

White River National Forest Hanging Lake Capacity Study



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13. ABSTRACT (Maximum 200 words) Due to overcrowding at Hanging Lake, the Volpe Center performed a capacity study for the White River National Forest. This capacity study examines the visitation and environmental constraints of Hanging Lake parking lot, trail, and site to develop three scenarios in which the U.S. Forest Service staff will use to determine the appropriate level of use at the site. Using data gathered from various data sources, the capacity study compares actual conditions during the 95 th percentile week and compares to reductions in visitation using a proposed capacity management system. The analysis includes a series of videos that demonstrate the flow of visitors to the site.				
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Introduction

In response to management, resource, and safety issues at Hanging Lake rest area and recreation site in Glenwood Canyon, Colorado, the U.S. Forest Service (USFS) asked the U.S. Department of Transportation's John A. Volpe National Transportation Systems Center (Volpe Center) to help facilitate and develop an interagency transportation study and assist in crafting a long-term solution for the site. The entire site, which includes a 112-space parking lot, rest area facilities (restrooms, picnic tables, etc.), a 1.2-mile trail, Hanging Lake, and Spouting Rock, is receiving more and more visitors over time, causing environmental conditions, public safety, and visitors' experiences to increasingly suffer.

As part of the Hanging Lake Transportation Study, the USFS asked the Volpe Center to conduct a trail and site carrying capacity analysis. Additionally, the National Park Service (NPS) performed an ecological assessment to assist the project team in better understanding the impacts of high and largely unregulated trail use. The Capacity Study will assist the USFS in determining an optimal capacity for the site to address issues related to congestion, safety, over-crowding, and the environmental degradation of the rest area, trail, and lake.

When the Colorado Department of Transportation (CDOT) constructed the Hanging Lake rest area facilities as a part of the overall Interstate 70 construction project in the 1980s, the parking lot was sized to be the limiting factor for visitation to Hanging Lake. Thus, for the purpose of this study, the constructed parking lot capacity is used as the baseline for calculating the capacity of the site. In order to establish a capacity based on this baseline, the study assumes that the area would be managed at least ten hours a day (7 AM to 5 PM¹), seven days a week, and from May to November.

Concurrent to the Capacity Study, the USFS requested that the Volpe Center develop a Transit Service Feasibility Analysis. This analysis will identify and evaluate public and commercially provided shuttle system options for both public and commercially provided shuttle systems to the Hanging Lake parking lot. The analysis will incorporate the data and use the baseline assumptions described in this capacity study.

Data Sources

The data used in this analysis came from four different sources: 1) TRAFX, which provided trail counter data at the Hanging Lake trailhead by hour, day, and month for summer 2015; 2) CDOT vehicle counter data located after the bridge leading into the Hanging Lake Rest Area for June 13-21, July 10-19, and August 7-16, 2015; 3) observational data collected by the Volpe Center project team on-site from July 9-13, 2015; and 4) an ecological assessment of the trail and lake performed by the National Park Service on September 18, 2015. Other general information about the trail was used as well, such as the round-trip length (2.4 miles) and elevation gain (1,000 feet). Additionally, the project team took photos during its site visit to create photo simulations of the volume of visitors under various scenarios as discussed in this document (Appendix A). The project team also created an animated video to depict the current and average accumulation and flow of visitors over the course of a nine-hour day.

¹ 5 PM is used as the last hour that hikers would be allowed on the trail; since a hike starting at 5 PM would likely end at 8 PM. Due to darkness safety reasons, and to give the environment a rest during the evening hours no hikes should start after 5 PM.

Results

Using the above data, the project team estimated carrying capacities by using the following variables:

- Average passengers per vehicle = 2.8
- Average group size = 3.2
- Number of original parking lot spaces = 112
- Average length of stay per vehicle = 3 hours
- Average length of stay at lake = 0.67 hours
- Average hiking time = 2.2 hours
- Percent of arrivals that are bicyclists = 5.7%

Table 1 outlines the results of the carrying capacity analysis (for more details on the calculations, please refer to Appendix B and for direct comparisons of the scenarios, please refer to Appendix C). Three different scenarios are provided to the USFS: Original Capacity, Slight Restrictions, and Environmentally-Sensitive. The scenarios operate under the assumption that the parking lot would be closed during non-operating hours (5 PM to 7 AM).

Table 1 Carrying Capacity Scenarios, Daily Averages

Carrying Capacity Scenario	Operating Hours	Capacity per Hour	Total Hikers per Day	Max Hikers on Trail/Lake	Max Hikers on Trail	Max Hikers at Lake	Max Hikers per 100ft (both ways)	Max Vehicles in Lot	Average # of Passings	Average Distance between Groups (ft.)
Actual Conditions (95 th Percentile Week)	24	n/a	1,050	355	293	62	4.31	113 ²	211 (at peak times)	80 (at peak times)
Actual Conditions Unmanaged (Mon - Wed)	24	n/a	979	371	309	69	4.81	136 ³	n/a	n/a
Actual Conditions Managed (Thurs - Sun)	24	n/a	1,108	341	285	58	4.07	113 ⁴	n/a	n/a
Original Capacity	10	111	1,110	332	278	56	3.85	112	198	110
Slight Restrictions	10	78	780	234	195	39	2.71	78	134	150
Environmentally – Sensitive	10	45	450	134	112	22	1.56	43	87	250

² June 13-19, 2015, CDOT vehicle counter data

³ June 15-17, 2015, CDOT vehicle counter data

⁴ June 13-14,18-19, 2015, CDOT vehicle counter data

Actual Conditions

The Actual Conditions of the site are depicted in Figure 1. The graph represents average daily site use from July 13 to 19, 2015. Based on TRAFX data, this week is a 95th percentile week in terms of visitation between May 1 and October 1, 2015, which means that five percent of the weeks during the summer had higher visitation than the week selected and 95 percent of the weeks had lower visitation. The average maximum total number of hikers at one time during this period was 355 (62 hikers at the lake and 293 on the trail), which equates to a maximum average of 4.31 hikers per 100 feet.

For a closer examination of the data, the project team separated unmanaged days from USFS-managed days of the week of July 13-19, 2015, to understand how USFS parking lot management affected trail capacity. Looking at the results above in Table 1 as well as in Figure 2 and Figure 3 below, visitation did differ. Although USFS-managed days (Thursdays-Sundays) saw higher total visitation, the visitation peaks were more spread out and therefore the maximum hikers on the trail, lake, and per 100 feet were notably lower than on unmanaged days. Due to outliers in the CDOT vehicle counter data for that week in July, the vehicle data is supplemented with vehicle counter data collected during June 15-17, 2015 (Monday-Wednesday, unmanaged days). It depicts similar inbound and outbound car data, although on the 95th percentile day, the parking lot would have likely been more crowded than what the June CDOT data shows. These data demonstrate that trail and lake congestion do benefit from some amount of parking lot management.

