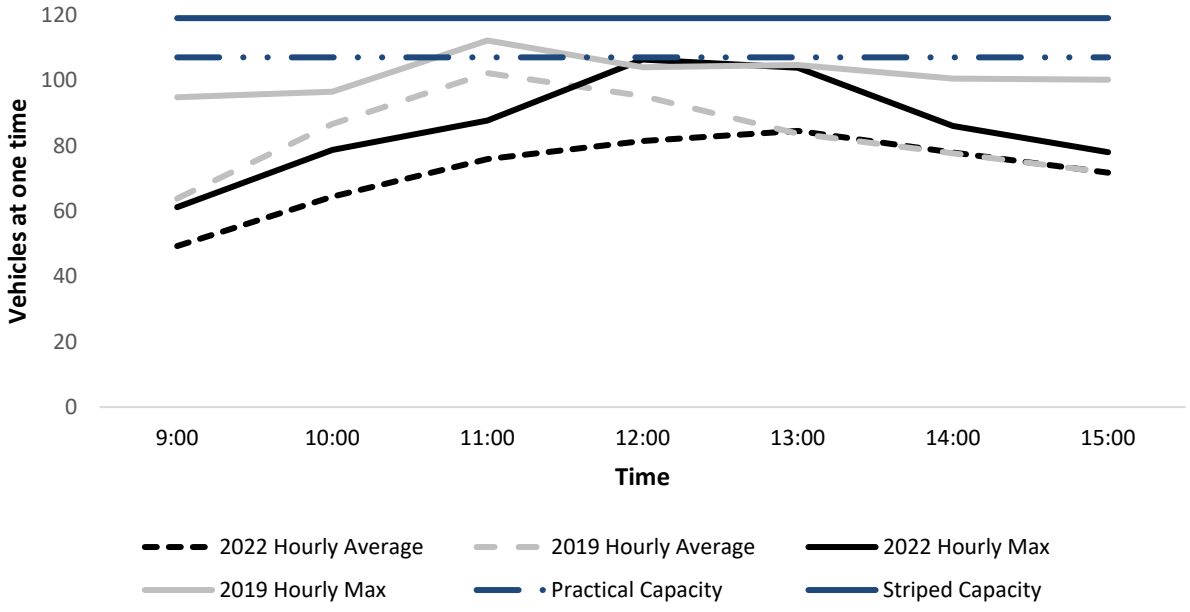

Figure 9: Vehicles-at-one-time in Windows parking lot (2019 and 2022 sampling periods)

How did visitor access to parking change in the Delicate Arch/Wolfe Ranch area?

Parking at Delicate Arch/Wolfe Ranch was below practical capacity about 97% of the time during the PTES observation periods (08/22/2022-09/29/2022; 09:00-15:59; 188 observations; Figure 10). Striped capacity was never exceeded during the PTES observation periods. In 2019, parking at Delicate Arch/Wolfe Ranch was below practical capacity about 83% of the time during observation periods (08/31/2019-09/10/2019; 09:00-15:59; 369 observations total). Striped capacity was exceeded about 10% of the time.

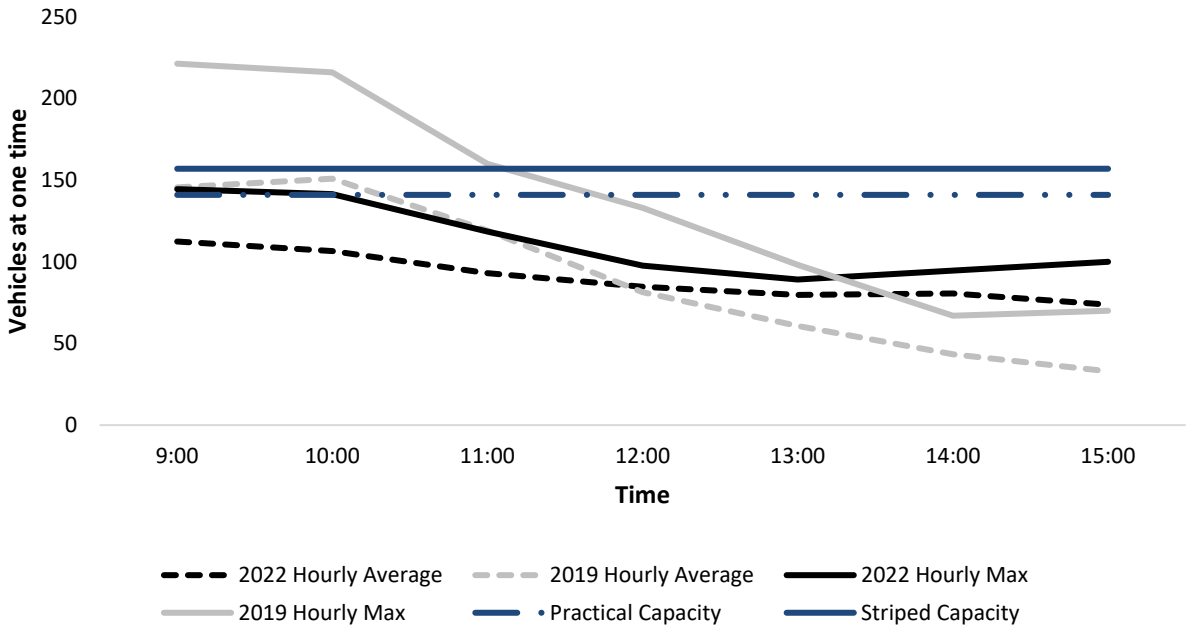

Figure 10: Vehicles-at-one-time in Delicate Arch/Wolfe Ranch parking lot (2019 and 2022 sampling periods)

How did visitor access to parking change in the Devils Garden area?

Parking at Devils Garden was below practical capacity about 95% of the time during the PTES observation periods (08/21/2022-09/28/2022; 09:00-15:59; 210 observations; Figure 11). Striped capacity was never exceeded during the PTES observation periods. In 2019, parking at Devils Garden was below practical capacity about 92% of the time during observation periods (08/31/2019-09/10/2019; 09:00-15:59; 416 observations total). Striped capacity was exceeded about 3% of the time.

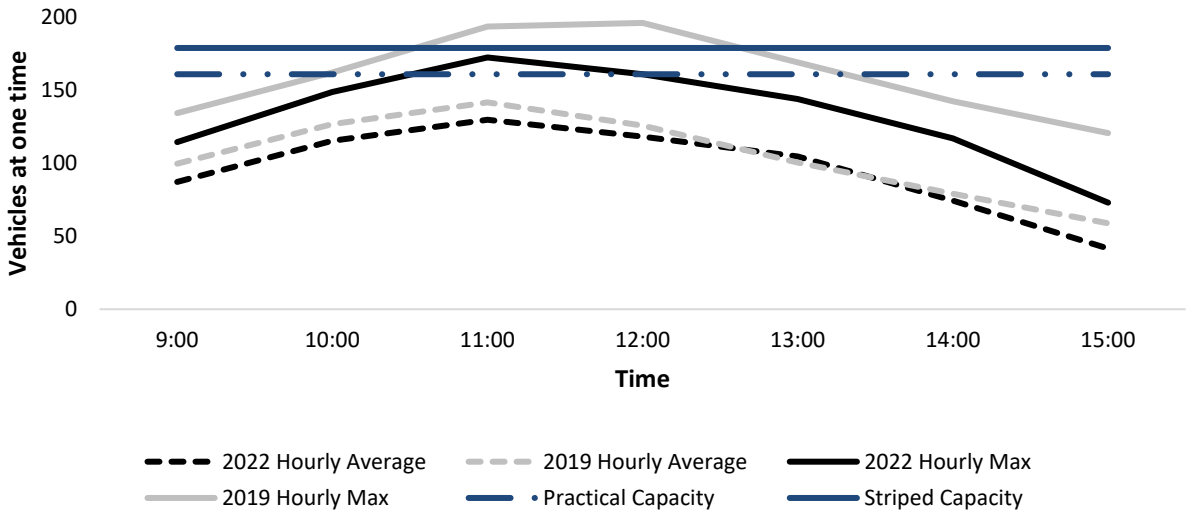

Figure 11: Vehicles-at-one-time in Devils Garden parking lot (2019 and 2022 sampling periods)

How did visitor experience quality change at key locations?

