City of Sedona
Off-Highway Vehicle Environmental Impact Assessment

Draft – June 2023

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1. Introduction

The City of Sedona has retained Kimley-Horn to develop an Environmental Impact Assessment for five locations in and around Sedona, Arizona that serve off-highway vehicles (OHV). This assessment builds on the Sedona Off-Highway Vehicle Report (Completed May 2019, 2017 Data), which researched the status of OHV use in Sedona, identified potential concerns related to OHVs, and recommended potential strategies.

The purpose of this assessment is to collect additional environmental data to support the City's decision-making process for potential actions appropriate to address these concerns.

The five locations studied in this assessment include the following:

- Forest Road (FR) 152C – Unpaved Roadway
- Dry Creek Road and Trailhead – Trailhead Parking, Paved Roadway, Unpaved OHV Trail, Parking Lot and the adjacent intersection of Dry Creek Road and Boynton Pass Road
- Soldier Pass Trailhead – Gated Trailhead Parking, Gated access to OHV Trail and adjacent paved roadway
- Schnebly Hill Trailhead – Trailhead Parking, Unpaved OHV Roadway
- Broken Arrow Trail - Trailhead Parking and Unpaved OHV Trail

The study locations are shown in Figure 1.

FIGURE 1. STUDY LOCATIONS

1.a. Resources Evaluated

The Environmental Impact Assessment was envisioned to be completed in three phases, with some resources studied during one season and other resources studied during multiple seasons, as summarized in Table 1-1.

TABLE 1-1. RESOURCE STUDY TIMEFRAMES

Season	Quantity and Type of OHVs	Speed of OHVs	Noise Level	Noise OHV Reference Level	Air Quality	Soil Compaction and Erosion
Spring	✔		✔		✔	
Summer	✔	✔	✔	✔	✔	
Fall	✔	✔	✔		✔	✔

OHV = off-highway vehicle

1.b. Spring 2023 Data Collection Schedule

Kimley-Horn staff initiated the data collection effort at 10:30 a.m. on Friday, March 17, 2023, and concluded at approximately 12 p.m. on Sunday, March 19, 2023. Staff set up the appropriate equipment for continuous vehicle data collection and visited each site throughout the data collection days to ensure equipment was working properly, that equipment was intact and undisturbed, to obtain manual traffic data, and to note general observations. Equipment was either removed in the evenings and replaced in the mornings or secured in place overnight.

2. Analysis Results

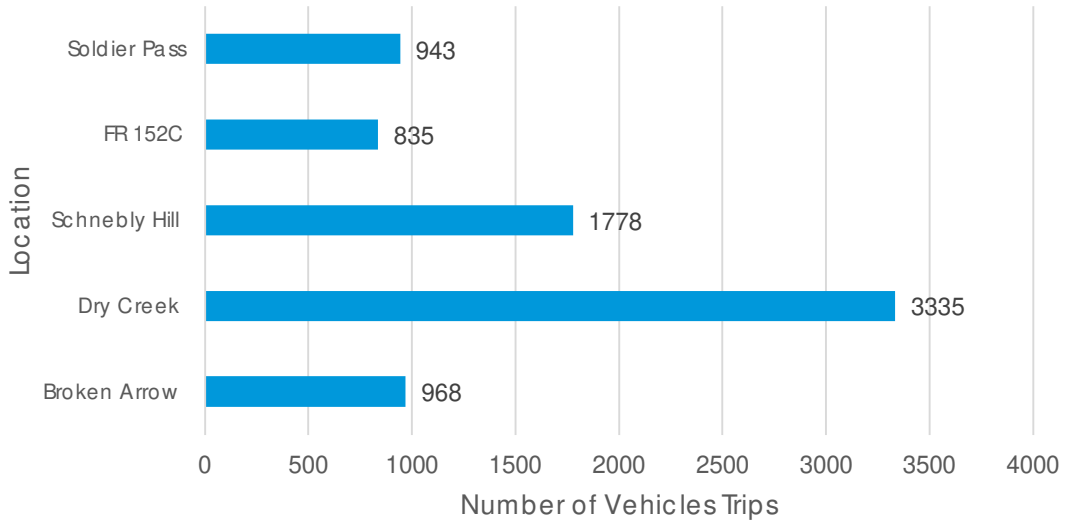
2.a. Quantity and Type of Off-Highway Vehicles

Video data was continuously collected from 10 a.m. on Friday, March 17, 2023, to approximately 12 p.m. on Sunday, March 19, 2023 at the five locations. Cameras were stationed at each of the locations to properly capture OHV entering off-road trails and/or trailhead parking lots. The traffic count data was processed to determine the total number of vehicles entering and exiting the locations, which include vehicles parking in the designated lot, entering the OHV trails, or circulating the site.

Total Vehicle Trips

Figure 2 provides the total number of vehicles trips at each location for the data collection period.

FIGURE 2. TOTAL NUMBER OF VEHICLE TRIPS



The number of visitors at each location vary depending on popularity of the trail, proximity to the City, parking, and accessibility. On the weekend of data collection, the most visited trail was Dry Creek Road/ Trailhead with approximately 3,335 vehicle trips entering the designated parking lot and off-road access to the trail. The second most visited trail was Schnebly Hill with approximately 1,778 vehicle trips entering the designated trailhead area. Parking at the two most visited trailheads is limited, therefore parking demand exceed the existing parking available, and vehicles are observed to circulate through the parking area and/or park along undesignated areas along both sides of the roadways near the trailhead vicinity.

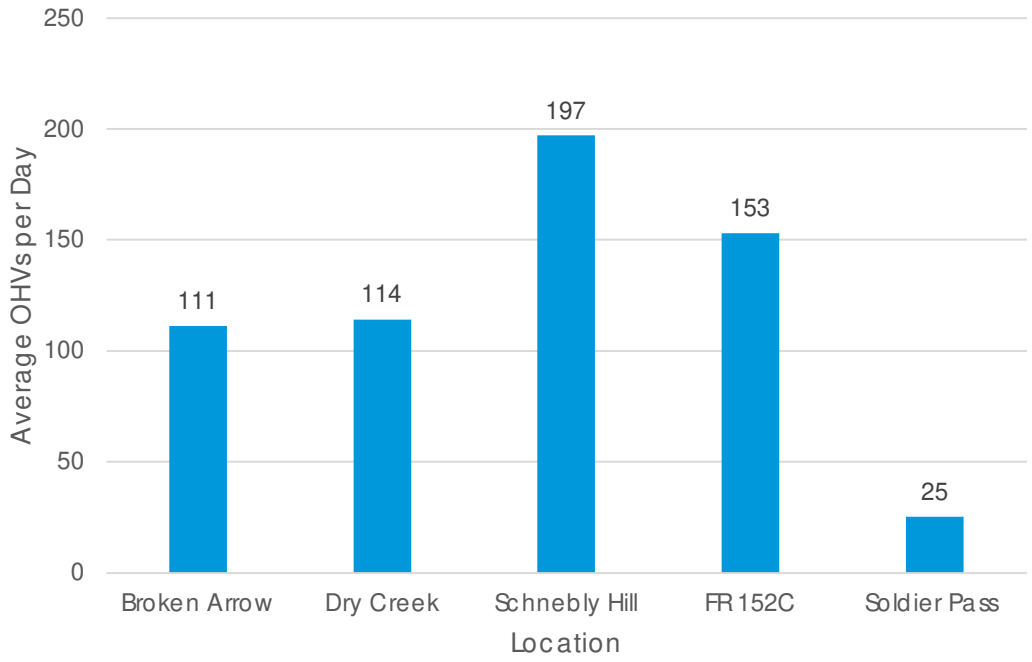
Additionally, although Soldier Pass Trailhead parking is restricted on Thursday-Sunday and OHV access is limited to 12 vehicles per day by permit, there were 943 vehicle trips counted on Canyon Shadows Drive which leads to this trailhead. During the data collection period, 525 vehicles were recorded as continuing eastbound. Canyon Shadows Drive provides access to SR-89A and dispersed caping areas.

Based on field observations and data collections, over 100 vehicles made an eastbound U-turn at the trail entrance over the entire data collection weekend. These were vehicles that drove to the site and turned around after realizing the trailhead was gated off. Video data and observations also highlighted many vehicles making drop-offs and pick-ups for passengers at the trail entrance.

Off-Highway Vehicle Quantities

The daily weighted averages of OHV vehicles entering and exiting the location on the weekend were calculated using the 3-day data. Figure 3 provides the average number of OHVs at each location.

FIGURE 3. AVERAGE NUMBER OF OFF-HIGHWAY VEHICLE PER DAY



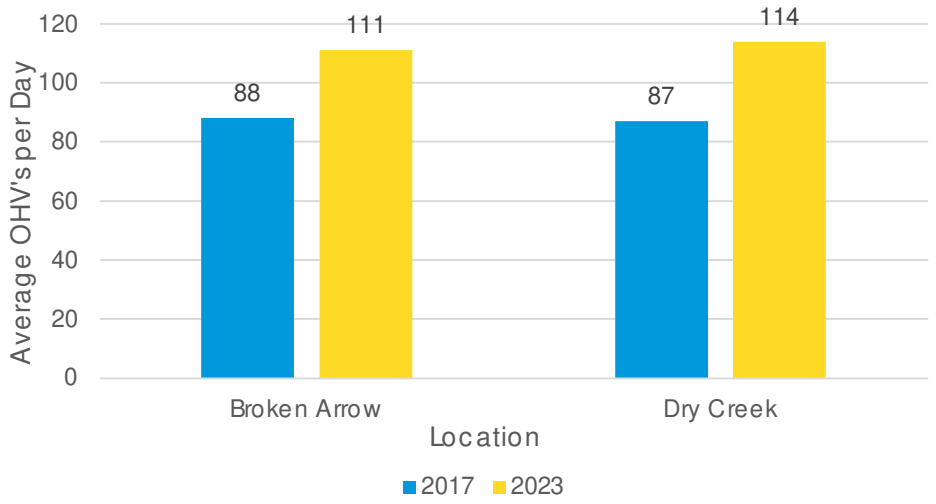
According to data collected during this 3-day period, Schnebly Hill is the most used trailhead by OHVs. FR 152C is the second most used, though it is important to note that this is a service road the provides access to SR-89A and dispersed camping areas.

The average number of OHVs using Soldier Pass Trail is small compared to the other trails due to limited public access. Soldier Pass Trail has restricted access where OHVs may only access the trail if they have a permit from the Forest Service. According to the Forest Service, only 12 permits are issued per day, with one vehicle per permit. Video data collection for Saturday, March 18 was manually reviewed and determined that 19 OHV vehicles (which includes 5 tours) entered the gated trail. From video observations, it seemed that in 3 instances of OHVs accessing the gated entrance, a vehicle closely followed behind. In these instances, it can be presumed that the vehicle was using one permit for a pair of cars.

The data collected for this study was compared to data collected in the City of Sedona's 2019 Off-Highway Vehicle Report to determine any trends in trail and OHV use. The 2019 report only collected data at Broken Arrow and Dry Creek Road/Trail location. Data in the study was also collected over 4 months. Figure 4 provides the comparison of OHV trail users in 2017 and 2023 at these two locations. Recognizing that the data collected for this study was over a busy March

weekend when compared to a four-month average from the 2019 study, it can neither be confirmed or denied that there has been an increase in OHVs at the trailheads. It can be stated that the data is equitable and there has not been a decrease since 2017.

FIGURE 4. COMPARISON OF OFF-HIGHWAY VEHICLES AT LOCATIONS



Off-Highway Vehicle Types

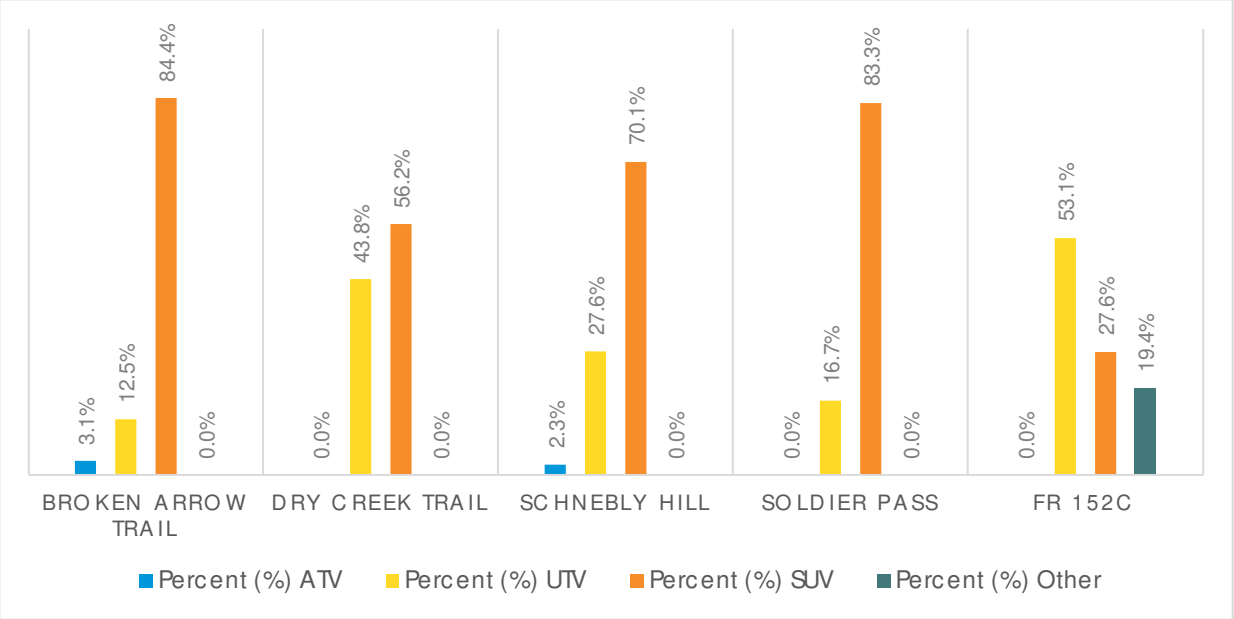
To supplement the video data, vehicle type data was manually collected at each location except for Forest Road (FR 152C) for one-hour periods twice a day at each location on Friday and Saturday. Manual data recorded included documenting the following types of vehicles entering and exiting trailheads:

- ATV (All-Terrain Vehicle) – A vehicle that travels on low-pressure tires, has a seat that is straddled by the operator and has handlebars.
- UTVs (Utility Terrain Vehicles) – A vehicle that operates by foot controls and a steering wheel with a minimum of two seats positioned side-by-side and enclosed within a roll cage structure.
- SUVs (Sports Utility Vehicles) – A roadway passenger vehicle with off-roading capabilities, such as a Jeep or 4X4 truck.