There are also hikers that did not arrive by car. Based on counts performed, the project team found that approximately 5.7 percent of arrivals to the trailhead were bicyclists during the week of July 9-13, 2015. Project partners note that several bicycle rental companies have recently opened in Glenwood Springs and the area has seen an increase in bicycling and, anecdotally, that some hikers bicycle to Hanging Lake trailhead to avoid the parking lot. Accordingly, if over-crowding in the parking lot is solved, it may reduce the number of bicyclists. The following scenario estimates account for the 5.7 percent of hikers arriving by bicycle.

Figure 1 Actual Average Daily Site Use from July 13 to 19, 2015⁵

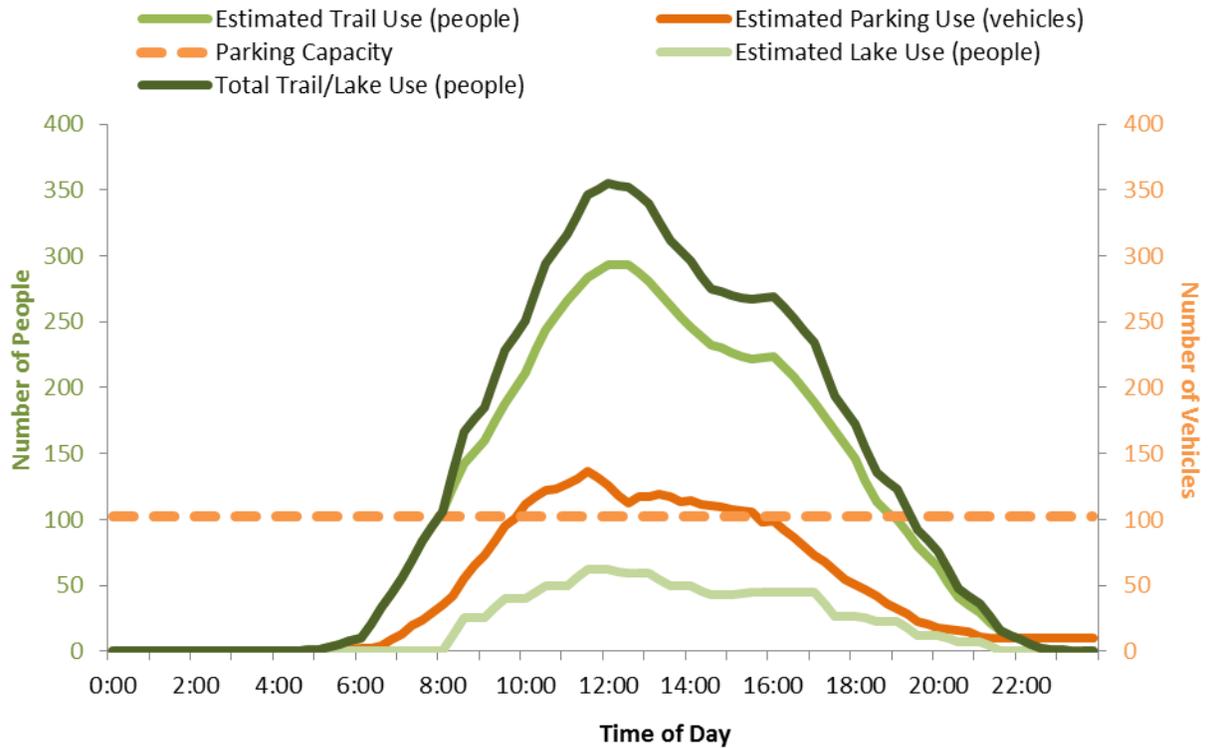
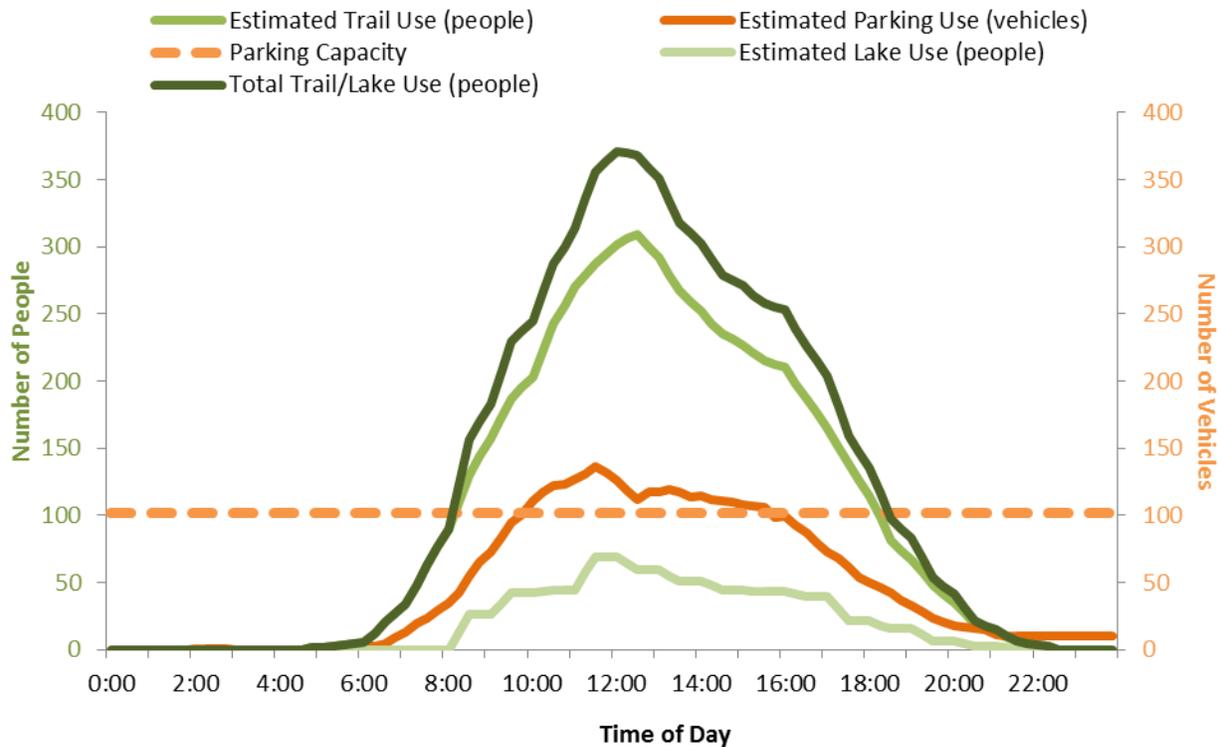