Visitor experience quality was measured by a people per viewscape (PPV) indicator and compared against metrics from existing research and planning (NPS, 1995; Table 3). PPV is a commonly used indicator to assess visitor experience quality. Evaluative comparisons include a "Management Action" condition and a "Displacement" condition. The Management Action condition is the density of PPV where visitors want the NPS to take action to deal with deteriorating visitor experience quality. The Displacement condition is where visitors would no longer visit the location because the density of PPV is too high.

Table 3. Visitor Experience Conditions at ARCH

Site	Management Action Condition	Displacement Condition
The Windows	30 PPV	47 PPV
Delicate Arch	49 PPV	67 PPV
Devils Garden	18 PPV	23 PPV

People per viewscape at Windows

In 2022, the Windows viewscape exceeded the Management Action condition 8% of the time during the sampling period (08/23/2022-09/10/2022; 09:00-15:59; 170 observations; Figure 12). In 2019, the Windows viewscape exceeded the Management Action condition 10% of the time during the sampling period (08/31/2019-09/10/2019; 09:00-15:59; 394 observations total).

During PTES, the Windows viewscape exceeded the Displacement condition 1% of the time during the sampling period. In 2019, the Windows viewscape exceeded the Displacement condition 1% of the time during the sampling period.

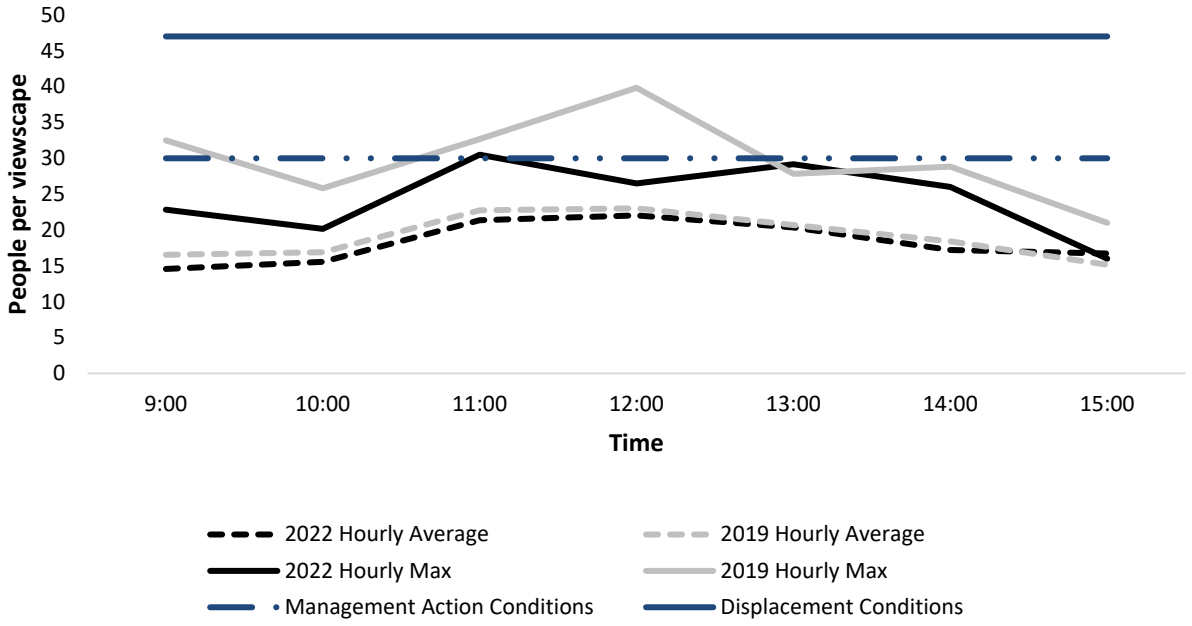

Figure 12. People per viewscape at Windows (2019 and 2022 sampling periods)

In addition to direct observations of PPV, previous research established relationships between trail arrivals and PPV at Windows (RSG, 2020). Using these established relationships, 225 trail arrivals per hour at Windows means the management action conditions (30 PPV) would be exceeded. At 344 trail arrivals per hour, displacement conditions (47 PPV) would be exceeded.

During the approximately 3,808 hours where data is available during the PTES (see Appendix B), less than 1% of hours demonstrated trail arrivals that would create management action conditions for PPV (30 PPV) at Windows (Figure 13). No hour demonstrated trail arrivals that would create displacement conditions (47 PPV).

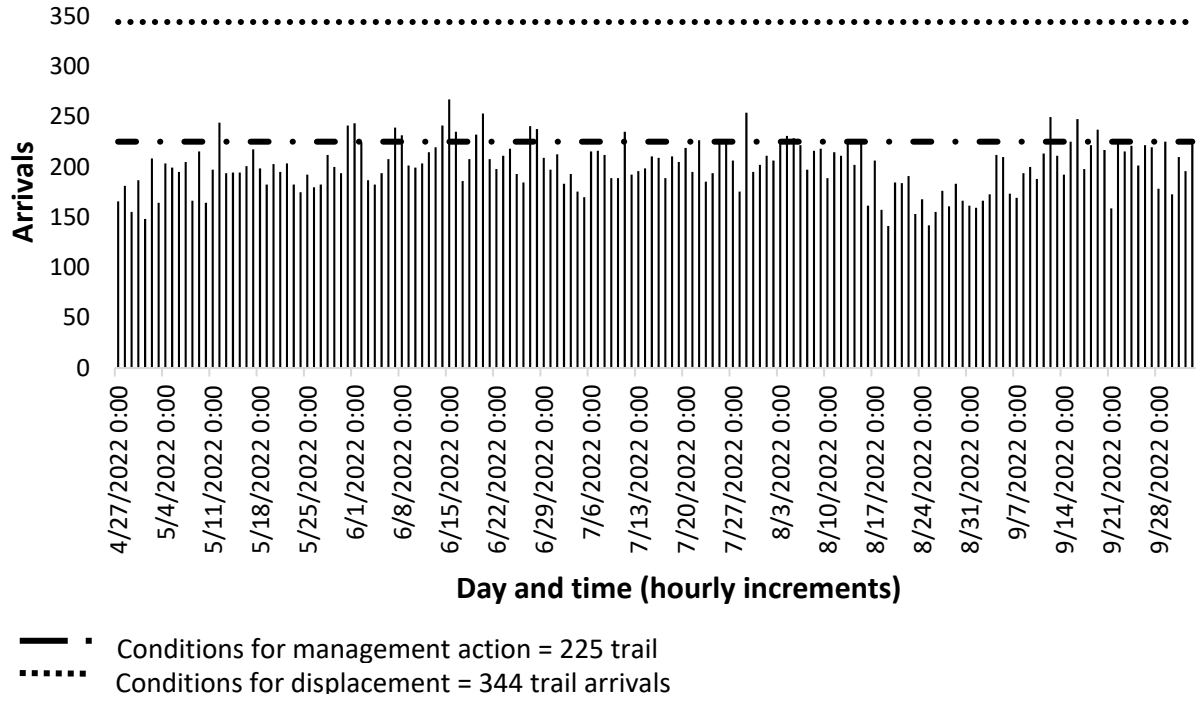

Figure 13. Estimated people per viewscape at Windows during Pilot Timed Entry System

People per viewscape at Delicate Arch

During PTES, the Delicate Arch viewscape exceeded the Management Action condition 21% of the time during the sampling period (08/22/2022-09/29/2022; 09:00-03:59; Figure 14). In 2019, the Delicate Arch viewscape exceeded the Management Action condition 25% of the time during the sampling period.