Although manual data was not collected for FR 152C, video data was manually reviewed post data collection to determine the peak period over the weekend at this location.

Figure 5 provides the percentage of vehicle types at each location based on the sample size of the manual data collected.

FIGURE 5. OFF-HIGHWAY VEHICLE TYPES AT EACH LOCATION



Based on data collected, SUVs were the most used vehicles at these locations. It's important to note that there was a negligent number of ATVs observed at all the locations. Based on further online research of various local ATV rental company websites, most companies do not currently offer ATV rentals and instead only offer UTV rentals which are "buggy style" vehicles. The number of ATVs on trails has drastically decreased compared to data collected in the 2019 report; ATVs accounted for nearly half of OHVs in the 2019 data collection period.

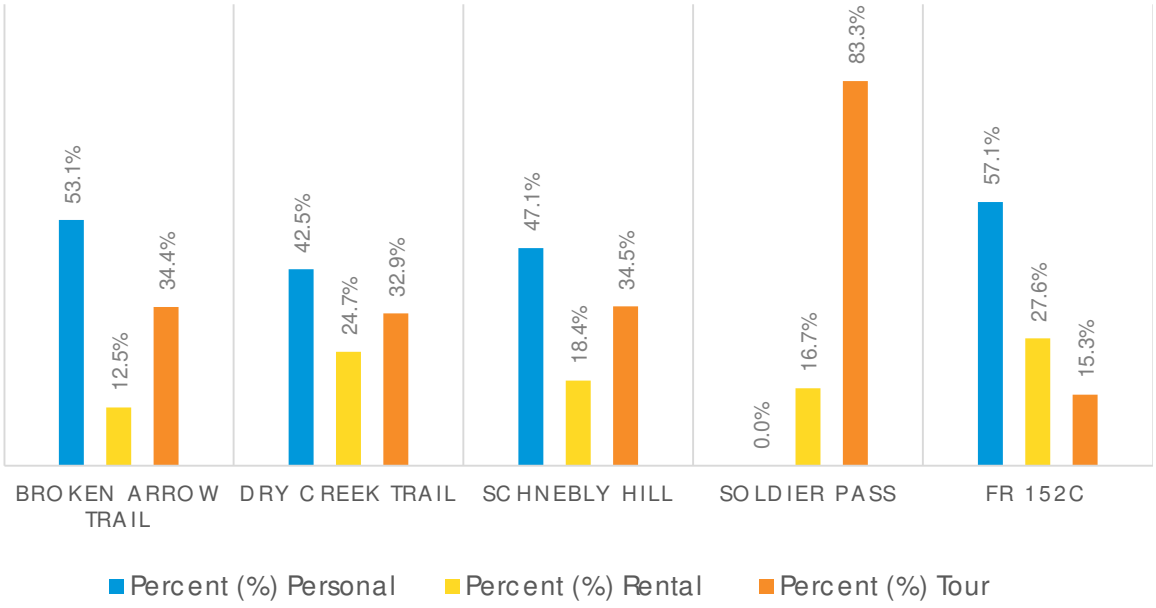
OHV Users

The manual data collected also recorded the user groups of OHV vehicles using the trails divided into the following categories:

- Personal – vehicles privately owned
- Rental – vehicles lent to users by companies for day use
- Tour – vehicles that provide guided tours (e.g., Pink Jeep Tours)

Personal OHVs made up most vehicles using Broken Arrow Trail, Dry Creek Road/Trailhead, and Schnebly Hill Trail. Figure 6 provides the percentage of vehicle user groups at each location based on the sample size of the manual data collected.

FIGURE 6. OFF-HIGHWAY VEHICLE USER GROUPS AT EACH LOCATION



2.b. Noise Level

The decibel system of measuring sound gives a rough connection between the physical intensity of sound and its perceived loudness to the human ear. Human perception of noise occurs in two separate ways. The steady state noise level is perceived by a person as the ambient continuous noise over a certain time period (measured as L_{eq}). The second perception of noise is the maximum sound pressure value with no time constant applied (measured as L_{peak}). This unit of noise exposure is perceived by a person as the highest instantaneous impulse level generated by a noise source.

Ambient noise includes all sounds present in an environment. The ambient noise level may be measured at any moment, but it will vary widely with time, e.g., with the coming and going of trucks and aircraft. Ambient sounds generally range from 30 dBA (very quiet) to 100 dBA (very loud). Unlike linear units such as inches or pounds, decibels are measured on a logarithmic scale, representing points on a sharply rising curve. On a logarithmic scale, an increase of 10 dBA is 10 times more intense than 1 dBA, while 20 dBA is 100 times more intense, and 30 dBA is 1,000 times more intense. A sound as soft as human breathing is about 10 times greater than 0 dBA. If the L_{eq} (or ambient) value is greater than 85 dBA, the noise would have the potential to cause a human health impact.

Sound monitoring equipment was established near the roadways at each of the five trailheads. Data was collected from approximately 10 a.m. on Friday, March 17, 2023, to approximately 12 p.m. on Sunday, March 19, 2023. The measured ambient noise levels were low, in the range of 30

to 40 decibels A-weighted (dBA).[1] This ambient noise level range is similar to the noise level in a quiet library. The highest ambient noise level observed was 62.8 dBA L_{eq}[2] collected at the Schnebly Hill Trailhead while the lowest ambient noise level observed was 48.6 dBA L_{eq} collected at the Soldier Pass Trailhead. These measurements support the perception that entrances of the trailheads are generally quiet, except for the passing of motorized vehicles onto the trails.

Physical damage to human hearing begins at prolonged exposure to noise levels higher than 85 dBA. Exposure to high noise levels affects our entire system, with prolonged noise exposure over 75 dBA increasing body tensions, thereby affecting blood pressure, functions of the heart and nervous system. In comparison, extended periods of noise exposure above 90 dBA could result in permanent hearing damage. When the noise level reaches 120 dBA, a tickling sensation occurs in the human ear even with short-term exposure. This level of noise is called the threshold of feeling. As the sound reaches 140 dBA, the tickling sensation is replaced by the feeling of pain in the ear. The perception of pain is different dependent on the type of noise generated (ambient or impulse). If the L_{peak} (impulse) value is greater than 120 dBA, the noise impulse noise would have the potential to cause a human health impact. The Department of Arizona State Parks & Trails limits the production of high levels of noise with the requirement that OHVs must include a noise dissipative device.

Impulse noise was collected at each location to determine potential human health effects. The recorded L_{peak} noise levels could be attributed to various vehicle types, pedestrian walk-bys, and vehicle idling since the traffic camera and the noise meter were placed adjacent to the trailhead. The Broken Arrow Trailhead produced the highest quality impulse data due to various sources' vehicle use.

Based on in-person observations and the collected data, the UTVs generated the loudest impulse noise levels of any vehicle type that frequented the trail. This elevated noise level was generated from the vehicle's engine noise, exhaust/muffler noise, and/or amplified voice or music through the vehicle's speakers. See Table 2-1 for noise levels observed.

TABLE 2-1. HIGHEST OFF-HIGHWAY VEHICLE NOISE LEVEL

Vehicle Type	Range of Noise Generated (L_{peak})	Highest Short-Term Noise (L_{peak}, dBA)	Average L_{eq} over vehicle activity time (dBA)
UTV/ATV	72.9 dBA to 98.7 dBA over 28 seconds	98.7 dBA	87.0 dBA
Multiple UTVs/ATVs	79.1 dBA to 96.3 dBA over 32 seconds	96.3 dBA	87.1 dBA

Individual UTVs were observed generating an average impulse noise level ranging between 75 dBA L_{peak} and 90 dBA L_{peak} which would be perceived by the ear as volumes between a loud conversation to a kitchen blender. Typically, this level of noise was generated by UTVs that accelerated to drive over the boulders at the entrances of the trailheads. In some cases,

[1] The A-weighted measure corrects for the relative frequency response of the human ear, whereby it de-emphasizes low and very high frequencies of sound

[2] L_{eq} is a convenient way to express the energy level of a varying noise source

impulse noise levels produced was above 96 dBA L_{peak} when the vehicles traveled in groups or when passengers of the UTVs would play loud music through speakers. The highest noise level observed by a multiple UTV pass-by was 98.7 dBA L_{peak} which would be similar to standing next to a gas-powered lawnmower. Noise generate by the UTVs is approximately 20 to 40 decibels higher than average L_{peak} value at the trailhead which is between 100 and 10,000 times louder.

2.c. Air Quality

Kimley-Horn was tasked with recording observations with respect to OHV generation of particulate matter (PM) and its contribution to potentially elevated levels of PM. Vehicle activity on unpaved roads contributes to PM through various mechanisms. When vehicles traverse these roads, the mechanical disturbance caused by tires and vehicle movement dislodges and fragments surface materials, generating airborne PM. Additionally, the friction between tires and the road surface leads to abrasion, releasing fine particles into the air. Vehicle emissions, especially from diesel-powered vehicles, like OHVs, also contribute to PM through combustion byproducts that can adhere to the road surface and be resuspended by subsequent vehicle activity.

Human Health Effects of Particulate Matter

For air quality regulatory purposes, particle matter is defined by its size, namely the diameter. Respirable particles, or particulate matter 10 (PM10) are inhalable into the lungs and can induce adverse health effects and refers to tiny particles or droplets in the air that are ten microns (µm) or less in width. The term fine particles, or particulate matter 2.5 (PM2.5), refers to tiny particles or droplets in the air that are two- and one-half microns (µm) or less in width. Like inches, meters and miles, a micron is a unit of measurement for distance. There are about 25,000 microns in an inch. The widths of the larger particles in the PM2.5 size range would be about thirty times smaller than that of a human hair. Fine particulate matter is defined as particles that are 2.5 microns or less in diameter (PM2.5); thus, PM2.5 comprises a portion of PM10.

Respirable PM may lead to a variety of health effects. Long-term exposures, such as those experienced by people living for many years in areas with high PM levels, have been associated with problems such as reduced lung function and the development of chronic bronchitis—and even premature death. Short-term exposures to particles (hours or days) can aggravate lung disease, causing asthma attacks and acute bronchitis, and may also increase susceptibility to respiratory infections. In people with heart disease, short-term exposures have been linked to heart attacks and arrhythmias.

The source and amount of particulate matter varies depending on the setting. Concentrations of larger sized particulate matter tend to be higher in urban areas and tend to be generated more frequently by various urban sources including vehicles, industrial facilities, and construction activities. This constant urban particulate matter is the type of particulate matter the National Ambient Air Quality Standards (NAAQS) was derived from. Rural particulate matter tends to be smaller and not generated consistently like urban areas. Therefore, when rural particulate matter is averaged over a 24-hour period, concentrations tend to be significantly lower than urban environments.

Dust emissions generated on roads depend on the presence of "silt loading" which refers to the silt-size material (less than 75 micrometers in diameter) per unit area of travel surface. This factor and the weight of the vehicles traveling on the road determines the PM emissions from a road surface. Silt loading can vary depending on the weather/climate of the region. Heavy silt loading tends to deposit onto roadways during winter and early spring. This heavy silt loading dries up in

the summer months and is released in greater quantities. The road type also influences the silt loading with poorly paved and unpaved roads having higher silt loading than newly paved roads. Therefore, dust dispersal and PM emissions tend to be highest on unpaved surfaces in the summer months.

The NAAQS for particulate matter are measured and enforced across a 24-hour average concentration level. PM10 has a threshold of 150 micrograms per meter cubed (µg /m^3) and PM2.5 has a threshold of 35 µg /m^3.

Methodology and Human Health Effects of Particulate Matter

The peak PM levels at the five locations vary based on multiple factors. PM at each of the sites was mainly generated by mobile sources; however, wind and pedestrians were observed to contribute to visible dust generation and, presumably, to monitored levels as well. Mobile sources at the sites included the pass-bys of passenger vehicles and shuttle buses accessing parking lots, OHVs accessing the trails, and, in the case of the FR 152C, on-road vehicles accessing the adjacent unpaved roads. To determine a correlation between vehicle activity and PM ambient levels, minute air quality data was linked to video taken at each location.