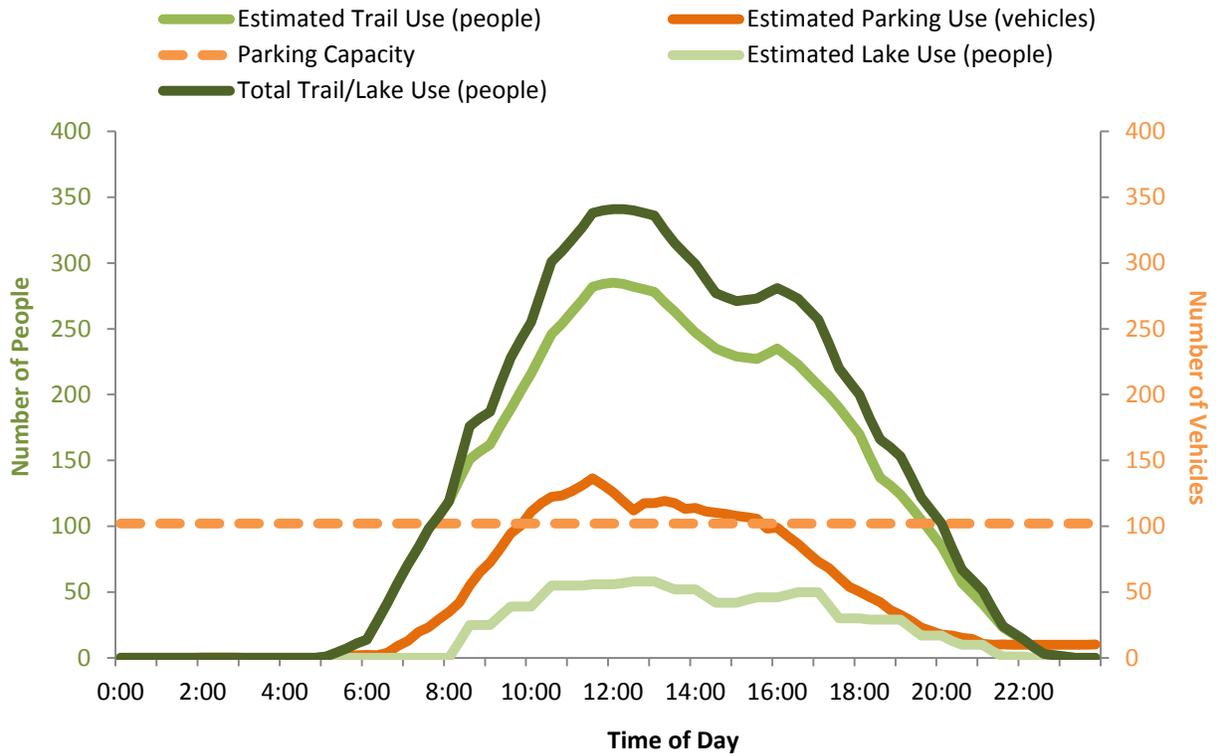
Figure 2 Actual Average Daily Use for Unmanaged Days (Monday-Wednesday, July 13-15, 2015)⁶



⁵ This data uses June 15-17, 2015, vehicle data.

⁶ This data uses June 15-17, 2015, vehicle data.

Figure 3 Actual Average Daily Use for USFS-Managed Days (Thursday-Sunday, July 16-19, 2015)⁷



Original Capacity

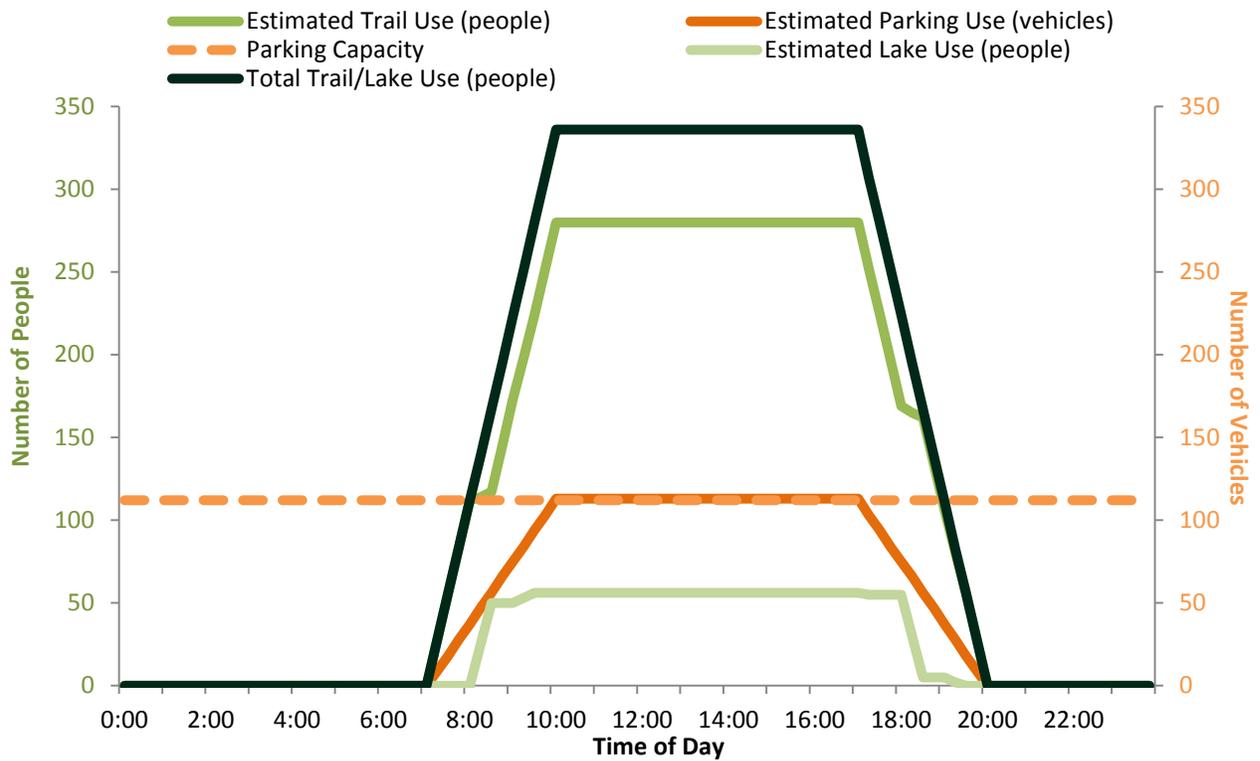
The Original Capacity scenario operates under the assumption that the original configuration of the parking lot sets the limit of the capacity of the site (Figure 4). This scenario allows 111 hikers per hour and results in a maximum of 112 vehicles in the parking lot, which is equivalent to the number of parking spaces available in the lot. As shown in Figure 5, limiting the number of hikers per hour under this scenario resulted in a maximum of 1,110 people per day based on an average length of stay of three hours.