During PTES, the Delicate Arch viewscape exceeded the Displacement condition 9% of the time during the sampling period. In 2019, the Delicate Arch viewscape exceeded the Displacement condition 14% of the time during the sampling period.

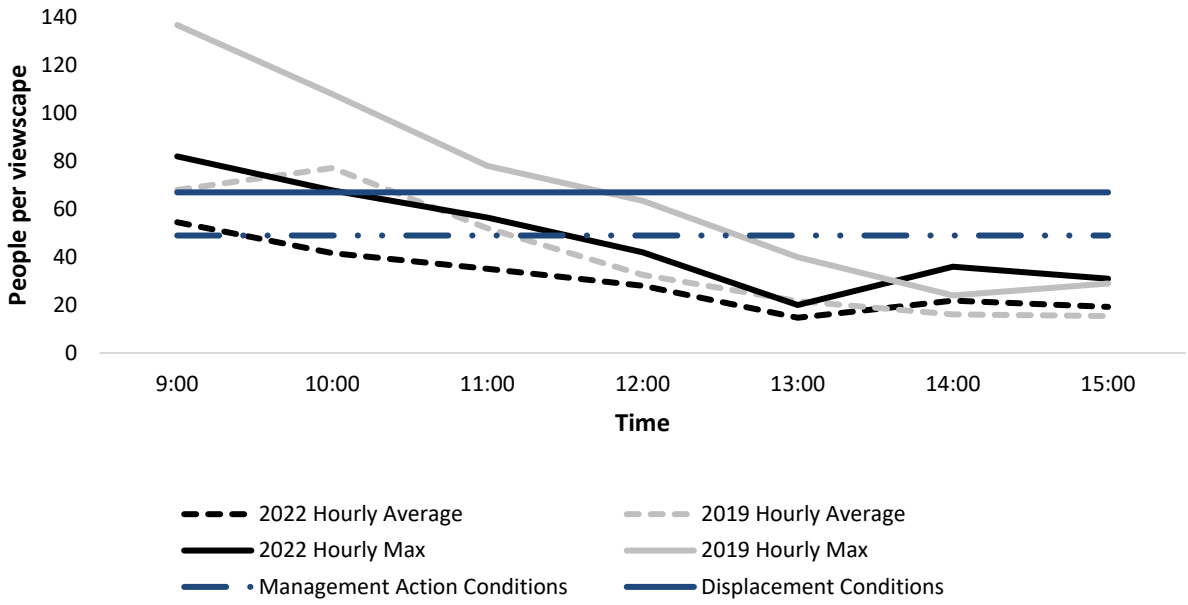

Figure 14. People per viewscape at Delicate Arch (2019 and 2022 sampling periods)

In addition to direct observations of PPV, previous research established relationships between trail arrivals and PPV at Delicate Arch (VUAE, 2019). Using these established relationships, 147 trail arrivals per hour at Delicate Arch means the management action conditions (49 PPV) would be exceeded (Figure 15). At 203 trail arrivals per hour, displacement conditions (67 PPV) would be exceeded.

During the 3,596 hours where data is available during the PTES (see Appendix B), approximately 3% of hours demonstrated trail arrivals that would create management action conditions for PPV (30 PPV) at Delicate Arch. Less than 1% of hours demonstrated trail arrivals that would create displacement conditions (47 PPV).

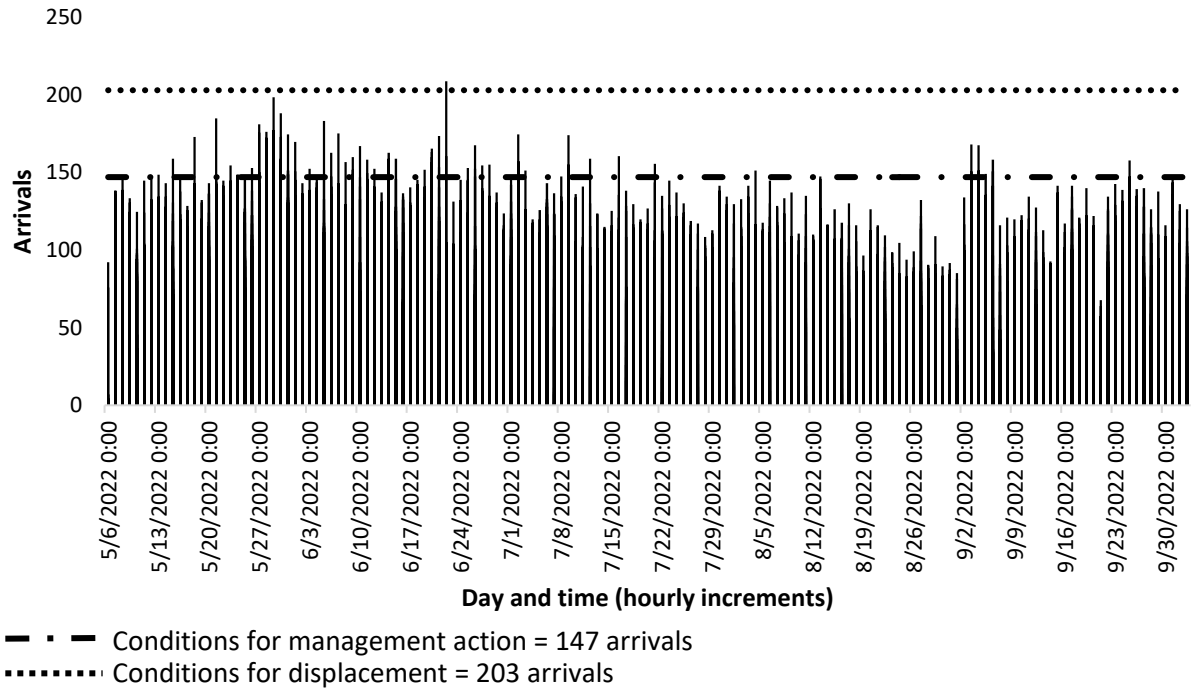

Figure 15. Estimated people per viewscape at Delicate Arch during Pilot Timed Entry System

People per viewscape at Devils Garden

During PTES, the Devils Garden viewscape exceeded the Management Action condition 9% of the time during the sampling period (08/21/2022-09/28/2022; 09:00-03:59; Figure 16). In 2019, the Devils Garden viewscape exceeded the Management Action condition 14% of the time during the sampling period. During PTES, the Devils Garden viewscape exceeded the Displacement condition 3% of the time during the sampling period. In 2019, the Devils Garden viewscape exceeded the Displacement condition 7% of the time during the sampling period.