The Broken Arrow Trailhead experiences substantial vehicle and pedestrian traffic at times, and meters were placed to allow for a comparison between upwind and downwind PM measurements. By taking measurements upwind (before the pollution source) and downwind (after the pollution source), it becomes possible to identify and characterize the source of pollution. Comparing PM concentrations between these two locations helps determine the contribution of a specific source to the overall PM levels.

Results

The results show a strong correlation between general vehicle activity at the locations and increases in PM levels. Periods of elevated PM levels, with peaks above 795 micrograms per cubic meter (µg/m3), were recorded contemporaneously with vehicle activity. However, health-based standards for PM exposure, such as the federal National Ambient Air Quality Standard (NAAQSs) standards, set average concentrations over longer time periods, such as 24-hours and annual. Table 2-2 summarizes the maximum PM levels time-averaged over each collection period at the five locations.

TABLE 2-2. MAXIMUM COLLECTION PERIOD FOR AVERAGE PARTICULATE MATTER LEVELS

Trail Location	Maximum Collection Period Average PM2.5 (µg /m3)	Maximum Collection Period Average PM10 (µg/m3)
FR 152C	30	66
Broken Arrow Trailhead – UW	11	21
Broken Arrow Trailhead – DW	11	41
Dry Creek Road/Trailhead	13	16
Schnebly Hill Trailhead	9	18
Soldier Pass Trailhead	13	21

Recent scientific literature finds exposure to PM levels above the federal guidelines, even for exposure periods of less than 24 hours, can trigger acute health conditions in highly sensitive individuals. One-hour rolling averages were found to exceed the federal NAAQS standards at two

locations, with the FR 152C experiencing elevated PM levels about NAAQs standards for multiple hours. Table 2-3 summarizes the maximum one-hour rolling average measured at each location.

TABLE 2-3. MAXIMUM ONE-HOUR AVERAGE PM LEVELS

Trail Location	Maximum 1-Hour Average PM2.5 (µg/m3)	Maximum 1-Hour Average PM10 (µg/m3)
FR 152C	75	178
Broken Arrow Trailhead – UW	31	72
Broken Arrow Trailhead – DW	40	154
Dry Creek Road/Trailhead	16	20
Schnebly Hill Trailhead	15	37
Soldier Pass Trailhead	15	37

Day-by-Day Comparison

The ground was well saturated from rain immediately prior to the data collection effort. However, with dry weather and vehicle use, the trails looked visibly drier each day throughout the weekend. By Saturday afternoon and Sunday, track out of soil onto paved surfaces was observed, including trailhead parking lots and public streets surrounding all locations except Soldier Pass (likely due to the controlled volume of vehicles accessing that trail).

Based on the discussion above, a comparison amongst the locations for each day highlights the various environmental factors that contribute to rural PM concentrations. Specifically, it is likely that the dampness of the unpaved roads and amount of paved road leading to each trailhead influenced how vehicle activity contributed to PM concentration trends. For the day-by-day comparison and analysis, only PM2.5 concentrations are used due to their established human health impacts at lower concentrations and because PM2.5 is a percentage of PM10.

Figure 7 and Figure 8 show the total concentration averages for PM 2.5 and total vehicle activity, respectively, over each testing day.

FIGURE 7. TOTAL AVERAGE PM2.5 CONCENTRATION

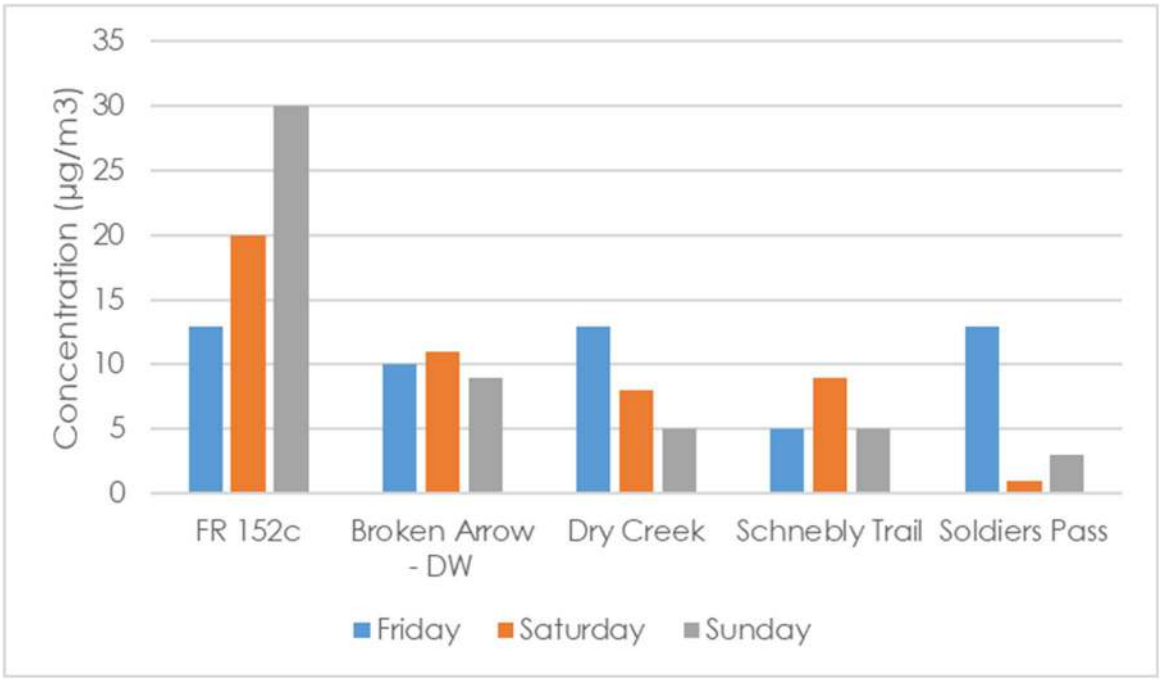


FIGURE 8. TOTAL VEHICLE ACTIVITY

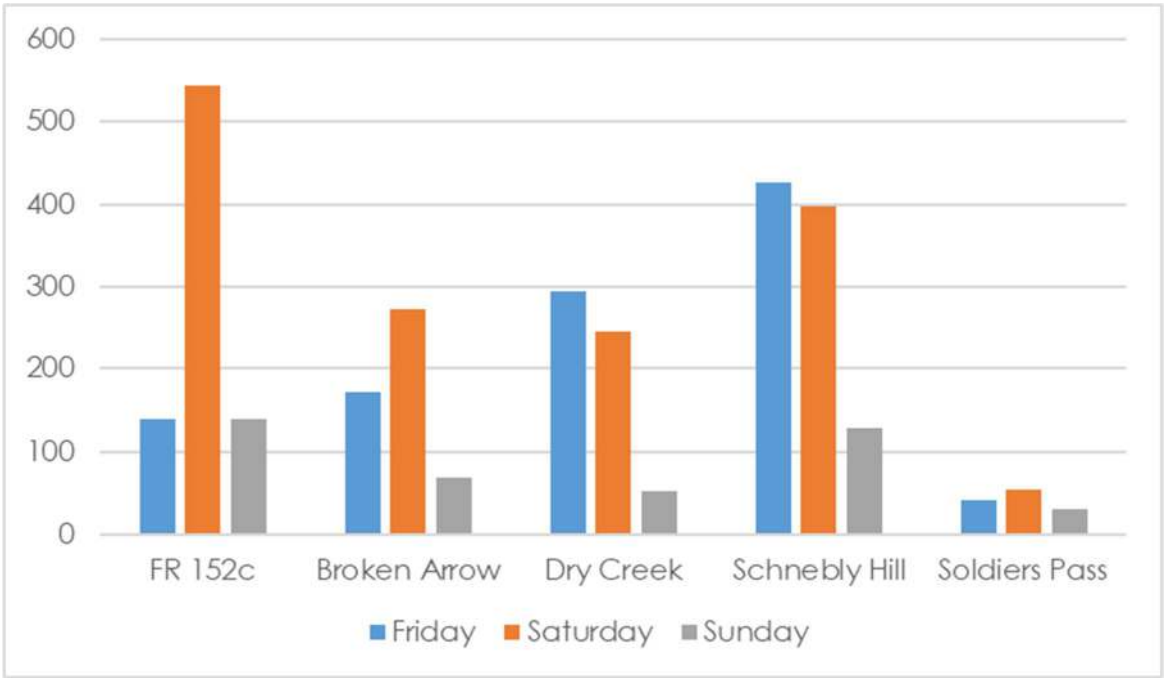


Figure 9 and Figure 10 show the maximum rolling one-hour averages for PM 2.5 average vehicle activity per hour, respectively, over each testing day.

FIGURE 9. MAXIMUM ROLLING 1-HOUR AVERAGE PM2.5 CONCENTRATION

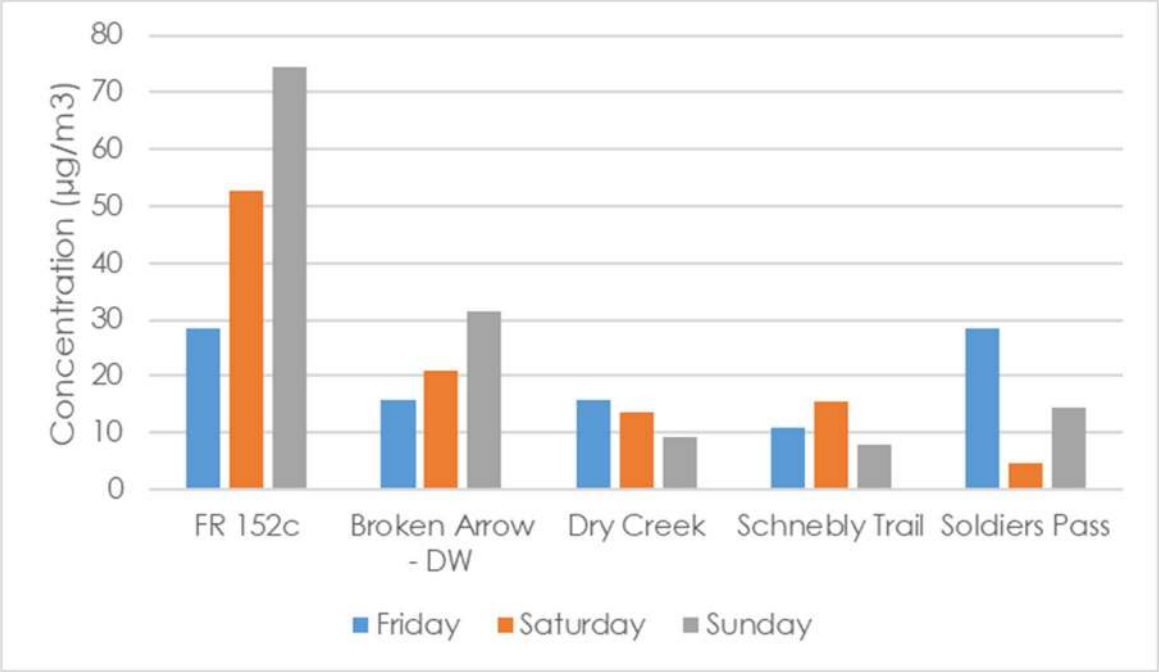
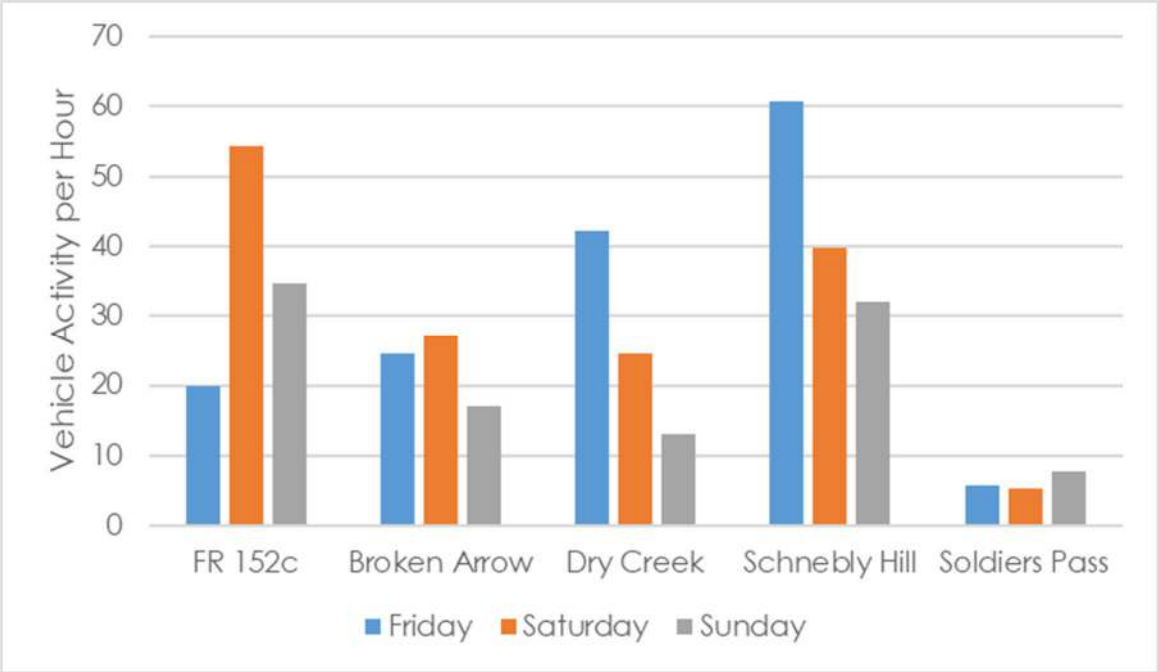


FIGURE 10. AVERAGE VEHICLE ACTIVITY PER HOUR



Comparing the data side-by-side creates two distinct conclusions based on two environmental factors:

- FR 152C and Broken Arrow Trailhead show a strong correlation between PM concentrations and the drying of the road dirt between Friday and Sunday.