⁷ This data uses June 15-17, 2015, vehicle data.

Figure 4 Aerial image of Hanging Lake parking lot (Source: Google Maps)

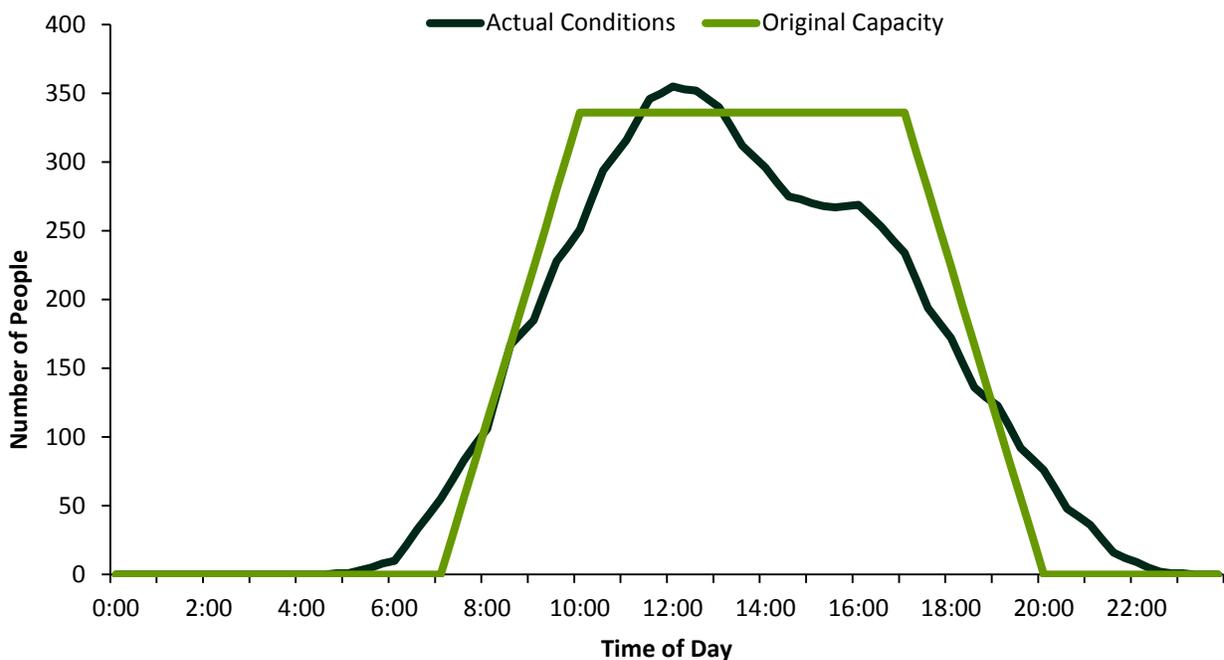


Figure 5 Original Capacity Scenario Estimated Average Daily Site Usage



The Original Capacity scenario closely mimics the Actual Conditions, particularly during the managed days, in terms of the number of people using the site per hour (Figure 6). Comparing the Actual Conditions managed days to the Original Capacity scenario demonstrates that having USFS staff monitoring and managing the flow of vehicles in the parking lot creates a smoother and more efficient flow of visitors similar to what the capacity model created. Even though the site would be open less hours of the day, it reaches peak visitation earlier in the day and so accommodates more visitors. By setting the capacity of the site to 111 persons per hour spread out across a 10-hour operating day, the USFS would be able to flatten the visitation peaks, however it would maintain the greatest periods of over-crowding typically experienced at the site for a longer portion of the day. As discussed with stakeholders and USFS staff, the current conditions of the site are already unsustainable due to the negative environmental and visitor experience impacts previously discussed. Under this scenario, the maximum number of hikers on the trail is 278 and at the lake is 56. This results in 3.85 hikers in both directions per 100 feet of trail on average. (See Appendix A for photo simulations of the trail and lake under each scenario.)

Figure 6 Comparison of Original Capacity Scenario and Actual Conditions total Trail/Lake Use