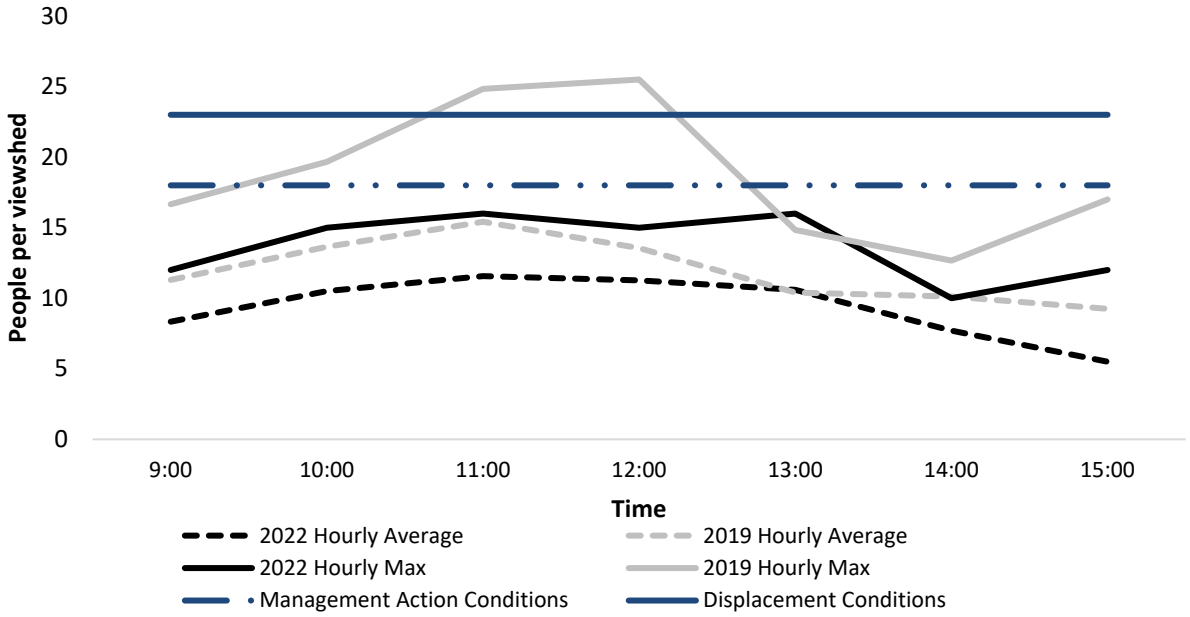

Figure 16. People per viewscape at Devils Garden (2019 and 2022 sampling periods)

In addition to direct observations of PPV, previous research established relationships between trail arrivals and PPV at Devils Garden (RSG, 2020). Using these established relationships, 233 trail arrivals per hour at Devils Garden means the management action conditions (18 PPV) would be exceeded (Figure 17). At 303 trail arrivals per hour, displacement conditions (23 PPV) would be exceeded.

During the 4,194 hours where data is available during the PTES (see Appendix B), less than 1% of hours demonstrated trail arrivals that would create management action conditions for PPV (18 PPV) at Devils Garden. No hours demonstrated trail arrivals that would create displacement conditions (23 PPV).

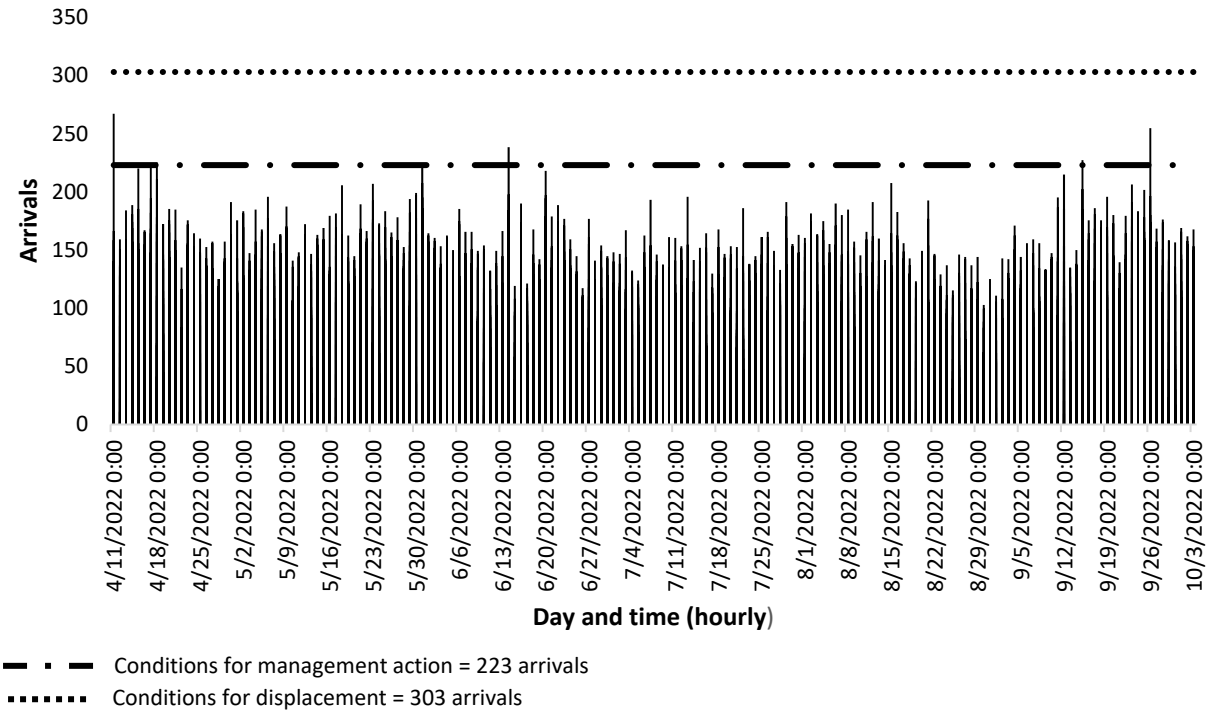

Figure 17. Estimated people per viewscape at Devils Garden during Pilot Timed Entry System

Discussion

The Entrance Station

Overall, visitor access improved during PTES as ARCH never experienced conditions that warranted closing the main entrance gate. However, processing time and the associated wait times for vehicles did increase from 2019 under PTES by an average of 48%. The additional increase in processing time and associated wait time for vehicles under PTES when compared to 2019 is likely attributed to three factors: 1) the time it takes to scan a timed entry ticket, 2) the time it takes to explain the new timed entry ticket requirements to the visiting public, and 3) the installation of a new point-of-sale software system in 2021 and associated internet speed issues. Collectively, this means that although visitors had more reliable access to ARCH, they generally waited longer to enter the park. During peak visitation hours under PTES (10:00-15:00), visitors could expect an approximately 20-30-minute wait to enter the park.

Daily visitation patterns were also more evenly distributed across the hours of the day during PTES with more visitors arriving earlier and later to ARCH. This shows that PTES was successful in more evenly distributing visitation throughout the day when compared to historic visitation patterns.

While the number of visitors arriving to the entrance gate during the timed entry pilot without a valid reservation dropped slightly after the first month of the pilot, that number remained stable at about 14% of all vehicles for the remaining five months. In the later summer months, many of these visitors were able to obtain a timed entry ticket and return to the park within the hour, as tickets were

consistently available. Increasing visitor awareness of the timed entry requirement and reducing the number of visitors arriving without a timed entry ticket are areas for improvement.

Total daily vehicle arrivals during PTES and total recreation visits in 2022 were both lower than 2019. At ARCH, visitation decreased about 12% from 2019 to 2022 (IRMA, 2023; Figure 18). However, the cause of this decrease is unknown. Across the entire Intermountain Region, other National Park units with a "National Park" naming designation (excepting YELL due to a flooding event that closed the park) saw an average decrease in visitation from 2019 to 2022 of about 9%, and several parks without any kind of timed entry system recorded decreased in visitation higher than ARCH (IRMA, 2023). Factors like gasoline prices, changing public preferences, and the success of campaigns to boost visitation at lesser-known parks may all play a factor in these changes (NPS, 2023).

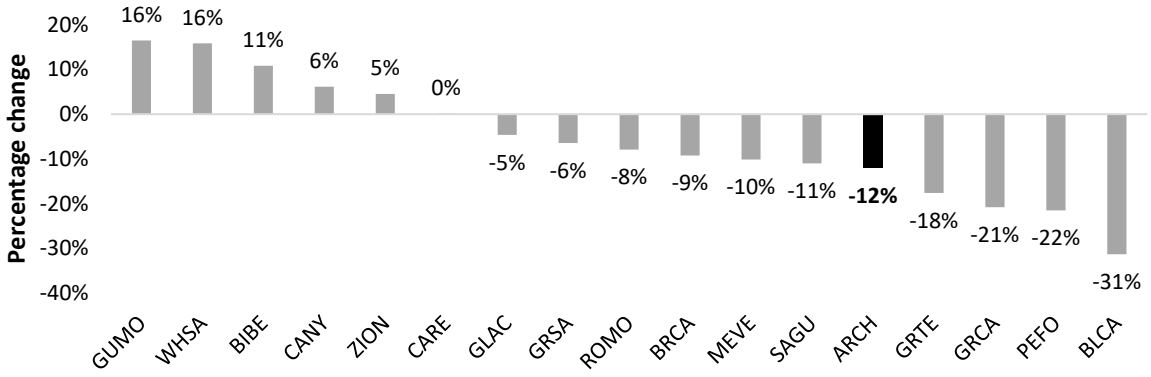

Figure 18. Change in annual visitation from 2019 to 2022 across National Parks in the Intermountain Region
Note: YELL not included due to the flooding event that closed the park

Visitor Access to Parking

Visitor access to parking improved during PTES. Collectively, no parking lots exceeded practical parking capacity (defined as 90% of striped capacity) more than 5% of the time during the PTES sampling periods, and no parking lot ever exceeded 100% of striped parking spaces during the same periods.