- Dry Creek Road/Trailhead and Schnebly Hill Trailhead show a stronger correlation between vehicle activity and PM concentrations when compared to the other locations. This is likely due to the amount of paved road leading up to each trailhead. FR 152C and Broken Arrow have at least 200 feet of unpaved road leading up to the trailhead, whereas Dry Creek and Schnebly Hill have paved roads leading up to the trailheads. This may allude that the reduced amount of unpaved road at the trailheads influences whether the silt loading or vehicle activity dominates the PM concentrations.

From an air quality perspective, this data establishes that vehicle activity is correlated to increased PM levels. However, external environmental factors play a role in PM concentrations and these concentrations exceeding levels known to negatively affect human health is inconclusive.

3. Conclusion

The findings of this study support the previously documented concerns at the five locations related to traffic, noise, and air quality. However, although the findings indicated that OHVs could be considered a nuisance, none of the measurements during the 3-day data collection period exceed allowable state or federal thresholds for a human health impact. The noise and air quality data were only evaluated at the trailheads and did not measure conditions at nearby residential areas. The data is summarized below and detailed in the appendices.

3.a. Findings of the Study

3.A.1. QUANTITY & TYPE OF OHV VEHICLES

An average of 1,500 vehicle trips were observed at the five locations included in this study. Dry Creek Road/Trailhead was the most visited location with approximately 3,335 vehicle trips entering and existing the designated trailhead to access parking and the off-road trail. The second most visited trail is Schnebly Hill with approximately 1,778 vehicle trips entering the designated trailhead area. Parking demand exceeds the existing parking capacity at these trails causing continuous circulation of vehicles at trailhead entrances throughout the day. Vehicles that were unsuccessful in finding parking in the designated lots often choose to park in undesignated areas along Boynton Pass Road (for Dry Creek) and along Schnebly Road (for Schnebly Hill). It is recommended to consider installing "No Parking" signs or boulders along both sides of the roadway and to enforce unlawful parking (similar to Dry Creek Road and Boynton Pass Road).

The average number of OHVs at the five locations ranges from 25 to 197 vehicles per day. Based on 2017 data from the City of Sedona's 2019 Off-Highway Vehicle Report. Due to the small sample size it can only be assumed the OHV traffic has not decreased since 2017. Additional data collection is needed to confirm a true increase in traffic. This comparison provides a general assumption that OHV activity has not decreased at the studied trails.

OHVs at Soldier pass averages at 25 vehicles per day; this is a restricted access trail where the Forest Service only issues 12 permits per day.

The most common types of OHV vehicles at the five locations are SUVs. A very minimal number of ATVs were observed at the trailheads. The number of ATVs on trails has drastically changed compared to data collected in the 2019 report. ATVs accounted for nearly half of OHV in the 2019 data collection period.

Although there are various rental companies and tour companies in the City of Sedona that offer day use or excursions to off-road trails, data observed determined that most OHVs using the trails are personal, private owned vehicles. All trails, except for Soldier Pass, are open to the public and free of charge. Therefore, it can be assumed that a large portion of visitors travel to Sedona for recreational use of off-road trails in their personal vehicles. It is recommended to consider restricting access to trailheads by issuing a limited number of permits or construct booths at trail entrances to control access onto trails. This will ultimately be dependent on the Sedona Shuttle system increasing routes throughout the city.

3.A.2. NOISE FINDINGS

Based on in-person observations, ambient noise levels at each of the trailheads are generally quiet. The primary cause of noise is vehicle traffic arriving and departing from the trails. In particular, noise generated by the OHVs was substantially louder than that generated by other types of vehicles. The loudest noises generated by all vehicles typically occurred during vehicle accelerations at the entrances of each trailhead. On occasion, OHVs would produce loud noise through speakers and music. In general, these loud noise events would only last a few seconds.

Ambient noise at all five of the trails is below the recognized human health impact threshold of 85 dBA L_{eq}. However, UTVs produced instantaneous noise levels above 96 dBA (the Arizona State Parks Threshold for OHV noise) up to a maximum of 98.7 dBA. This noise level is significantly louder than the average L_{peak} noise levels at the trail, and the presence of the UTVs causes an environmental disturbance that could affect people using the trail. The highest noise level produced by the UTVs is still below the human health impact threshold for impulse noise of 120 dBA. The noise produced by all vehicles could be considered a nuisance to trail users, considering the surrounding area is a natural space that typically experiences low ambient noise levels. It is recommended to consider studying noise impacts directly at sensitive receptors as OHVs drive between neighborhoods to the trailheads.

3.A.3. AIR QUALITY FINDINGS

Based on in-person observations and recorded data, vehicles traveling at the trailheads entrances can substantially elevate dust and disperse it to surrounding areas like parking lots, paved roadways, and nearby hiking trails. On multiple occasions, it was observed that vehicles exiting unpaved surface trails would carry dust onto the paved roadway surfaces. This led to a buildup of dust at the paved entrances of the trailheads and the generation of re-entrained PM at locations such as public roads. The rain event which occurred prior to the study is suspected to have greatly suppressed the generation of PM. As the unpaved trail surface began to lose moisture over the weekend, the dust generated by vehicles increased.

Recorded PM10 levels show maximum 1-hour concentrations of greater than 178 µg/m^3 and greater than 75 µg/m^3 PM2.5. While 24-hour averages for both PM10 and PM2.5 were below the federal guidelines for human health impacts, exposure to elevated PM levels has the potential to trigger acute health conditions in highly sensitive and sensitive individuals, even over exposure periods of less than 24 hours. Elevated levels of PM above the federal guidelines were measured at the FR152C and Broken Arrow trails. However, only the FR152C Trail, on Sunday, had PM10 and PM2.5 exposure above the federal guidelines for more than one single hour. All other trailheads only exceeded federal guidelines for PM10 and PM2.5 human health impacts for less than the established 24-hour averaging period.

3.b. Data Resources

In addition to collecting data in the field, data was also gathered from the following sources:

- Health and Environmental Effects of Particle Pollution (Health and Environmental Effects of Particulate Matter (PM) | US EPA)
- Federal Interagency Committee on Noise, Federal Agency Review of Selected Airport Noise Analysis Issues, August 1992.
- Coconino National Forest Recreation (https://www.recreation.gov/permits/4251901)

- OHV Rental Websites
    - Sedona ATV (https://www.atvsedona.com/)
    - Red Rock Rentals (https://atvrentalssedona.com/)
    - Vortex ATV Rental (https://www.vortexatvrental.com/)

Appendix A. Methodology and Detailed Data – Quantity and Type of Off-Highway Vehicles

1 Methodology

The following section summarizes the data collected at the five locations. Video data was continuously collected from approximately 10 a.m. on Friday, March 17, 2023 to approximately 12 p.m. on Sunday, March 19, 2023. Miovision cameras were stationed at each of the locations to capture OHV entering, paved roads, off-road trails and/or trailhed parking lots. See Figures A-1 through A-5 for the locations of the traffic cameras used for data collection at each of the sites.

FIGURE A-1. TRAFFIC CAMERA LOCATION – FR 152C

FIGURE A-2. TRAFFIC CAMERA LOCATIONS – DRY CREEK ROAD/TRAILHEAD

FIGURE A-3. TRAFFIC CAMERA LOCATION – SOLDIER PASS TRAILHEAD

FIGURE A-4. TRAFFIC CAMERA LOCTION – SCHNEBLY HILL TRAILHEAD

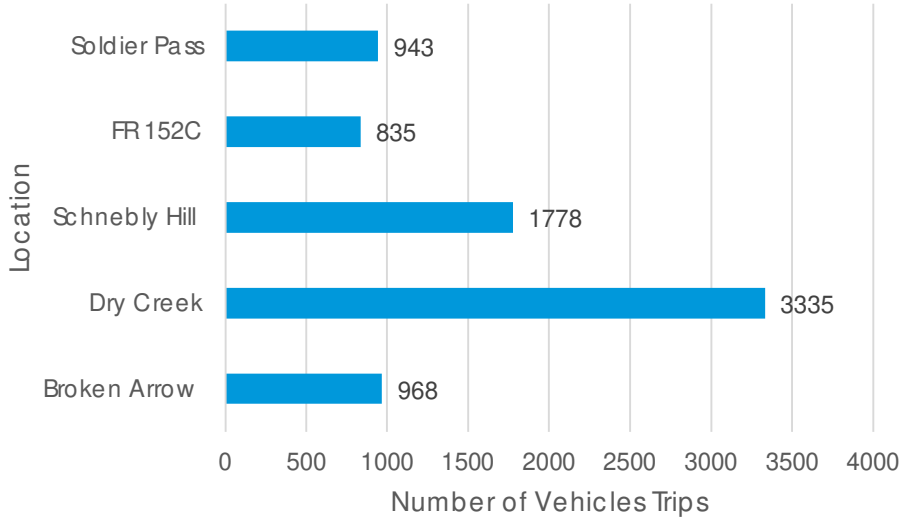
FIGURE A-5. TRAFFIC CAMERA LOCATION – BROKEN ARROW TRAILHEAD

Video data was processed through Miovision's software and provided to Kimley-Horn in table format in 15-minute bin intervals.

1 Total Number of Vehicles at Trails

The traffic count data was processed to determine the total number of vehicle trips entering and exiting the locations, which include vehicles parking in the designated lot, entering the OHV trails, or circulating the site. Figure A-6 provides the total number of vehicle trips at each location for the data collection period. It should be noted, one vehicle entering and exiting the location would be considered two vehicle trips.

FIGURE A-6. TOTAL NUMBER OF VEHICLE TRIPS



The number of visitors at each location varies depending on popularity of the trail, proximity to the City, parking, and accessibility. On the weekend of data collection, the most visited location was Dry Creek Road/Trailhead with approximately 3,335 vehicle trips accessing the designated parking lot and off-road access. Parking at the trailhead is limited, with 37 marked spaces available. Therefore, a significant number of the vehicles entering the trailhead area were vehicles circulating to find parking and exiting when unsuccessful. The vehicles that do not find parking often exit Dry Creek Road and park along Boynton Pass Road. Vehicles park along both sides of Boynton Road north of Dry Creek Doad, starting approximately ½ mile north of the intersection.

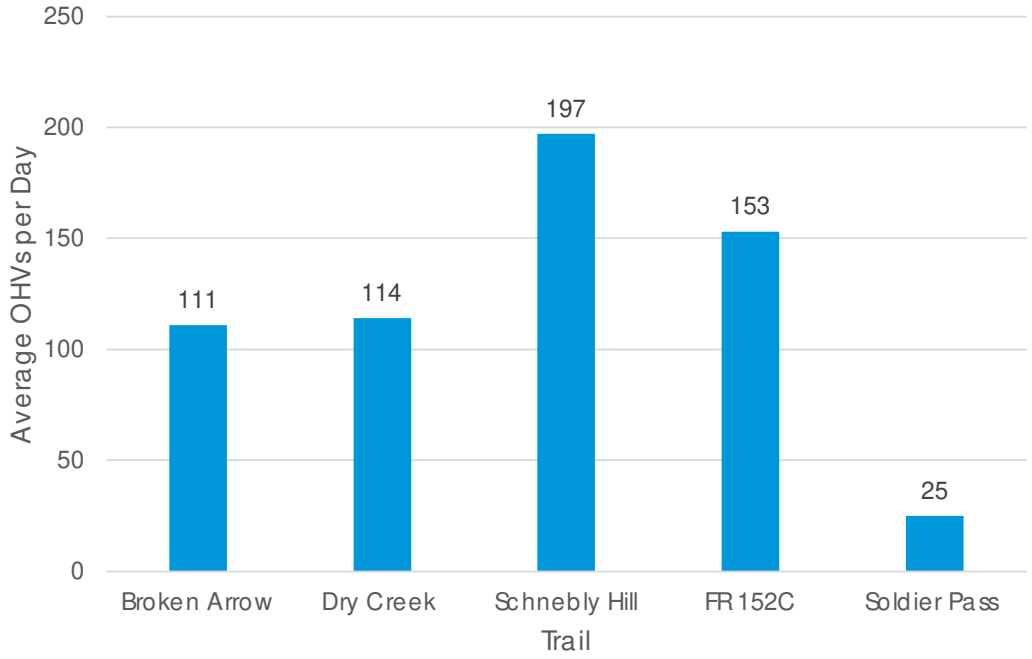
The second most visited location was Schnebly Hill Trailhead with approximately 1,778 vehicle trips entering the designated trailhead area. Similar to Dry Creek, demand for parking exceeds the existing parking availability and vehicles were observed to be parking along both sides of Schnebly Hill Road.