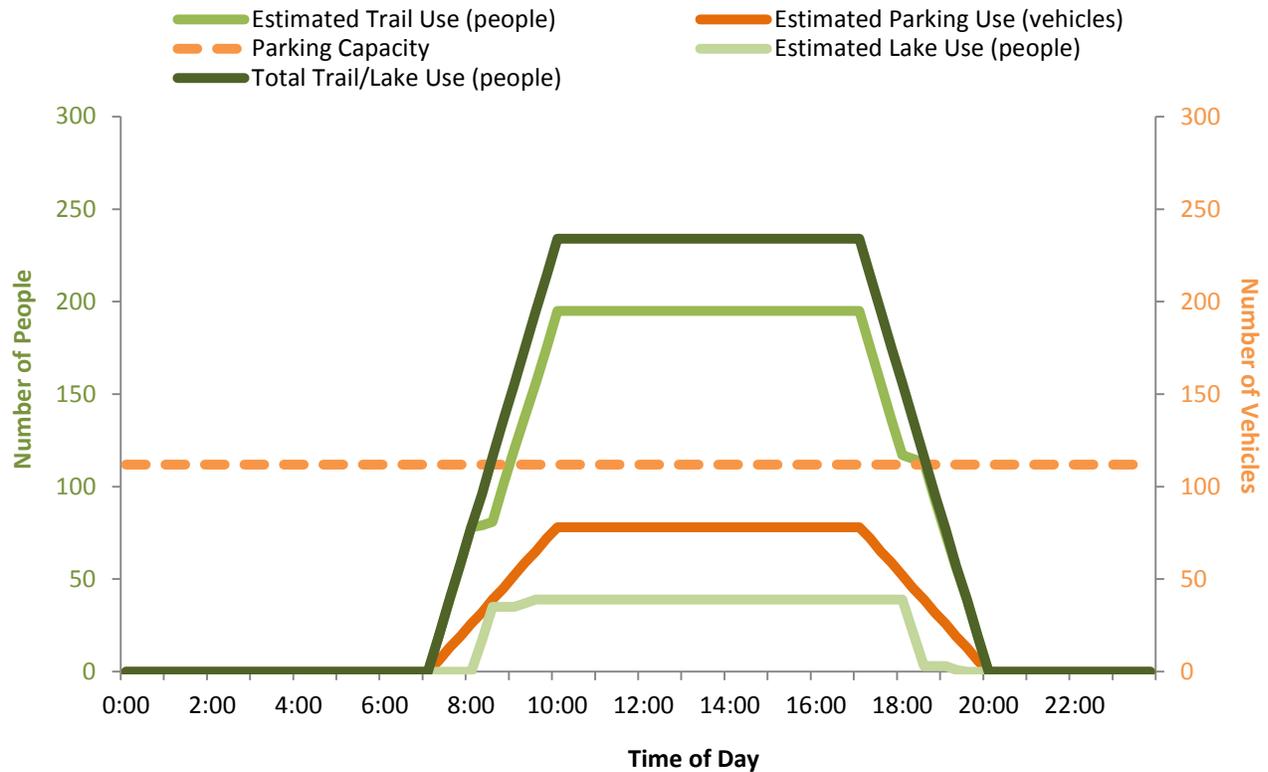


Slight Restrictions Capacity

USFS staff, stakeholders, and the public agree that the trail is crowded. Using the Original Capacity scenario as the baseline, since it resembles how visitation to the site was initially intended to be, the project team developed a scenario that reduces the Original Capacity scenario by 30 percent to address trail crowding and associated natural resource impacts. The project team selected this percentage since it limits the number of hikers to a more sustainable level and allows the USFS to improve the management of the site. Studies for other congested USFS sites in Colorado suggest similar percentage decreases to improve visitors' experiences and conditions, environmental and otherwise, along the trail

and at the destination(s).⁸ The Slight Restrictions scenario therefore caps the number of hikers at 78 people per hour, with a total of 780 hikers per operating day. This capacity results in a maximum of 234 hikers on the trail and lake (Figure 7) with the maximum of trail hikers estimated to be 195 and lake hikers to be 39. This restriction results in 2.71 hikers in both directions per 100 feet of trail. That is one less person every 100 feet than in the Original Capacity scenario and in Actual Conditions. One less person per 100 feet can make a difference in affecting trail widening as well as visitor experience.

Figure 7 Slight Restrictions Scenario Average Daily Site Usage



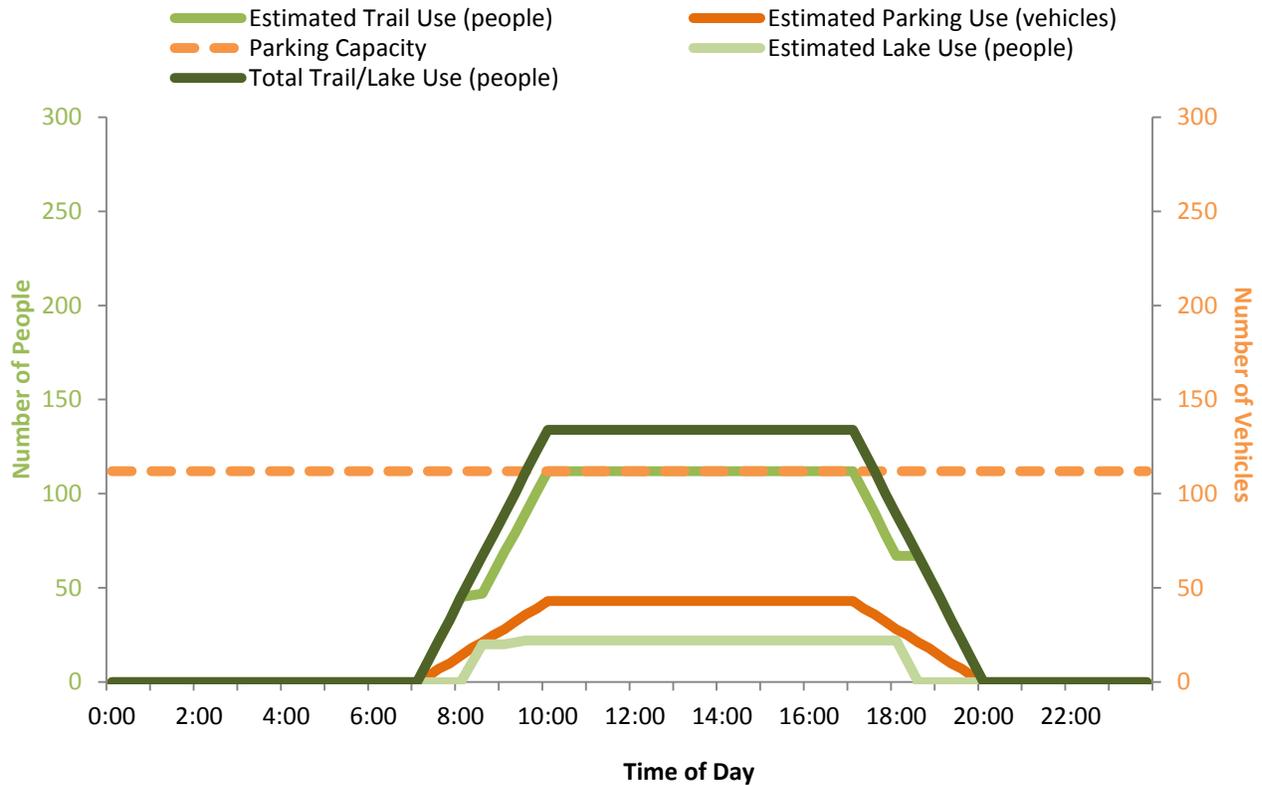
Environmentally-Sensitive Capacity

The ecological assessment performed by National Park Service staff found degradation of conditions on the trail and at the lake as well as above the falls around Spouting Rock. To help stem this degradation, the assessment team suggested that the USFS could reduce the number of hikers on the trail to minimize the two-lane effect taking place as hikers pass one another, both in terms of downhill hikers passing uphill hikers and faster hikers passing slower hikers, and to enable site personnel (i.e., USFS, concessionaire, or outfitter staff or volunteers) to better monitor people’s behavior and enforce the rules. While a more significant reduction will not undue all of the ecological damage already done to the trail, it would help ensure conditions do not degrade further and may help give the vegetation and wildlife a chance to regenerate as well. Moreover, the lake and the area above the falls are suffering from visitors breaking rules and a lack of commensurate enforcement by the USFS due to staffing limitations. The assessment team recommended a greater staff presence at the lake and above the falls to enforce rules, such as not swimming in the lake, and reducing the number of hikers up at the lake and at Spouting Rock at one time.