Visitor Experience Quality

Visitor experience quality as measured by people-per-viewscape (PPV) was improved in all locations measured (Windows, Delicate Arch, Devils Garden) under PTES. While average PPV counts slightly improved, maximum PPV counts improved more markedly. This means that extremely high visitor volumes were lessened under PTES. Under PTES, PPV was more frequently below conditions that indicate that park management needs to take action to deal with the density of people, as well as conditions that indicate that people would no longer visit the area due to the density of people. Throughout the entire pilot, less than 3% of hours at all locations (Windows, Delicate Arch, Devils Garden) demonstrated conditions where visitors would want the NPS to action to address the density of people at key locations, and less than 1% of hours at all locations (Windows, Delicate Arch, Devils Garden) demonstrated conditions where people would no longer visit the area due to the

density of people. Collectively, this information demonstrates that visitor satisfaction in key areas of the park was likely improved during PTES.

Limitations

Like all research, there are several limitations to consider in these findings. First, dynamic changes occurred between 2019 and 2022, including a global pandemic and the highest level of inflation in decades. The influence of these changes is difficult if not impossible to identify. However, the quasi-experimental approach used in this research that compares visitor use data before and during a managed access system provides a unique, robust opportunity to evaluate change. Second, the number of days data collection occurred in 2019 (RSG, 2020) was generally greater than the amount collected during PTES. This was largely due to limited staffing resources during PTES. However, the sampling conducted during PTES still provides robust data to evaluate change.

Appendix A: Literature Cited

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Appendix B: Methods

This section outlines the methodology used to collect and analyze the data in this report

Study Area

Data collected, associated analyses and model testing for this study simulate the basic approach taken in the Visitor Use, Access, and Experience Study (RSG, 2020) at ARCH. These efforts focused on site-specific examination of key areas and subsystems of the park – mainly the ARCH entrance area, the Windows, Wolfe Ranch/Delicate Arch, and Devils Garden (Figure B-1).

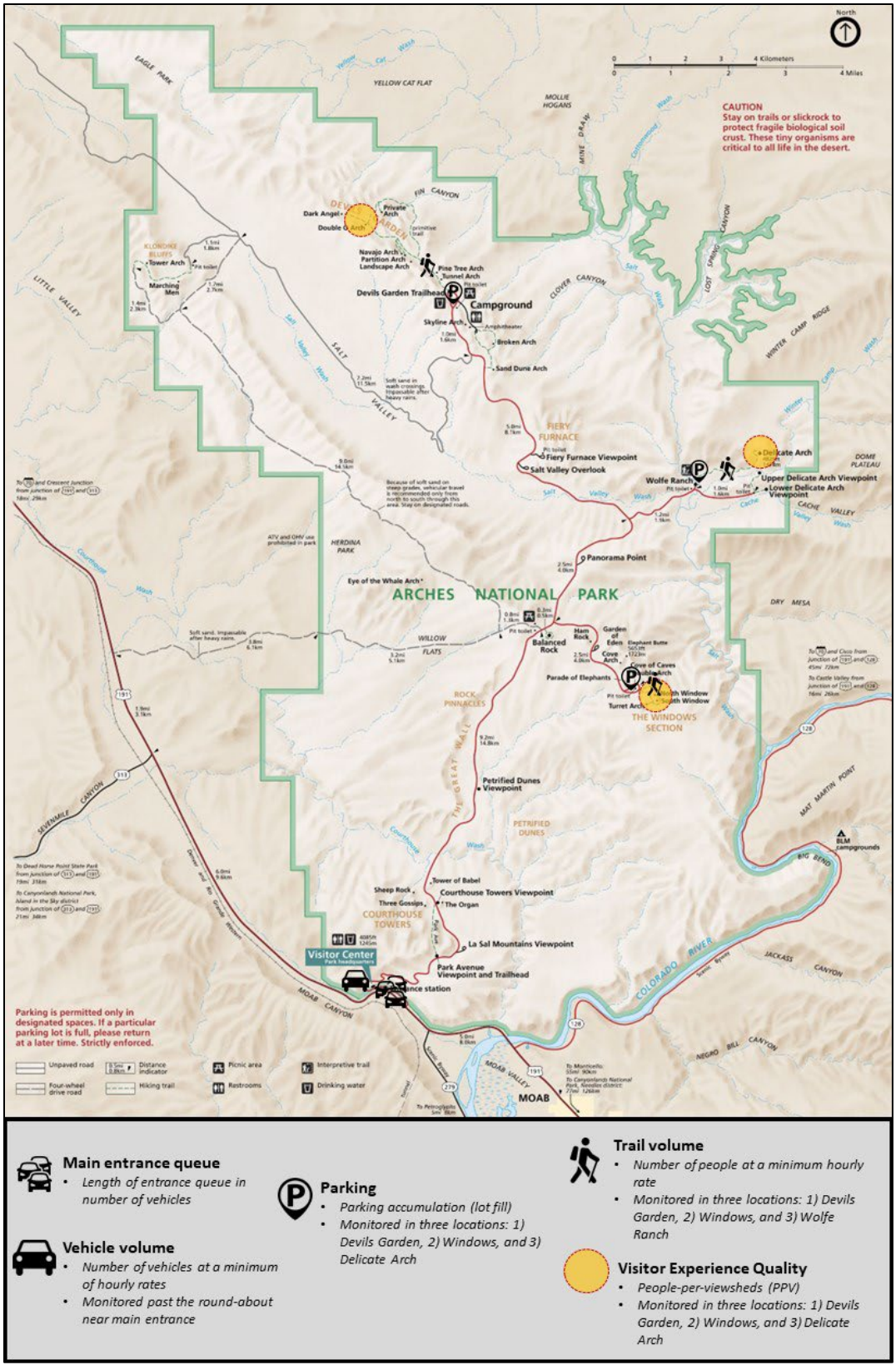

Figure B-1. Map showing analysis at ARCH

Arches National Park Main Entrance Area

A pneumatic tube vehicle counter (Diamond Omega G Vehicle Counter) was placed between the roundabout and the Visitor Center to monitor inbound park vehicle volume. Beyond the roundabout, visitors can access the main travel corridor, including the Visitor Center, Scenic Drive, and most developed areas and geologic features.

The number of visitors arriving at the park without a valid timed entry ticket were measured by staff manually counting vehicles. Staff were stationed in the roundabout to direct visitors with a reservation into the park or to turn visitors around if they did not have a reservation. These staff used a hand clicker to count turnarounds. All vehicles observed turning around either before the booths or at the roundabout were counted. Counts were collected on all days during the timed entry pilot and during all pilot hours (06:00 to 17:00). Counts were collected and tallied on a daily scale between April 3 and June 21, 2022 and on an hourly scale from June 22 to October 3, 2022. Turnarounds are used to identify how many potential visitors arrived at the park unaware of the timed entry reservation requirements; however, visitors were also turned around if they arrived early or late for their reserved entry time window or if they arrived on the wrong day.