Although Soldier Pass Trailhead parking is restricted on Thursday-Sunday and OHV access is limited to 12 vehicles per day by permit, there were 943 vehicle trips along Canyon Shadows Drive. Based on field observations and data collections, there 103 vehicles made an eastbound U-turn at the trail entrance. These were vehicles that drove to the site and turned around after realizing the trailhead was gated off. Additionally, there were a high number of vehicles making drop-offs and pick-ups for passengers at the trail entrance.

2 Quantity of Off-Highway Vehicles

The data was processed by Kimley-Horn to calculate daily averages of OHV vehicles entering and exiting the locations on a busy weekend. Figure A-7 provides the average number of OHVs at each location.

FIGURE A-7. AVERAGE OFF-HIGHWAY VEHICLES PER DAY



Schnebly Hill was the most used trailhead amongst OHV users during the 3-day counts. FR 152C was the second most used, though it is important to note that this is a service road that also provides access to SR-89A. During field observations, many non-off-road vehicles (such as sedans) were observed using this road. Navigation apps such as Google Maps or Apple Maps direct users to use FR 152C to access SR 189A when in the vicinity of that area. Forest Service rangers also commented that FR 152C is frequently used to access dispersed camping areas along FR 9559 (Coconino National Forest Dispersed Camping Area at FR 9559).

The average number of OHVs using Soldier Pass Trail was small compared to the other trails due to limited public access. Soldier Pass Trail has restricted access where OHVs may only access the trail if they have a permit from the Forest Service. According to the Forest Service, only 12 permits are issued per day, with one vehicle per permit, in addition to approved tours. Video data collection for Saturday, March 18 was manually reviewed and 19 OHV vehicles (which includes 5 tours) entered the gated trail. From video observations, in three instances of OHVs accessing the gated entrance, a vehicle closely followed behind. In these instances, it can be presumed that the vehicle was using one permit for a pair of cars.

The data collected for this study was compared to data collected in the City of Sedona's 2019 Off-Highway Vehicle Report to determine any trends in trail and OHV use. The 2019 report only collected data at Broken Arrow Trailhead and Dry Creek Road/Trailhead) and was collected over a 4-month period. Figure A-8 provides the comparison of OHV trail users in 2017 and 2023.

FIGURE A-8. COMPARISON OF DATA

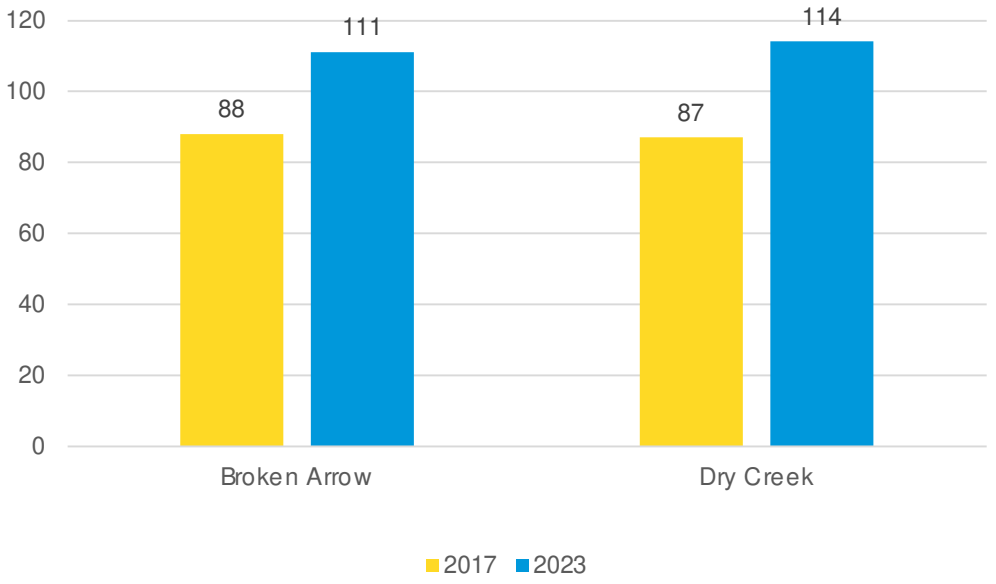
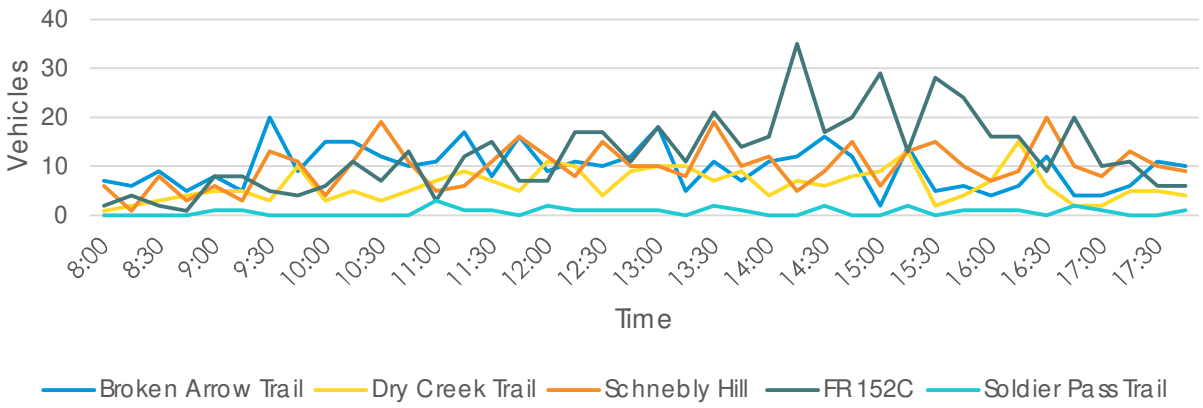


Figure A-9 shows the number of OHVs entering and exiting at each location throughout Saturday, March 18. Although traffic was fairly steady, there were ebbs and flows throughout the day. There is no real "peak" of trailhead access during this date except for FR 152C which experienced a peak at 2:15 p.m.

FIGURE A-9. OFF-HIGHWAY VEHICLES PER TIME INTERVAL – SATURDAY



3 OHV Types

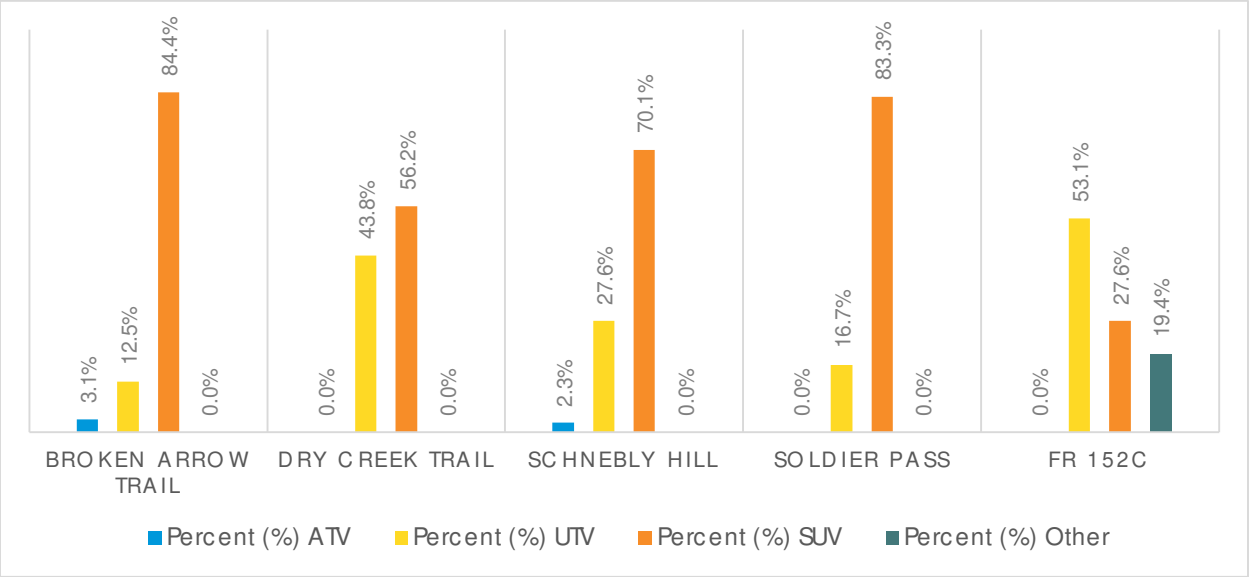
Manual data collection was obtained at all trailheads except for FR 152C, for one-hour periods twice a day on Friday and Saturday. Manual data recorded included documenting the following types of vehicles entering and exiting trailheads:

- ATV (All-Terrain Vehicle) – A vehicle that travels on low-pressure tires, has a seat that is straddled by the operator and has handlebars.

- UTVs (Utility Terrain Vehicles) – A vehicle that operates by foot controls and a steering wheel with a minimum of two seats positioned side-by-side and enclosed within a roll cage structure.
- SUVs (Sports Utility Vehicles) – A roadway passenger vehicle with off-roading capabilities, such as a Jeep or 4X4 truck.

Figure A-10 provides the percentage of vehicle types at each location based on the sample size of the manual data collected.

FIGURE A-10. OFF-HIGHWAY VEHICLE TYPES



Based on data collected, SUVs were the most used vehicles at trailheads. It's important to note that there was a negligent number of ATVs observed at all the trails. Based on online research of various ATV rental company websites, most companies do not currently offer ATV rentals and instead only offer UTV rentals which are "buggy style" vehicles. The number of ATVs and UTVs using the trailheads has changed since the data collected for the 2019 Off-Highway Vehicle Report. Figure A-11 and A-12 provide a visual comparison of the percentage of vehicle types using Dry Creek Road/Trailhead and Broken Arrow Trailhead between 2017 and 2023. The number of UTVs at the Broken Arrow Trailhead and Dry Creek Road/Trailhead have nearly doubled, but ATVs have decreased dramatically.

FIGURE A-11. COMPARISON OF UTVS ON TRAILS

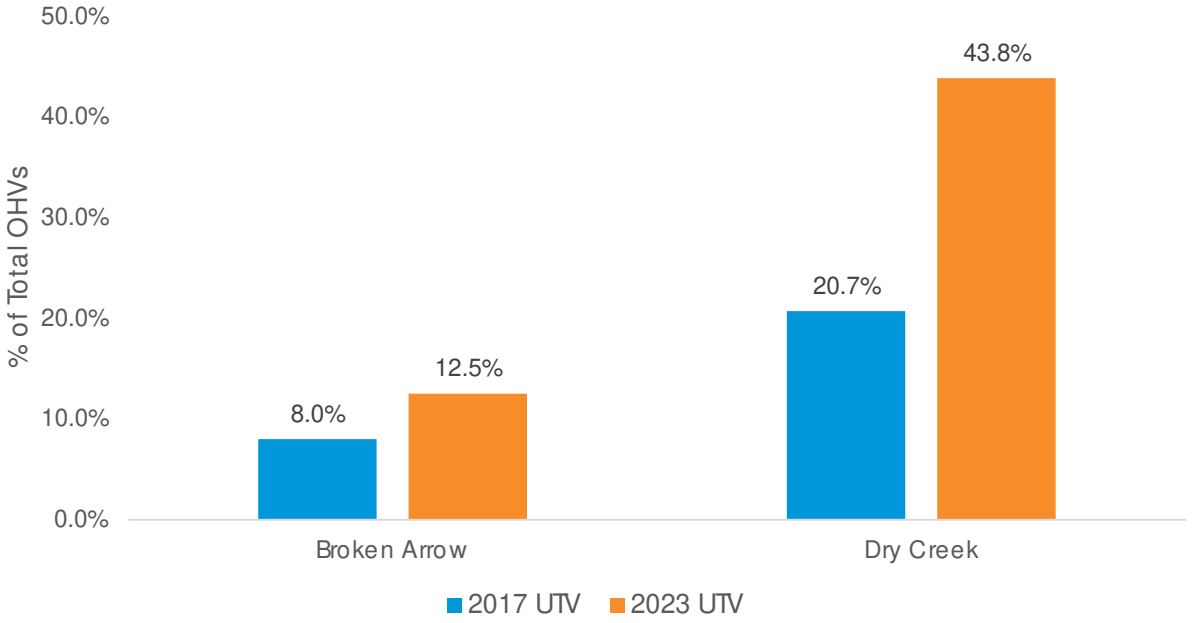
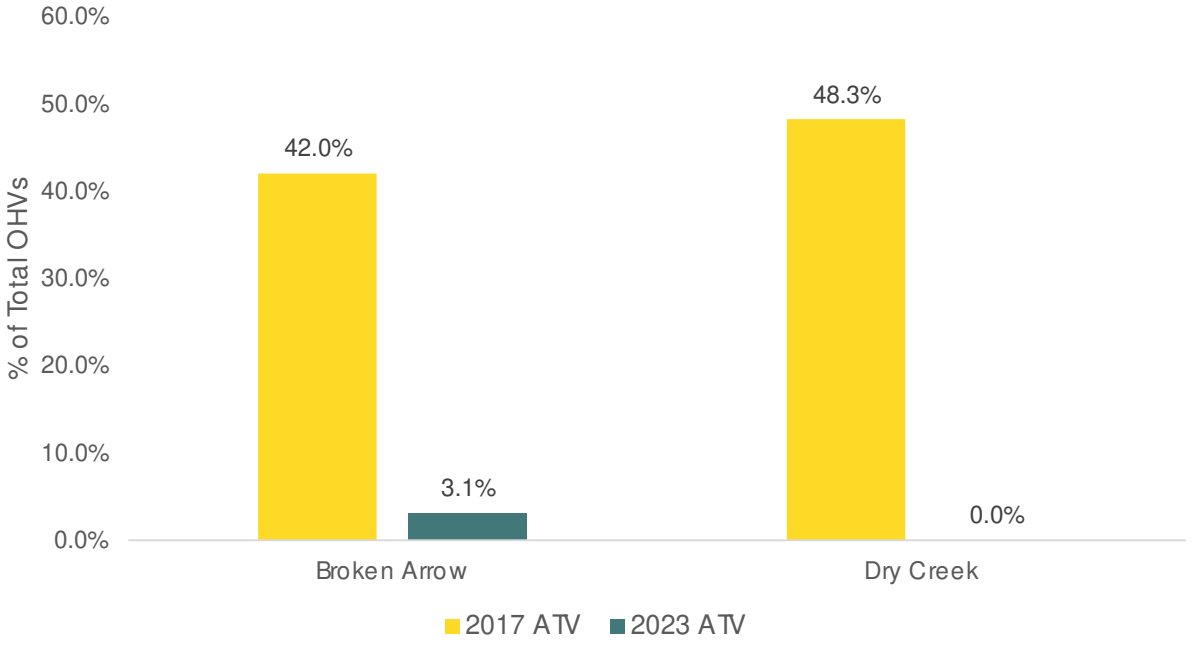