⁸ Includes: Arapaho and Roosevelt National Forest Alternative Transportation Study, 2016, Volpe (not yet published);

To minimize two-way traffic and minimize the number of visitors at the lake and Spouting Rock, the project team reduced the number of total hikers from the Original Capacity scenario by 60 percent. Under this scenario, 45 hikers would be on the trail each hour, which results in a maximum of 100 hikers on the trail on average, 20 hikers at the lake (which includes Spouting Rock) on average, and a total of 360 hikers per day (Figure 8). This number hikers at the lake would also be a manageable number for staff to watch and monitor.

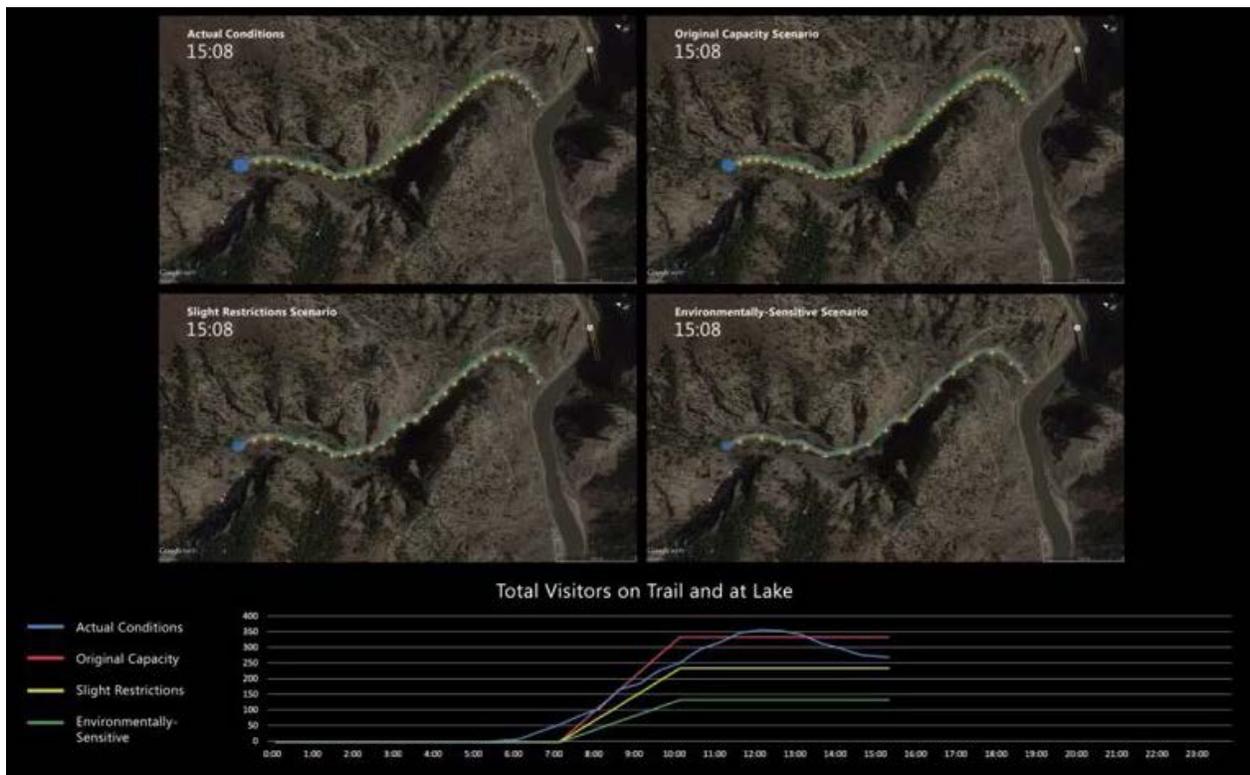
Figure 8 Environmentally-Sensitive Scenario Average Daily Site Usage



Video Analysis

Using the results from the capacity analysis, the Volpe Center developed three animated videos of the three scenarios and the Actual Conditions. One video displays only the Actual Conditions, a second video displays each of the scenarios then a side-by-side comparison of the three, and a third video displays all three scenarios and the Actual Conditions side-by-side (Figure 9).

Figure 9 Screen capture of video comparing Actual Conditions and the three scenarios



The videos provide a visual representation of the flow of hikers on the trail and at the lake throughout the day. By examining the video, the project team estimated the average number of group passings and the average distance between groups for the three scenarios. The videos can be found on this [YouTube playlist](#).

Conclusion

This document presents three capacity scenarios for the USFS to consider as the project moves into the National Environmental Policy Act (NEPA) public process and subsequent management plan for the site. The scenarios look at the capacity of the parking lot, trail, and lake and the movement of visitors through all three of those locations. It is possible to revisit and adjust the assumptions, numbers, and scenarios presented in this document to fit the USFS's desired future condition of the site as identified in the management plan. The USFS may use these capacity numbers to inform management alternatives currently under development and to perform a cost analysis to determine the most cost-effective scenario that balances the overall goals and objectives of the Hanging Lake project, which are to protect natural resources, manage congestion at Hanging Lake parking lot, enhance public safety, improve visitor experience, and support local tourism.

APPENDIX A: Photo Simulation

The following photos depict 100-feet of trail as well as an aerial view of the lake with the estimated number of hikers for each scenario presented in the analysis.