Entrance station queue counts were conducted using a Bushnell game camera set to photograph the queue analysis area (Figure B-2) on the hour, every hour, starting on May 26, 2022 during the Timed Entry System pilot. Two months of hourly camera data were later analyzed and input into a Microsoft Excel spreadsheet to illustrate queue lengths. Data were analyzed to explore the 6:00 to 17:00 time periods. Analysis occurred between May 26 and June 25, 2022 and September 1 and September 30, 2022. The game camera was placed near a pullout along the Scenic Drive to capture the ARCH entrance road from the booths, down to “10-minute parking” near the ARCH sign and U.S. Route 191. All vehicles between these points, and not including the parking area, are included in the queue analysis. Commercial vehicles were not separated out of the queue analysis given the types of commercial vehicles which may be present in the ARCH queue that may not be obviously identifiable as commercial vehicles. Vehicles processed at the entrance stations were included in this analysis and counts were made of vehicles present before the service road entrance and after.

Figure B-2. Entrance station queue analysis area

The Windows

The Windows is a popular developed area providing access to several of the largest arches in the park including North and South Windows, Double Arch, and Turret Arch. This area is 12 miles from the park entrance off the scenic drive and has large parking areas and short trails to access the arches (Figure B-3). The maximum parking capacity of the Windows is 119 vehicles. The Windows viewscape is a primary site to measure visitor experience quality in ARCH. Additional monitoring strategies implemented in this area include a calibrated infrared trail counter along the main Windows trail system and a pneumatic tube vehicle counter to monitor incoming vehicle traffic and parking lot accumulation.

The overall Windows study area is highlighted green in Figure B-2. The Windows viewscape is highlighted blue. The viewscape is highlighted in green in Figure B-3 and corresponds to the area used in visitor surveys in ARCH during the 1990s to establish measured of visitor experience quality (NPS, 1995). These preferences were later used to inform VERP. In this study, counts of people-per-viewscape (PPV) were taken in the highlighted area of Figure B-4 to align with data collected in the 1990s (NPS, 1995) and with data collected in 2019 (RSG, 2020). In previous data collection efforts, these counts were referred to as “people-at-one-time” (PAOT).

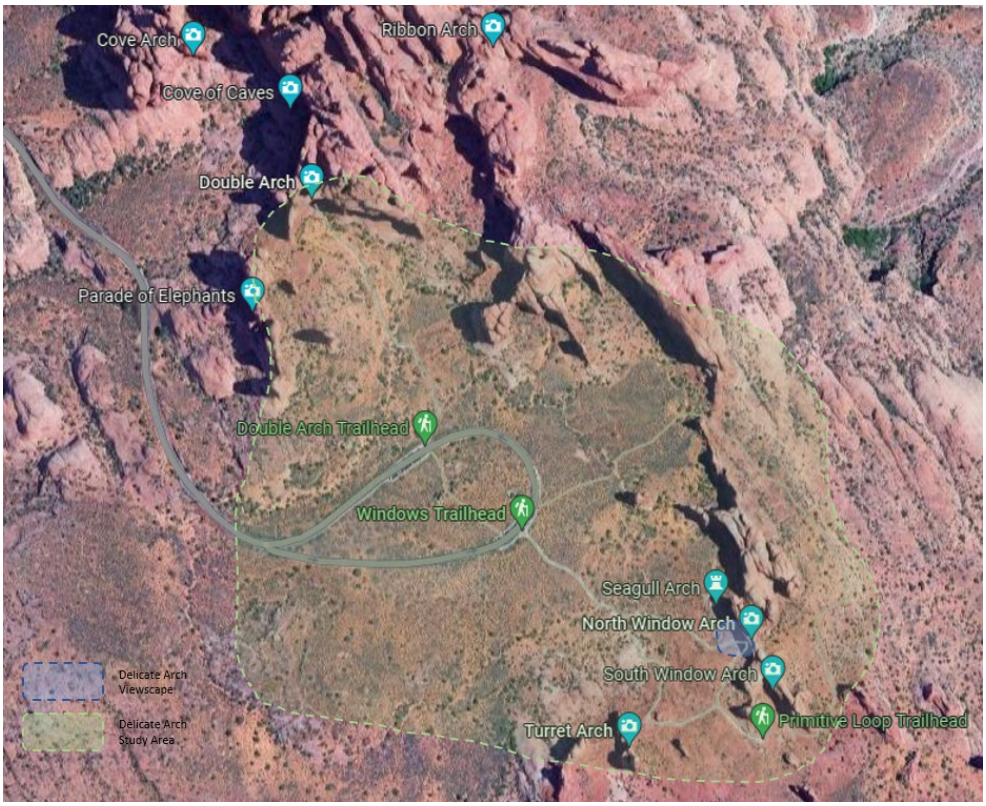

Figure B-3. Windows Study Area.

Figure B-4. Windows Viewscape

Delicate Arch

The Wolfe Ranch and Delicate Arch area is roughly 13 miles from the ARCH entrance off the Scenic Drive. This area is one of the focal areas of management at ARCH (Figure B-5). Delicate Arch is an iconic location in the National Park System and is the primary attraction for ARCH visitors (RSG, 2020). A spur road accesses this area and the main parking area and overflow parking at Wolfe Ranch contains 157 spaces. This main parking area accesses the 3-mile round trip hiking trail to Delicate Arch, and road-proximate interpretive areas accessing historic Wolfe Ranch and rock art created by Ute peoples prior to mass Euro-American settlement of the region. Further along the spur road is a second parking lot accessing the Delicate Arch Viewpoint – a 0.7-mile one-way trail to view the arch from a mile away (Figure B-5). The overall Delicate Arch study area is highlighted green in Figure B-4. The Delicate Arch viewscape is highlighted blue in Figure B-4.

The Delicate Arch viewscape (Figure B-6) is a key location for measuring visitor experience quality at ARCH and corresponds to the area used in visitor surveys in ARCH during the 1990s to establish visitor preferences for crowding levels. These preferences were later used to inform VERP (NPS, 1995). This site was used again during the 2019 data collection effort (RSG, 2020). This viewscape is highlighted green in Figure 5. PPV was measured in this study and methods are outlined later in this report. Additional automated data collection at Delicate Arch was facilitated with an infrared trail counter situated on the main Delicate Arch Trail.