FIGURE A-12. COMPARISON OF ATVS ON TRAILS



4 OHV Users

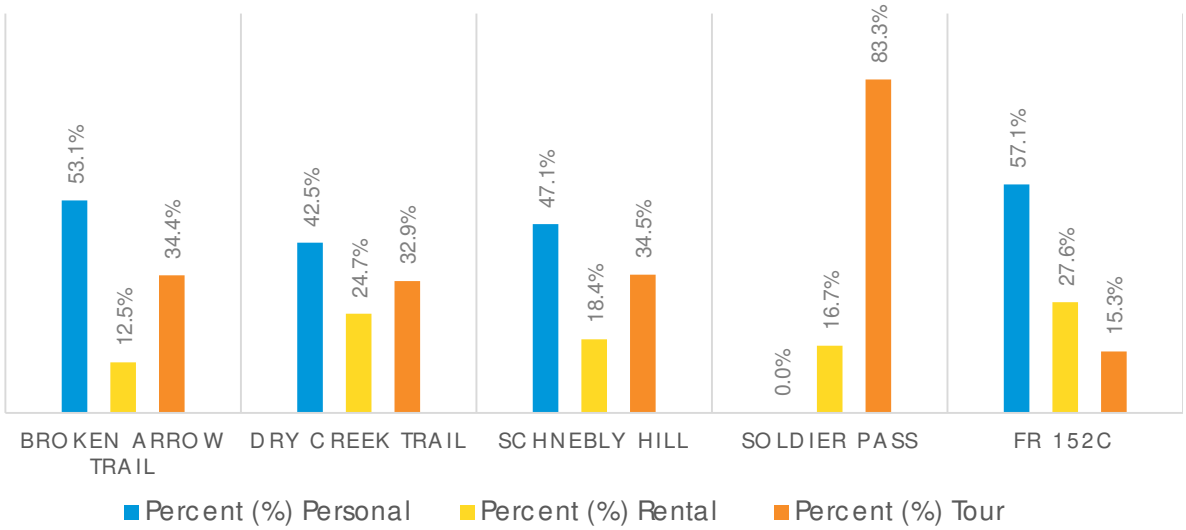
The manual data collected also recorded the user groups of OHV vehicles using the trails divided into the following categories:

- Personal – vehicles privately owned
- Rental – vehicles lent to users by companies for day use

- Tour – vehicles that provide guided tours (e.g., Pink Jeep Tours)

Figure A-13 provides the percentage of vehicle user groups at each location based on the sample size of the manual data collected.

FIGURE A-13. OFF-HIGHWAY VEHICLE USER GROUPS



Personal OHVs made up the majority of vehicles at the Broken Arrow Trailhead, Dry Creek Road/Trailhead, and Schnebly Hill Trailhead. Due to the public access restriction on weekends at Soldier Pass, tours account for a major portion of off-road use at this trail. All trails except for Soldier Pass are open to the public and free of charge.

5 Dry Creek Road & Boynton Pass Road Intersection

Turning movement counts using Miovision cameras were collected at the Dry Creek Road/Trailhead entrance on Boynton Pass Road and Dry Creek Road during the same time period OHV data was collected. Data was processed to identify the peak hour of the data collection and determine operations at the stop-controlled intersection.

Boynton Pass Road and Dry Creek Road is a T-intersection with stop control in the westbound approach and a marked crosswalk on the north leg. During the three-day collection period, the peak hour at the intersection was Friday, March 17th at 12:45 p.m. to 1:45 p.m. Figure A-14 provides the lane configurations and the peak hour volumes for the study Intersection

FIGURE A-14. DRY CREEK ROAD & BOYNTON PASS ROAD INTERSECTION VOLUMES

The intersection was analyzed using Highway Capacity Manual 6th Edition (HCM 6) methodology to determine the intersection level of service (LOS). According to the HMC 6th Edition results, the intersection movements operate at acceptable LOS B or better. The LOS results and average delay for each movement are provided in Table A-1.

TABLE A-1. BOYNTON ROAD & DRY CREEK ROAD INTERSECTION OPERATIONS

Movement	LOS	Delay (sec/veh)
Northbound Through	-	-
Northbound Right	-	-
Southbound Through	A	0.0
Southbound Left	A	8.0
Westbound Through/Right	B	13.5

2 Field Observations

1 General Field Conditions

The weekend of March 17, 2023 to March 19, 2023 was chosen because it coincides with local "spring break" sessions, a time of year when the City of Sedona historically sees a high number of visitors. That weekend, as anticipated, staff noticed a high number of visitors, especially during the mid-day hours (12 p.m. to 4 p.m.). As staff were traveling from site to site, they noted traffic that queued along SR 89A and SR 179 heading into Uptown Sedona, especially during the mid-day peak.

The weather was slightly colder than historic average temperatures. Sedona experienced substantial snowfall earlier in the month, and rainfall the two days immediately prior to the data collection visit, with scattered clouds generally present into the weekend. Table A-2 provides the weather conditions for the weekend of data collection based on historic data from KAZSEDON105 weather station.

TABLE A-2. WEATHER DATA

Date	Temperature Average (°F)	Temperature High (°F)	Temperature Low (°F)	Average Wind (mph)	Condition
3/17/2023	47.6	62.1	36.3	2.2	Cloudy
3/18/2023	49.1	61.3	38.5	2.9	Fair
3/19/2023	47.6	55.8	39.7	2.6	Fair

2 Quantity and Type of Off-Highway Vehicles

Staff visited the locations throughout the day to record manual OHV classification counts. Miovision cameras were set up at all five trailhead locations to collect count data. Continuous data was collected from approximately 10 a.m. on Friday, March 17 to approximately 12 p.m. on Sunday, March 19. The following observations were noted:

1 General

- More private OHVs were observed on the trailhead than tours or rental vehicles.
- Few to no ATVs were seen on the trails.
- Pink Jeep Tours were the most popular tour company vehicles seen on trail paths.
- Private SUVs (such as Jeeps) and 4x4 truck (such as Toyota Tacoma) were popular at all trailheads, but especially at Broken Arrow and Schnebly Hill.
- The rental company lots along SR 89A were full of OHVs in the evening and empty during the day.
- There was a high number of UTVs driving along SR 89A and SR 179 within city limits.
- Vehicles were observed to approach the 4x4 trail and park while one person got out to inspect the beginning of the trail and evaluate if their vehicle was suitable for the trail.

2 Forest Road 152C

- On Friday and Saturday there was little to no OHV activity.
- On Sunday, staff noted more private tours.

3 Dry Creek Road/Trailhead

- High number of Pink Jeep Tours.
- Various private OHVs would enter trailhead and then backup up to enter parking lot.
- Many vehicles were observed to circulate through the parking lot, looking for parking while the lot was full. Many vehicles diverted and parked on Boynton Pass Road.

4 Soldier Pass Trailhead

- Very little private OHV activity.

- More Red Rock Western Jeep Tours than Pink Jeep Tours.
- Very quiet activity.
- No UTVs or ATVs.
- Bikes were observed entering and exiting the trail.

5 Schnebly Hill Trailhead

- Vehicles were observed to park outside the parking lot along the road, but before the 4x4 road started.
- Some tour companies approached the trailhead but did not proceed into the trail and instead turned around. It seemed that it was part of the tour.

6 Broken Arrow Trailhead

- Many private OHVs were observed such as Jeeps, trucks, and other 4x4 vehicles like Subaru.
- High number of Pink Jeep Tours.
- Private OHV vehicles very slowly entered the trail path due to uneven terrain.
- Tractor activity was observed on Friday and Saturday. The tractor was moving dirt and rocks to/from the trail. It appeared that the tractor was maintaining the trail path.

According to a local Sedona resident, rental companies were not renting out ATVs or UTVs due to weather conditions. However, during manual traffic count collection, KH staff observed various rental company UTVs using trailheads. These were distinguishable based on their colored flags and a few with had their logo company on the vehicle.

Additionally, there were very few ATV rentals observed on trailheads. ATVs travel on low-pressure tires with a straddle-style seat and handlebars. Staff conducted quick online research and noted that according to various OHV rental company websites, most companies do not offer ATV rentals and instead only offer UTV rentals which are "buggy style" vehicles.

3 Traffic

As previously mentioned, traffic peaked during the mid-day at around 12 p.m. to 4 p.m. When staff traveled from site to site, they noticed traffic congestion along SR 89A and SR 179 heading toward Uptown Sedona. On Saturday, vehicle congestion was past Dry Creek Road/Arroyo Pinon Drive on SR 89A heading eastbound and past Morgan Road on SR 179 heading northbound.

Most trailhead parking lots were full by around 1 p.m. and vehicles were circling in and out attempting to find a parking space. At Dry Creek Road/Trailhead, vehicles were parking roadside on Boynton Pass Road due to overflow. At Schnebly Hill Trailhead, vehicles were parking along roadside along Schnebly Hill Road due to overflow.

Soldier Pass Trailhead parking is gated and closed off to the public Thursday-Sunday. During manual traffic data collection, staff noticed that a lot of vehicles drove in an attempt to enter the parking lot without knowing it was closed. Vehicles would make a U-turn or continue west on Canyon Shadow Drive when realizing the gate to the parking lot was closed. Additionally, staff also noticed various personal vehicle drop-off and pick-ups at the trailhead.

Appendix B. Methodology and Detailed Data – Noise Levels

3 Background and Methodology

Noise is defined as unwanted sound and is known to have several adverse effects on people, including hearing loss, speech and sleep interference, physiological responses, and annoyance. Based on these known adverse effects of noise, the federal government, the State of Arizona, and many local governments have established criteria to protect public health and safety and to prevent disruption of certain human activities.

1 Human Health Impacts

Sound pressure is measured through the A-weighted measure to correct for the relative frequency response of the human ear. That is, an A-weighted noise level de-emphasizes low and very high frequencies of sound similar to the human ear's de-emphasis of these frequencies.

Unlike linear units such as inches or pounds, decibels are measured on a logarithmic scale, representing points on a sharply rising curve. On a logarithmic scale, an increase of 10 dBA is 10 times more intense than 1 dBA, while 20 dBA is 100 times more intense, and 30 dBA is 1,000 times more intense. A sound as soft as human breathing is about 10 times greater than 0 dBA. The decibel system of measuring sound gives a rough connection between the physical intensity of sound and its perceived loudness to the human ear. Ambient sounds generally range from 30 dBA (very quiet) to 100 dBA (very loud).

Time variation in noise exposure is typically expressed in terms of a steady-state energy level equal to the energy content of the time varying period (called L_{eq}), or alternately, as a statistical description of the sound level that is exceeded over some fraction of a given observation period. This report analyzes the maximum sound pressure value with no time constant applied (called L_{peak}). This unit of noise exposure gives the instantaneous impulse level generated by a noise source.

Physical damage to human hearing begins at prolonged exposure to noise levels higher than 85 dBA. Exposure to high noise levels affects our entire system, with prolonged noise exposure in excess of 75 dBA increasing body tensions, and thereby affecting blood pressure, functions of the heart and the nervous system. In comparison, extended periods of noise exposure above 90 dBA could result in permanent hearing damage. When the noise level reaches 120 dBA, a tickling sensation occurs in the human ear even with short-term exposure. This level of noise is called the threshold of feeling. As the sound reaches 140 dBA, the tickling sensation is replaced by the feeling of pain in the ear. This is called the threshold of pain.

2 Regulatory

1 State Regulations

The Arizona State Parks regulates the noise produced by OHVs that utilize the State's trails. The maximum allowable noise level for OHVs is 96 decibels. The State's Parks also require OHVs to install a muffler or noise dissipative device to ensure noise reduction below the allowable level. The Arizona State Parks does not specify whether the 96 decibels threshold is an instantaneous

noise level or a time dependent noise level. This report assumes the Arizona State Parks threshold is an instantaneous noise threshold of 96 dBA L_{peak}.