Actual Conditions

(Average of 4 hikers per 100 feet of trail and 62 hikers at the lake)



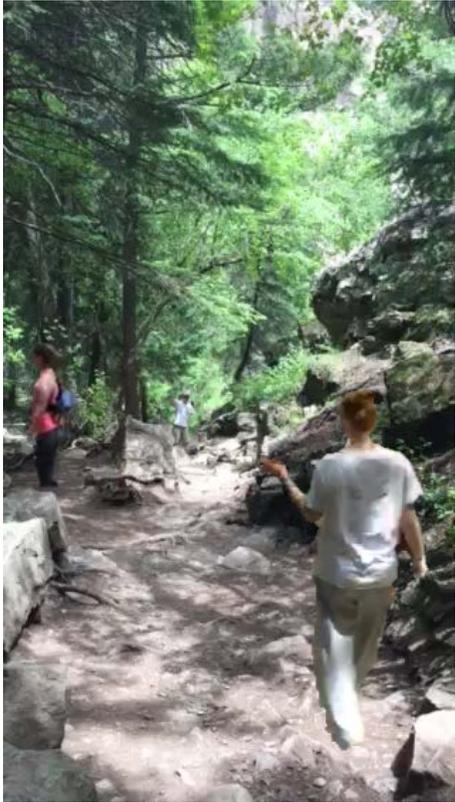
Original Capacity Scenario

(Average of 4 hikers per 100 feet of trail and 56 hikers at the lake)



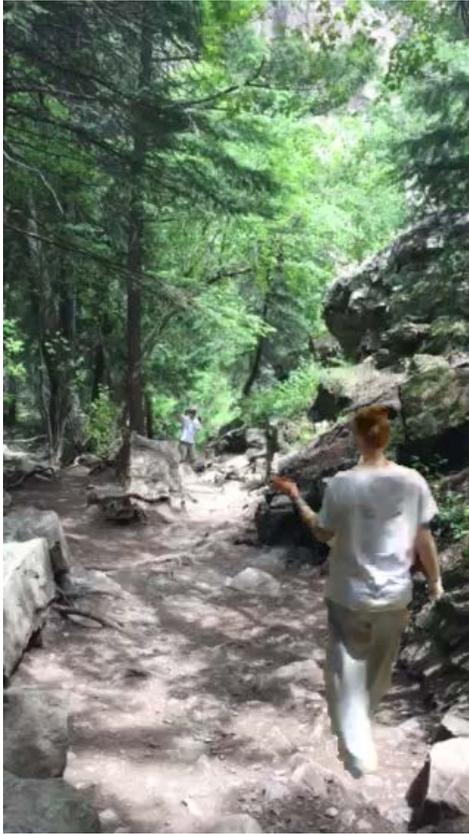
Slight Restrictions Scenario

(Average of 3 hikers per 100 feet of trail and 39 hikers at the lake)



Environmentally-Sensitive Scenario

(Average of 2 hiker per 100 feet of trail and 22 hikers at the lake)



APPENDIX B: Comparison Graphs

Figure 10 Comparison of Estimated Total Trail/Lake Use (people) for Unmanaged and Managed Conditions to the Three Scenarios

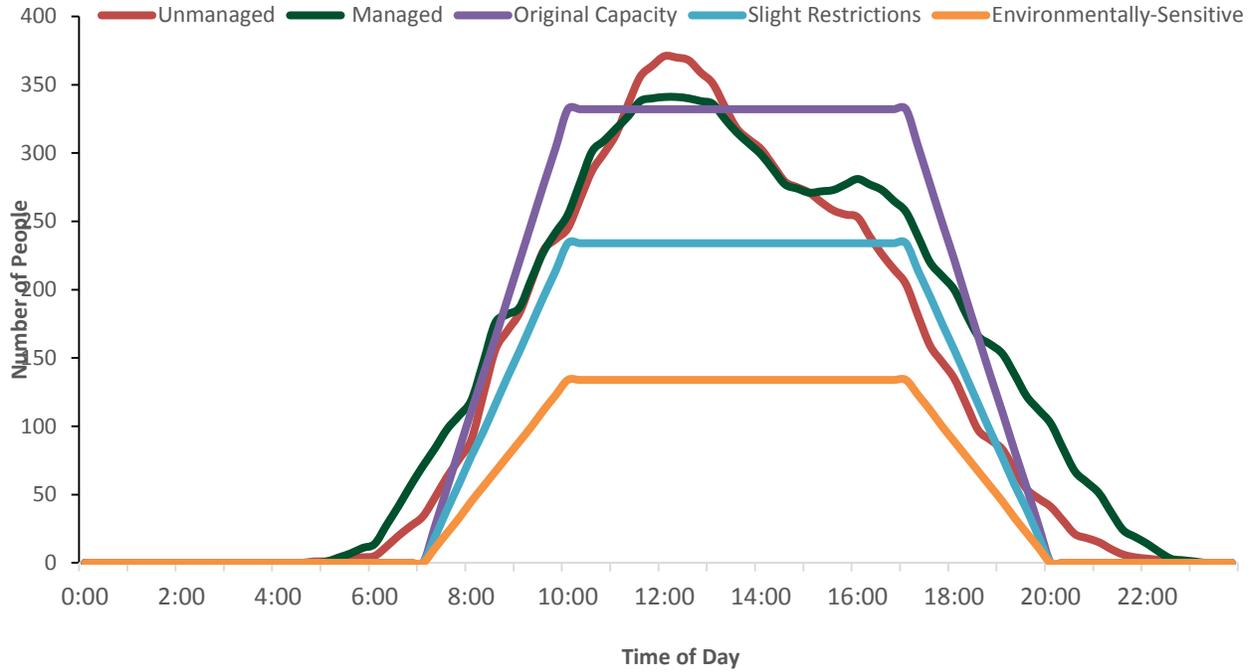


Figure 11 Comparison of Estimated Parking Lot Use (vehicles) for Unmanaged and Managed Conditions to the Three Scenarios (uses June 15-17 unmanaged CDOT data; managed day data is not included due to errors)