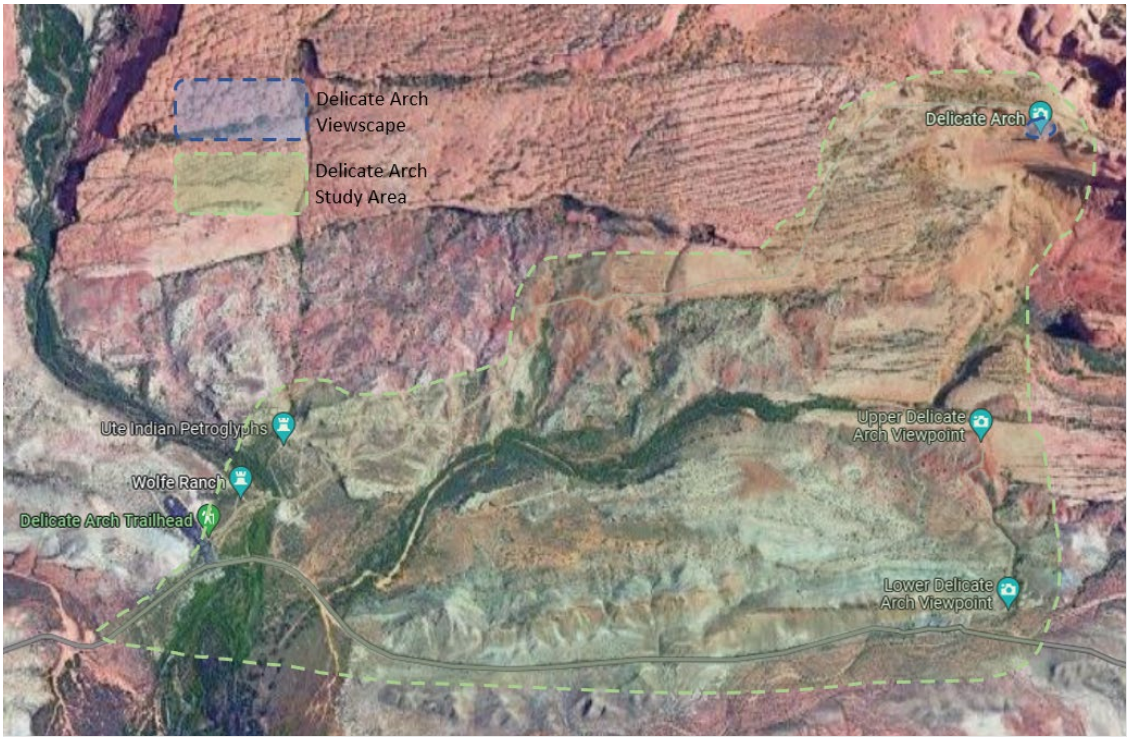

Figure B-5. Delicate Arch Study Area

Figure B-6. Delicate Arch Viewscape

Devils Garden

Devils Garden is the terminus of the Scenic Drive approximately 18 miles north of the park entrance. It is one of the most popular destinations in the park and features the largest concentration of established hiking trails in ARCH including the primary access trail to Landscape Arch, the longest arch in North America. The Devils Garden area, including the trail to Landscape Arch and beyond to Double-O Arch and the "Primitive Loop", is accessed by a large parking area with 179 spaces (Figure B-7). The overall study area is highlighted green in Figure B-7, with the Devils Garden viewscape highlighted blue.

The Devils Garden viewscape is also a key location to measure visitor experience quality in ARCH using PPV counts. The viewscape is highlighted green in Figure B-8 below. The viewscape corresponds to a section of trail used during surveys in the 1990s (NPS, 1995). This site was used again in data collection in 2019 (RSG, 2020). PPV was measured in this study and methods this study component are outlined later in this section. Additional automated data collection at Devils Garden was facilitated with an infrared trail counter situated on the main Landscape Arch Trail.

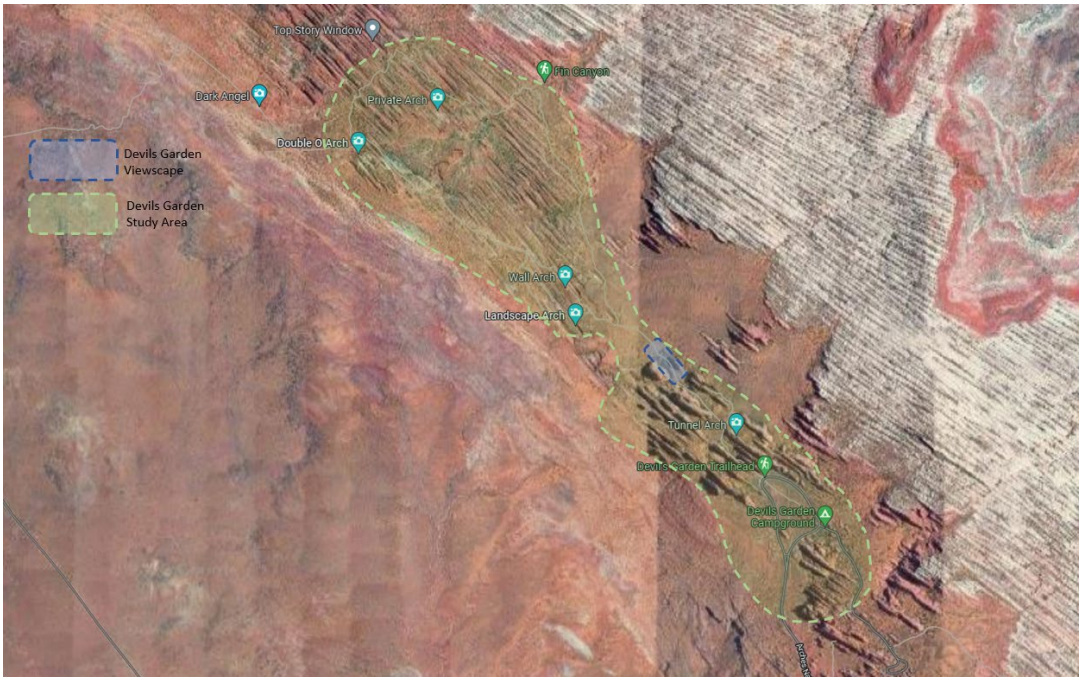

Figure B-7. Devils Garden Study Area.

Figure B-8. Devils Garden Viewscape.

Processing Time

Processing time at ARCH is difficult to accurately predict given the variables involved. This measure is primarily a function of pass sales, individual visitor to staff interactions, presence of commercial operators, and other variables. With the introduction of PTES at ARCH, new variables were added, including technological capacity to quickly scan timed entry reservations, informing visitors about the timed entry requirement and new interactions with visitors based on that requirement, and directing some visitors to turnaround beyond the booth.

Quantifying processing time is further complicated by variability in entrance queue length. Nonetheless, a method was defined to provide a preliminary analysis of the influence of the timed entry system on processing time. This brief section summarizes a comparison of processing time between June 2019 and June 2022 (during PTES).

In 2019, it was determined there was always a queue present between the hours of 09:00 and 14:00 using the permanently installed inductive loop vehicle counter near the park entrance station. Criteria were established to include the most accurate 2019 data which only included times with greater than 100 hourly entrances (a continuous flow of traffic) and hours with no closures or line flushing procedures. Four hours were removed for the second criteria. Zero hours were removed for the first criteria.

In 2022, turnaround data (from manual counts) were added to hourly arrivals using the inductive loop counter. Daily, not hourly, turnaround data were collected in June 2022, so a substitute hourly rate was added by using the average daily turnaround rate for each day in June. These data were added because the inductive loop counter's location is beyond the roundabout and does not capture/count visitors turned around there. A queue was always present between the hours of 09:00 and 14:00 (a continuous flow of traffic) in 2022 with verification provided by a game camera installed to monitor queue length. Arrivals were then compared between the two years to provide an estimate of managed access's influence on processing time. Data for June 1 and June 2, 2022 were removed due to counter malfunction. Two counts were also removed due to a criterion established for 2022 requiring greater than 90 hourly arrivals for inclusion in analysis to account for assumed increased processing time.

Aside from these omissions, a full comparison is made between June 1-30, 2019, and June 3-30, 2022, for the hours of 09:00 to 14:00. Hourly arrivals were divided into 3600 (seconds per hour) and multiplied 2 to account for both entrance booths. Thus, an estimate of processing time is determined using basic analysis in Microsoft Excel.

Summary Statistics

Summary statistics were generated using reports from Recreation.gov (Rec.gov), where timed entry reservations are sold, and outside of TES-window (06:00 to 17:00) data were collected using a pneumatic tube vehicle counter (Diamond Traffic Products Omega-G) placed beyond the entrance station and roundabout. Data on turnarounds were collected using a hand clicker by visitor services staff always stationed at the roundabout during the PTES (Table B-1).

No-shows were generated by tallying total tickets purchased and total tickets scanned. The number of visitor/vehicles that booked a reservation and never showed up (never scanned in at the entrance booth) was tracked through Rec.gov and analyzed through Rec.gov reporting tools. No-shows for timed entry reservations are summarized in Table 11.

Table B-1. Summary Statistics Methods.

DATA STREAM	METHOD
NO-SHOWS FOR RESERVATIONS	Data auto reported by Recreation.gov and delivered to SEUG staff.
OUTSIDE-TIMED ENTRY HOURS DATA	Data surmised using pneumatic tube vehicle counter.
TURNAROUNDS (NO RESERVATION)	Data collected by visitor services staff stationed in the roundabout.

Entrance Station Traffic Counts

Entrance station traffic counts were collected using permanently installed inductive loop counters near the entrance station and via a pneumatic tube vehicle counter (Diamond Traffic Products Omega-G) installed beyond the roundabout for the duration of the season. These counters record traffic in hourly bins. The pneumatic tube vehicle counter is primarily used for analysis in this study with data compared to the inductive loop counter. Data were collected bi-weekly via USB and tubes were changed as needed, often monthly.