2 Local Regulations

A noise ordinance is intended to control unnecessary, excessive, and annoying sounds from stationary, non-transportation noise sources. Noise ordinance requirements are not applicable to mobile noise sources such as traffic traveling on public roadways. Federal and State laws preempt control of mobile noise sources on public roads. Noise ordinance standards generally apply to industrial and commercial noise sources, as well as parks and schools affecting residential areas.

The City of Sedona code sets an exterior noise standard for specific areas in the City. Table B-1 lists the multiple areas and their exterior noise standards.

TABLE B-1. EXTERIOR NOISE STANDARDS

Zone	Time	Noise Standard Maximum (dBA)
Residential	10 p.m. – 7 a.m.	50
	7 a.m. – 10 p.m.	60
Commercial	10 p.m. – 7 a.m.	65
	7 a.m. – 10 p.m.	65
Industrial	10 p.m. – 7 a.m.	65
	7 a.m. – 10 p.m.	70
Source: City of Sedona, 2022.		

The City code regulates motor vehicle noise separate to exterior noise. Section 8.25.040 Part C states that motor vehicles must be equipped with a muffler that is in constant operation to prevent excessive noise. Furthermore, motor vehicles must not exceed the noise limits listed in Table B-2. The noise limits listed in the table are based off the distance of 50 feet from the center of the lane and the specified speed limits.

TABLE B-2. VEHICLE NOISE STANDARDS

Vehicle Type	Speed Limits of 35 mph or Less	Speed Limits of More Than 35 mph
Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 pounds or more, or any combination of vehicles towed by such motor vehicle, and any motorcycle other than a motor-driven cycle (moped).	88 dBA	92 dBA
Any other motor vehicle and any combination of vehicles towed by such motor vehicles.	82 dBA	86 dBA
Source: City of Sedona Code, 2022.		

3 Methodology

Noise measurements were conducted at five locations around the City of Sedona. These locations provide access to trailheads that are accessible to the passenger vehicles and OHVs. The noise meters were set up within 50 feet of the entrances to the trailheads. These locations were selected as areas that would capture noise generated through vehicular traffic entering and exiting the trail. See Figure B-1 through B-5 for the exact locations of the noise measurements at each of the sites. All the noise measurements were conducted during the daytime and were set in position early in the morning to capture peak traffic noise. The noise meters were set to manual stop to obtain the largest amount of data at each of the sites.

FIGURE B-1. NOISE AND AIR QUALITY MEASUREMENT LOCATION – FR 152C

FIGURE B-2. NOISE AND AIR QUALITY MEASUREMENT LOCATION – DRY CREEK ROAD/TRAILHEAD

FIGURE B-3. NOISE AND AIR QUALITY MEASUREMENT LOCATION – SOLDIER PASS TRAILHEAD

FIGURE B-4. NOISE AND AIR QUALITY MEASUREMENT LOCATION – SCHNEBLY HILL TRAILHEAD

FIGURE B-5. NOISE AND AIR QUALITY MEASUREMENT LOCATION – BROKEN ARROW TRAILHEAD

4 Field Observations

1 Noise Level

Noise at each of the sites was primarily generated by mobile vehicle sources, parking lot noise, and visitor pass-bys:

- Mobile sources at the sites included the pass-bys of regular passenger vehicles, OHVs, and shuttle buses traveling between sites.
- Parking lot noise is mainly associated with car door slamming, engine start up, and vehicle idling. Parking lot noise also includes conversations in parking areas.
- Noise from visitor pass-bys includes noise generated from tourists hiking and conversing on the trailheads.

Each of the sites varied in the number of times each noise source was observed. For instance, Dry Creek Road/Trailhead, Schnebly Hill Trailhead, and Broken Arrow Trailhead experienced noise through mobile sources, visitor pass-bys, and their parking lots due to their ease of access and popularity. The Soldier Pass Trailhead produced mainly visitor pass-by noise with little mobile source noise and parking lot noise due to the restricted access of the parking lot. The FR 152C was primarily mobile source noise due to the remote location of the trailhead and the lack of any parking in the trailhead's vicinity.

5 Results

The peak vehicle noise at the five trailheads varies based on multiple factors. However, the two main factors that influenced noise generated by vehicles at the trailheads was accessibility and popularity of the trailhead and vehicle type.

1 Accessibility

Vehicle trips to each of location vary greatly due to their accessibility and their popularity to residents and visitors. For example, Dry Creek Road/Trailhead and Schnebly Hill Trailhead resulted in substantially more vehicle trips per day than the other locations, likely due to their parking lot access, their close proximity to the City, and the availability of paved surface roads up to the trailhead. Over the course of the weekend, Dry Creek Road/Trailhead produced the most vehicle trips with 3,335 vehicles and Schnebly Hill Trailhead produced the second highest vehicle trips with 1,778 vehicles. Dry Creek Road and Schnebly Hill Road also experienced the highest ambient noise level of 55.5 dBA L_{eq} and 52.3 dBA L_{eq} at 50 feet which are both below the daytime exterior residential noise standards established by the City (see Table B-1). Therefore, roadways that lead to trails close to the City with accessible parking lots would experience more vehicle noise, and sensitive receptors along those roadways would be subject to heightened vehicle noise.

2 Vehicle Type

There are a wide range of vehicle types that travel to the trailheads for recreation. These vehicles include typical on-road passenger vehicles and off-road vehicles (ATVs/UTVs and "Pink" 4x4 Jeeps).

1 On-Road Vehicles

On-road vehicles that travel to the site are generally common passenger vehicles that produce basic roadway noise similar to noise levels observed within the streets of a city. This noise level

would typically range from 70 to 80 dBA at a distance of 50 feet from the roadway center line.[3] Based on the noise measurements collected at each site, similar levels of noise are produced by passenger vehicles. The peak noise generated by passenger vehicles occurs during off-road drive bys or when accelerating over the boulders at the entrances of the off-road sections of the trailheads. Examples of the peak levels observed for passenger vehicles are shown in Table B-3.

TABLE B-3. PASSENGER VEHICLE NOISE

Location	Time	Vehicle Type	Noise Level at 15 feet (LA_{peak})
Broken Arrow[1]	Friday, 1:27:02 P.M. to 1:27:17 P.M.	Sedan	80.2 dBA
Broken Arrow[2]	Saturday, 9:54:52 A.M. to 9:55:02 A.M.	Sedan	83.4 dBA
Broken Arrow[3]	Friday, 11:55:40 A.M. to 11:55:52 A.M.	Truck/SUV	82.1 dBA
Broken Arrow[4]	Saturday, 11:08:40 A.M. to 11:08:59 A.M.	Truck/SUV	84.4 dBA

1.See Figure B-6 for image of vehicle.
2.See Figure B-7 for image of vehicle.
3.See Figure B-8 for image of vehicle.
4.See Figure B-9 for image of vehicle.

[3] FHWA, Living with Noise, July 2003

FIGURE B-6. SEDAN, FRIDAY 1:27:13 P.M. – BROKEN ARROW TRAILHEAD

FIGURE B-7. SEDAN, SATURDAY 9:54:59 A.M. – BROKEN ARROW TRAILHEAD

FIGURE B-8. TRUCK, FRIDAY 11:55:46 A.M. – BROKEN ARROW TRAILHEAD

FIGURE B-9. TRUCK, SATURDAY 11:08:52 A.M. – BROKEN ARROW TRAILHEAD

Typically, on-road vehicle pass-by noise would cause noise levels to peak at around 83 dBA for on-road passenger vehicles at the noise meter located about 15 feet away from the roadway centerline. When accounting for distance, the noise level produced is approximately 72.5 dBA at 50 feet from the roadway centerline. However, there were occasions in which common vehicles may produce more noise than levels discussed above. For instance, when multiple vehicles are accelerating over the boulders at the trail entrances, the noise generated by the multiple vehicles compounds to a higher peak noise level. Some vehicles also have altered mufflers that produce more sound. However, these spikes in noise are uncommon and only occur for short periods of time at the entrance of each trailhead.

2 Off-Road Vehicles

Off-road vehicles are a frequent occurrence at each of the trailheads and vary in their noise levels based on the type of vehicle. There are two main off-road vehicles that utilize the trails: ATVs/UTVs and the "Pink" 4x4 Jeeps. As mentioned previously, noise levels tend to peak when these vehicles are accelerating over the boulders at the entrances of the trailheads. Examples of this peak noise generated through the acceleration is shown in Table B-4.

TABLE B-4. OFF-ROAD VEHICLE NOISE

Location	Time	Vehicle Type	Noise Level at 15 feet (LA_{peak})
Broken Arrow[1]	Saturday, 11:17:40 A.M. to 11:17:49 A.M.	Pink Jeep	79.8 dBA
Broken Arrow[2]	Saturday, 1:48:25 P.M. to 1:48:46 P.M.	Pink Jeep	82.4 dBA
Broken Arrow[3]	Friday, 2:59:32 P.M. to 3:00:11 P.M.	UTV/ATV	98.7 dBA
Broken Arrow[4]	Saturday, 2:45:13 P.M.to 2:45:59 P.M.	Multiple UTVs/ATVs	96.3 dBA

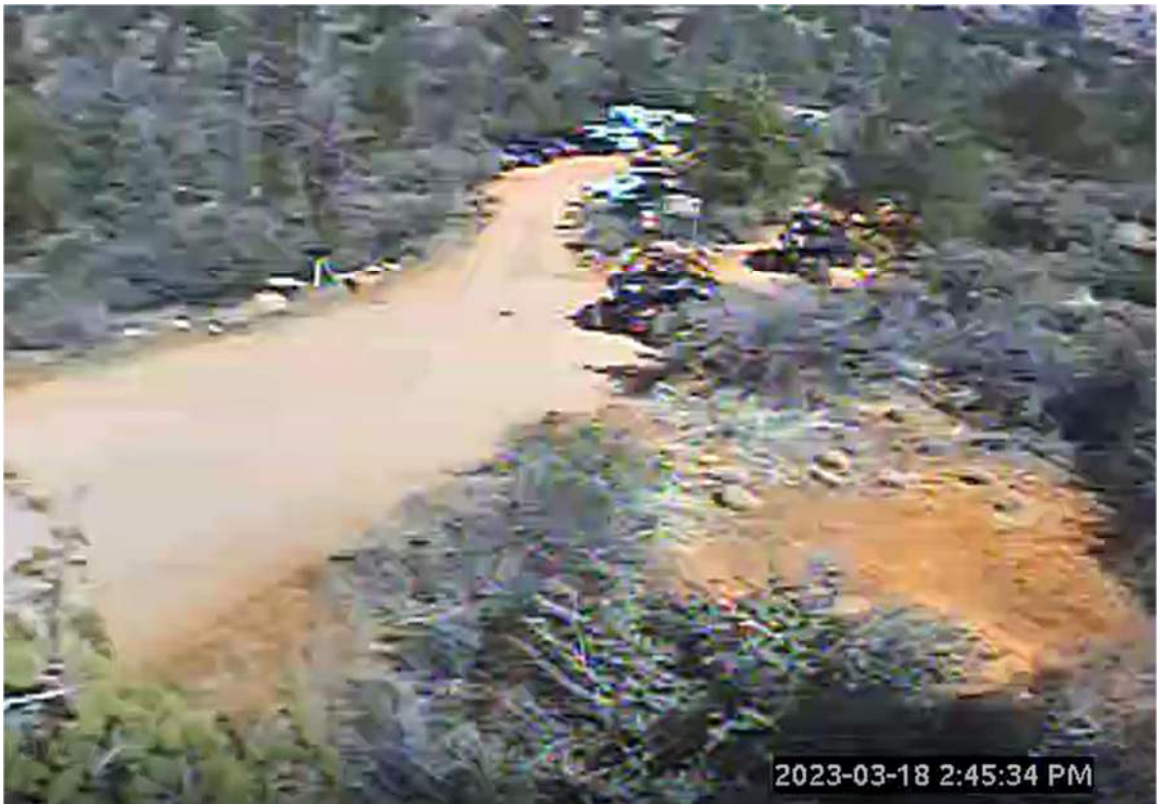
1.See Figure B-10 for image of vehicle.
2.See Figure B-11 for image of vehicle.
3.See Figure B-12 for image of vehicle.
4.See Figure B-13 for image of vehicle.

FIGURE B-10. PINK JEEP, SATURDAY 11:17:45 A.M. – BROKEN ARROW TRAILHEAD

FIGURE B-11. PINK JEEP, SATURDAY 1:48:33 P.M. – BROKEN ARROW TRAILHEAD

FIGURE B-11. UTV, SATURDAY 2:59:40 P.M. – BROKEN ARROW TRAILHEAD

FIGURE B-13. MULTIPLE UTVS, SATURDAY 2:45:34 P.M. – BROKEN ARROW TRAILHEAD



The Pink Jeeps are used by tour group companies and provide private off-road tours of the City's trails. These Jeeps produce peak levels of noise similar to typical on-road vehicles of about 83 dBA, which at a distance of 50 feet is approximately 72.5 dBA. Additional noise may be generated on the Pink Jeeps due to speakers on the vehicles which are used by tour guides to play music or talk to tourists. Similar to passenger vehicles, noise levels may result in higher peaks if multiple Pink Jeeps are using the trailhead at the same time.