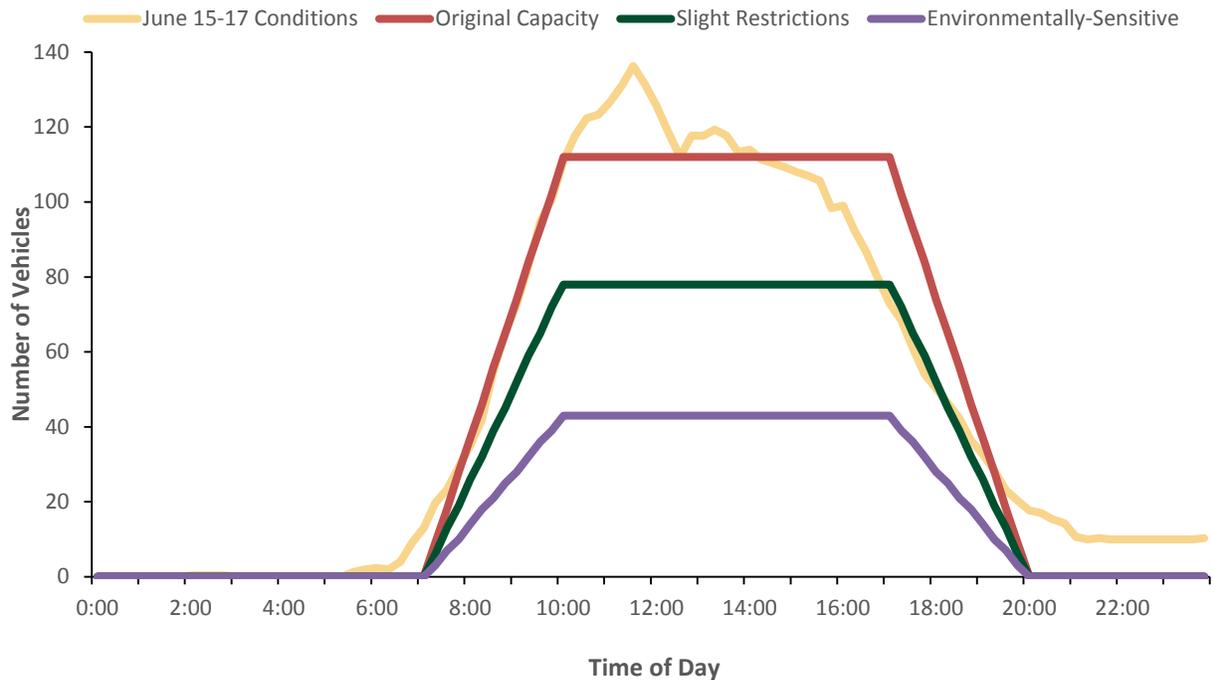
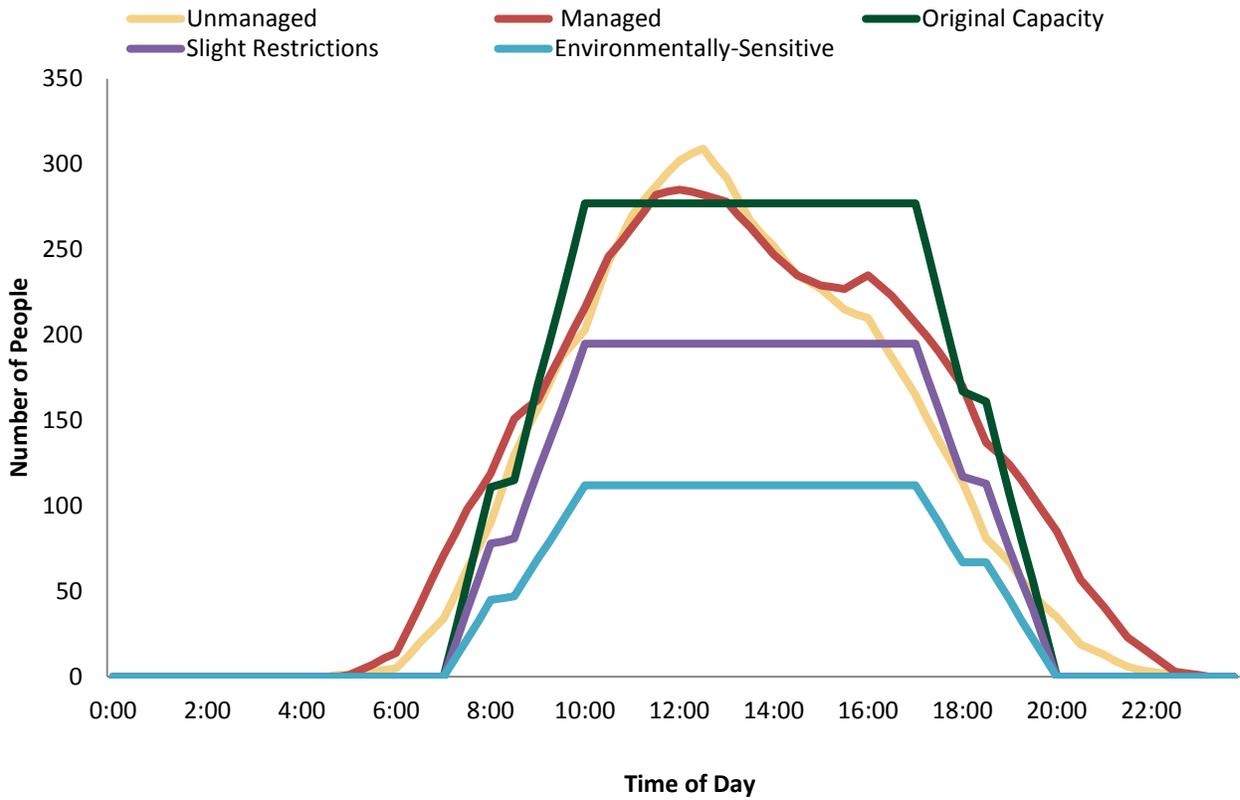


Figure 12 Comparison of Estimated Trail Only Use (people) for Unmanaged and Managed Conditions to the Three Scenarios



APPENDIX C: Capacity Calculation Methodology

To calculate the **Actual Conditions**, the project team went through the following steps:

1. Downloaded 24-hour average TRAFX data for the appropriate days (July 13-19, 2015)
2. Divided the hourly average TRAFX data by four to develop 15-minute arrival rates
3. Based on 15-minutes arrivals, developed 15-minute departure rates based on average length of stay for the site, trail, and lake
4. Applied the arrival and departure rates over a 24-hour period; subtracted arrivals and departures to develop totals
5. CDOT vehicle counter data came in 15-minute counts with inbound and outbound traffic; inbound vehicles were subtracted from outbound vehicles

To calculate the **Scenarios**, the project team went through the following steps:

1. Applied the hourly permit total as the hourly arrival rate and divided by four to develop 15-minute arrival and departure rates
2. Applied the arrival and departure rates over a ten-hour period; subtracted arrivals and departures to develop totals
3. Vehicle arrivals were estimated hourly by dividing the number of capacity-limited visitors by average passengers per vehicles (2.8). Project team calculated the estimated number of visitors who might arrive by bicycle (5.7 percent) and subtracted that from the vehicle estimates. This was divided by four to develop 15-minute estimates for arrival and departure rates based on total length of stay at the site (three hours). The arrival rates were applied over a 10-hour period, while the departure rates applied until all vehicles exited as vehicles that arrived at 5:00 PM would not be down the mountain until 7:00 PM.