Parking Lot Accumulation and Vehicles-at-One-Time (VAOT) Calculation

Parking lot accumulation, or counts of parked vehicles in each location, was calculated using a hybrid method on days when PPV data were collected (see *people-per-viewscape* section methods below). An initial count was taken prior to the VUM assistant hiking to the PPV sampling sites. Using pneumatic tube vehicle counters (Diamond Traffic Products Omega-G) collecting timestamped "event" data, arrivals and departures were added and subtracted, respectively, from initial counts to provide grounded estimates of Vehicles-at-One-Time (VAOT) in 10-minute buckets over five days at each primary study site (Figures 2, 4, and 6). These counters were located before the Windows parking loop, before the entrance to the Devils Garden area, before the Wolfe Ranch parking lot access along the Delicate Arch spur road, and between the Wolfe Ranch parking lot access and the Delicate Arch Viewpoint parking lot. In the Delicate Arch area, an initial count was also taken on each of these days for the Delicate Arch Viewpoint parking lot and an additional counter was placed to capture this parking lot. These counts were also added and subtracted from the primary Wolfe Ranch/Delicate Arch traffic counts. Data were postprocessed in Microsoft Excel.

The sampling schedule for parking lot accumulation is illustrated in Table B-2. Dates and time of season were selected to best replicate the timeframe of the VUAE data collected in 2019 (RSG, 2020). Given operational and personnel constraints, an exact temporal replication was not conducted. Weekend days and Mondays were sampled at each site (these were the three days sampled twice

during 2019). Midweek days were selected randomly to provide two additional days of data collection at each site.

Table B-2. Parking Lot Accumulation Sampling Schedule (2022).

DATE	DAY OF WEEK	TIME	LOCATION
AUGUST 23	TUESDAY	08:00 – 16:00	WINDOWS
AUGUST 29	MONDAY	08:00 – 16:00	WINDOWS
SEPTEMBER 4	SUNDAY	08:00 – 16:00	WINDOWS
SEPTEMBER 9	FRIDAY	08:00 – 16:00	WINDOWS
SEPTEMBER 10	SATURDAY	08:00 – 16:00	WINDOWS
AUGUST 22	MONDAY	08:00 – 16:00	DELICATE ARCH
AUGUST 28	SUNDAY	08:00 – 16:00	DELICATE ARCH
SEPTEMBER 3	SATURDAY	08:00 – 16:00	DELICATE ARCH
SEPTEMBER 7	WEDNESDAY	08:00 – 16:00	DELICATE ARCH
SEPTEMBER 29	THURSDAY	08:00 – 16:00	DELICATE ARCH
AUGUST 21	SUNDAY	08:00 – 16:00	DEVILS GARDEN
AUGUST 27	SATURDAY	08:00 – 16:00	DEVILS GARDEN
SEPTEMBER 5	MONDAY	08:00 – 16:00	DEVILS GARDEN
SEPTEMBER 27	TUESDAY	08:00 – 16:00	DEVILS GARDEN
SEPTEMBER 28	WEDNESDAY	08:00 – 16:00	DEVILS GARDEN

Trail Use Counts

This study examines three TRAFx brand infrared trail counters. One each at the Windows, Delicate Arch, and Devils Garden (see Figure B-1).

Trail counters were mounted on signposts (Figure B-9). These three counters were installed in April 2022 and began collecting data in early May. They remained active through PTES and collect data in hourly bins. Counters were calibrated using a regression-based method (Pettebone, Newman, & Lawson, 2010). Prior to direct observation, counters were set to collect data in timestamps which were later grouped into 10-minute bins. Calibration data were collected for five hours at each counter.

Figure B-9. SEUG signpost trail counter with “Your Steps Matter” message.

Regression analyses modeled the relationship between raw mechanical trail counter data and manual calibration counters collected via direct observation in spring 2022. This provided a correction factor to convert raw trail counter data to estimates of actual visitor use. Separate regression models were run for each counter with the corresponding regression coefficient acts as the calibration factor in this method (Pettebone et al., 2010). This coefficient is multiplied by the raw TRAFx data to illustrate more accurate estimates of use. Strong statistical relationships were found in regression results between direct observation counts and TRAFx data:

- Regression models with intercept terms were used for all three trail counters.
- Adjusted R^2 values were .99 for the Windows, .96 for Delicate Arch, and .94 for Devils Garden.
- Coefficients were 1.371 for the Windows, 1.205 for Delicate Arch, and 1.336 for Devils Garden. These values are high due to the wide nature of all three trails.

The calibrated data were used for all analyses contained in this report pertaining to trail use data.

People-Per-Viewscape (PPV) Counts

People-per-viewscape (PPV) counts were conducted for five days each at the Windows, Delicate Arch, and Devils Garden using locations selected during previous planning efforts (NPS, 1995) and used during data collection in 2019 (RSG, 2020). These counts were conducted using direct observation, a hand clicker, and photographs. The PPV counts were recorded as instantaneous counts once every 10-minutes for approximately eight hours per day, starting at 8:00 each day of the

sampling period (15 total days across sites in August and September 2022). A total of 212 PPV counts were recorded at the Windows, 216 at Delicate Arch, and 217 at Devils Garden (Tables B-3 to B-5). Data gaps are attributed to above-average afternoon monsoon events in summer 2022 and extreme heat (i.e., 105+ degrees on exposed slickrock at Delicate Arch) rendering data collection hazardous.

Table B-3. Windows PPV Sampling (2022).

DATE	LOCATION	# OF OBSERVATIONS
AUGUST 23	WINDOWS	48
AUGUST 29	WINDOWS	46
SEPTEMBER 4	WINDOWS	47
SEPTEMBER 9	WINDOWS	36
SEPTEMBER 10	WINDOWS	35
TOTAL	WINDOWS	212

Table B-4. Delicate Arch PPV Sampling (2022).

DATE	LOCATION	# OF OBSERVATIONS
AUGUST 22	DELICATE ARCH	48
AUGUST 28	DELICATE ARCH	48
SEPTEMBER 3	DELICATE ARCH	42
SEPTEMBER 7	DELICATE ARCH	38
SEPTEMBER 29	DELICATE ARCH	40
TOTAL	DELICATE ARCH	216

Table B-5. Devils Garden PPV Sampling (2022).

DATE	LOCATION	# OF OBSERVATIONS
AUGUST 21	DEVILS GARDEN	44
AUGUST 27	DEVILS GARDEN	48
SEPTEMBER 5	DEVILS GARDEN	48
SEPTEMBER 27	DEVILS GARDEN	41
SEPTEMBER 28	DEVILS GARDEN	36
TOTAL	DEVILS GARDEN	217

Trail counts to people-per-viewscape

Previous research established robust relationships between hourly trail arrivals and hourly average PPVs at Windows, Delicate Arch, and Devils Garden (RSG, 2020). These models were used to estimate PPV at all three sites throughout the duration of the pilot. Equations are provided below.

$$\textit{Windows PPV during the same hour} = 0.1422(\textit{trail arrivals}) - 1.9827$$

$$p<.05;\ R^2=0.619$$

Delicate Arch PPV one hour delay = 0.3201(trail arrivals) + 1.8631
$p<.05$; $R^2=0.512$

Devils Garden PPV during the same hour = 0.0718(trail arrivals) + 1.2687
$p<.05$; $R^2=0.468$

Trail arrivals were calculated using calibration data from the 2019 study (RSG. 2020), which collected direction of travel during calibration efforts. Data on arrivals from these calibrations were averaged throughout the data collection period. Arrival proportions are as follows: Windows=51%; Delicate Arch=45%; Devils Garden=49%. Trail arrivals were applied to total calibrated trail volume, then included in the regression equations above to arrive at PPV.

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