Based on the in-person observations at all five of the trailheads, the ATVs/UTVs produce the highest level of noise of all the vehicles that frequent the trails. The noise measurement data shows that these vehicles produce instantaneous peak noise levels above 96 dBA occasionally during acceleration or when traveling in a group. Therefore, noise levels produced by ATVs/UTVs exceed the noise threshold established by the Arizona State Parks in certain circumstances. Individual ATV/UTVs produce a noise level of 87 dBA. At 50 feet from the roadway centerline, individual vehicles would produce a noise level of 76.5 dBA. During the peaks above 96 dBA, vehicles would produce a noise level greater than 82 dBA.

6 Discussion

As mentioned previously, noise generated by ATVs/UTVs would exceed both the Arizona State Parks noise standards and produce noise that could be considered a nuisance. During quick accelerations or when traveling in groups, ATVs/UTVs would create significant volumes of noise. Regarding human health impacts, noise generated by any of the vehicle types tends to remain below 100 decibels and would not create constant noise at high levels near people using the trails. Therefore, the vehicles, including OHVs, would not pose a human health impact for people using the trails.

However, based on the collected data, analyzing the impacts of OHVs on the nearby residential receptors that lead up to the trailheads would not appropriately reflect existing conditions based on the data collected during this 3-day period. Vehicle noise impacts on surrounding receptors depends on various factors included the road surface type, vehicle speed, distance to receptors, the presence of noise attenuating structures, etc. The noise measurements taken on this initial trip were conducted at the trailheads and not at locations close to sensitive receptors that are impacted by traffic noise. Therefore, noise collected on this first trip would not be indicative of the traffic noise impacts on the sensitive receptors that lead up to the trailheads. In the subsequent data collection trips, noise measurements will be taken along roadways that lead up to the trails in areas near to sensitive receptors. Furthermore, a reference noise level of the rentable UTVs will be taken during idling and at the allowable street speed to gauge their impacts as they drive within public roads in the City.

7 References

Arizona State Parks, OHV Laws and Regulations, Accessible at: https://azstateparks.com/ohv-laws-regulations

City of Sedona, Chapter 8.25 Noise Regulations, Sedona Municipal Code, Accessible at: https://sedona.municipal.codes/SCC/8.25

Federal Highway Administration, Living with Noise, Accessible at: https://highways.dot.gov/public-roads/julyaugust-2003/living-noise

Appendix C. Methodology and Detailed Data – Air Quality Levels

8 Background and Methodology

1 Regulatory Setting

1 Federal Clean Air Act

Air quality is federally protected by the Federal Clean Air Act (FCAA) and its amendments. Under the FCAA, the United States Environmental Protection Agency (EPA) developed the primary and secondary NAAQS for the criteria air pollutants including ozone (O3), nitrous oxide (NO2), carbon monoxide (CO), sulfur dioxide (SO2), particulate matter of 10 and 2.5 microns (PM10 and PM2.5 respectfully) and lead. Proposed projects in or near nonattainment areas could be subject to more stringent air-permitting requirements. The FCAA requires each state to prepare a State Implementation Plan to demonstrate how it will attain the NAAQS within the federally imposed deadlines.

The EPA can withhold certain transportation funds from states that fail to comply with the planning requirements of the FCAA. If a state fails to correct these planning deficiencies within two years of Federal notification, the EPA is required to develop a federal implementation plan for the identified nonattainment area or areas. The provisions of 40 Code of Federal Regulations Parts 51 and 93 apply in all nonattainment and maintenance areas for transportation-related criteria pollutants for which the area is designated nonattainment or has a maintenance plan. The EPA has designated enforcement of air pollution control regulations to the individual states. Applicable NAAQS are summarized in Table C-1.

TABLE C-1. FEDERAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	National Standards2
Ozone (O_3) [2,]	8 Hour	0.070 ppm
	1 Hour	NA
Carbon Monoxide (CO)	8 Hour	9 ppm (10 mg/m^3)
	1 Hour	35 ppm (40 mg/m^3)
Nitrogen Dioxide (NO_2)	1 Hour	0.100 ppm [11]
	Annual Arithmetic Mean	0.053 ppm (100 µg/m^3)
Sulfur Dioxide (SO_2) [5]	24 Hour	0.14 ppm (365 µg/m^3)
	1 Hour	0.075 ppm (196 µg/m^3)
	Annual Arithmetic Mean	0.03 ppm (80 µg/m^3)
Particulatnaaqsstane Matter (PM10) [1, 3]	24-Hour	150 µg/m^3
	Annual Arithmetic Mean	NA
Fine Particulate Matter (PM2.5) [3, 4, 6]	24-Hour	35 µg/m^3
	Annual Arithmetic Mean	12 µg/m^3
Sulfates (SO_{4-2})	24 Hour	NA
Lead (Pb) [7]	30-Day Average	NA
	Calendar Quarter	1.5 µg/m^3
	Rolling 3-Month Average	0.15 µg/m^3
Notes:		

ppm = parts per million; µg/m³ = micrograms per cubic meter; mg/m³ = milligrams per cubic meter; – = no information available.

1 National standards shown are the "primary standards" designed to protect public health. National standards other than for O_3, particulates and those based on annual averages are not to be exceeded more than once a year. The 1-hour O_3 standard is attained if, during the most recent three-year period, the average number of days per year with maximum hourly concentrations above the standard is equal to or less than one. The 8-hour O_3 standard is attained when the 3-year average of the 4th highest daily concentrations is 0.070 ppm or less. The 24-hour PM10 standard is attained when the 3-year average of the 99th percentile of monitored concentrations is less than 150 µg/m³. The 24-hour PM2.5 standard is attained when the 3-year average of 98th percentiles is less than 35 µg/m³.

2 Except for the national particulate standards, annual standards are met if the annual average falls below the standard at every site. The national annual particulate standard for PM10 is met if the 3-year average falls below the standard at every site. The annual PM2.5 standard is met if the 3-year average of annual averages spatially-averaged across officially designed clusters of sites falls below the standard.
NAAQS are set by the EPA at levels determined to be protective of public health with an adequate margin of safety.

3 On October 1, 2015, the national 8-hour O_3 primary and secondary standards were lowered from 0.075 to 0.070 ppm. An area will meet the standard if the fourth-highest maximum daily 8-hour O_3 concentration per year, averaged over three years, is equal to or less than 0.070 ppm. EPA will make recommendations on attainment designations by October 1, 2016, and issue final designations October 1, 2017. Nonattainment areas will have until 2020 to late 2037 to meet the health standard, with attainment dates varying based on the O_3 level in the area.

4 The national 1-hour O_3 standard was revoked by the EPA on June 15, 2005.

5 On June 2, 2010, the EPA established a new 1-hour SO_2 standard, effective August 23, 2010, which is based on the 3-year average of the annual 99th percentile of 1-hour daily maximum concentrations. The existing 0.030 ppm annual and 0.14 ppm 24-hour SO_2 NAAQS however must continue to be used until one year following EPA initial designations of the new 1-hour SO_2 NAAQS.

6 In December 2012, EPA strengthened the annual PM2.5 NAAQS from 15.0 to 12.0 µg/m³. In December 2014, the EPA issued final area designations for the 2012 primary annual PM2.5 NAAQS. Areas designated "unclassifiable/attainment" must continue to take steps to prevent their air quality from deteriorating to unhealthy levels. The effective date of this standard is April 15, 2015.

7 National lead standard, rolling 3-month average: final rule signed October 15, 2008. Final designations effective December 31, 2011.

Source: South Coast Air Quality Management District, Air Quality Management Plan, 2016;

2 Human Health Impacts

Particulate matter (PM) is a significant concern due to its detrimental effects on human health. Composed of tiny particles, PM can penetrate deep into the respiratory system, causing respiratory symptoms, reduced lung function, and the development of respiratory diseases. It is also associated with an increased risk of cardiovascular diseases and can aggravate existing cardiovascular conditions. Furthermore, PM's diverse sources and composition make it challenging to control and mitigate its specific health risks. Vulnerable populations, including children, the elderly, and individuals with pre-existing respiratory or cardiovascular conditions, are particularly susceptible to the health impacts of PM. Therefore, effective pollution control measures and public awareness are essential for safeguarding human health from the widespread presence and adverse effects of particulate matter.

Ambient air quality standards are designed to prevent impacts on health and the environment by defining the maximum amount of pollutant that can be present without harming human health. The United States Environmental Protection Agency (U.S. EPA) sets National Ambient Air Quality Standard (NAAQS) for PM10 nationwide. The Clean Air Act requires EPA to set two types of outdoor air quality standards: primary standards, to protect public health, and secondary standards, to protect the public against adverse environmental effects. The law requires that primary standards be "requisite to protect public health with an adequate margin of safety," including the health of people most at risk from PM exposure. These include people with heart or lung disease, children, older adults and people of lower socioeconomic status. Secondary standards must be "requisite to protect the public welfare" from both known and anticipated adverse effects.

3 Vehicle Activity and Particulate Matter

Vehicle activity on unpaved roads contributes to PM through various mechanisms. When vehicles traverse these roads, the mechanical disturbance caused by tires and vehicle movement dislodges and fragments surface materials, generating airborne PM. Additionally, the friction between tires and the road surface leads to abrasion, releasing fine particles into the air. Vehicle emissions, especially from diesel-powered vehicles, like off-highway vehicles (OHVs), also contribute to PM through combustion byproducts that can adhere to the road surface and be resuspended by subsequent vehicle activity. Furthermore, vehicle-induced turbulence and wind dispersal play roles in lifting and dispersing the loose particles would increase the concentration of PM in the surrounding areas. These combined mechanisms result in elevated levels of PM on and near unpaved roads, posing potential health risks to nearby populations.

4 Methodology

An assessment of background data, upwind data vs. downwind data, spatial analysis, etc. helps to determine the extent of contribution from a specific source to air quality and informs health-protective recommendations. As mentioned previously, air quality measurements were conducted at five trailheads around the City of Sedona. The trailheads chosen are accessible to passenger vehicles and OHVs. The air quality meters were set up within 50 feet of the entrances to the trailheads. These locations were selected as areas that would capture particulate matter generated through vehicular traffic entering and exiting the trail. All the air quality measurements were conducted during the daytime in accordance with Forest Service usability hours and were set in position early in the morning to capture peak traffic activity. The air quality meters were set to manual stop to obtain the most amount of data at each of the sites. To verify the sources of potential PM disturbances and to determine the contribution of PM impacts on the surrounding environment, Broken Arrow trail consisted of both upwind (UW) and downwind (DW) measurements.

9 Field Observations

The ground was well saturated from rain immediately prior to the data collection effort. However, with dry weather and vehicle use, the trails looked visibly drier each day throughout the weekend. By Saturday afternoon and Sunday, the KH team noted obvious track out of soil onto paved surfaces including trailhead parking lots and public streets surrounding all locations except Soldier Pass (likely due to the controlled volume of vehicles accessing that trail).

The Dustrack™ equipment generally performed as expected and PM data were successfully collected at all five locations. PM measurements were conducted at each of the five trailheads from early morning to approximately sun set. The monitors were located in proximity to high traffic areas at the entrances to each of the trailheads. Meteorological data monitoring (wind speed, direction, and precipitation) was conducted at two of the trailheads, and specific locations were selected in accordance with manufacturers' recommendations. See Figure B-1 through B-5 for the exact locations of the air quality and weather measurements at each of the sites.

Particles originate from a variety of stationary and mobile sources and may be directly emitted (primary emissions) or formed in the atmosphere (secondary emissions) by transformation of gaseous emissions. Primary PM sources are derived from both human and natural activities and, for context of the trailheads, can originate from entrainment of road dust into the air and windblown dust. Secondary PM sources directly emit air contaminants into the atmosphere that

form or help form PM. Hence, these pollutants are considered precursors to PM formation. These secondary pollutants include SO2, NO2, volatile organic compounds (VOCs), and ammonia.

10 Results

The results show a strong correlation between general vehicle activity at the trailhead entrances and increases in PM levels. Periods of elevated PM levels, with peaks above 795 micrograms per cubic meter (µg/m3), were recorded contemporaneously with vehicle activity. However, health-based standards for PM exposure, such as the federal National Ambient Air Quality Standard (NAAQSs) standards, set average concentrations over longer time periods, such as 24-hours and annual. Table C-2 summarizes the maximum PM levels time-averaged over each collection period at the trailheads.

TABLE C-2. MAXIMUM COLLECTION PERIOD AVERAGE PM LEVELS

Trail Location	Maximum Collection Period Average PM2.5 (µg/m3)	Maximum Collection Period Average PM10 (µg/m3)
FR 152C	30	66
Broken Arrow Trailhead – UW	11	21
Broken Arrow Trailhead – DW	11	41
Dry Creek Road/Trailhead	13	16
Schnebly Hill Trailhead	9	18
Soldier Pass Trailhead	13	21

Recent scientific literature finds that exposure to PM levels above the federal guidelines, even over exposure periods of less than 24 hours, has the potential to trigger acute health conditions in highly sensitive and sensitive individuals. One-hour rolling averages were found to exceed the federal; NAAQs standards at two trailheads (in bold below), with the FR 152C experiences elevated PM levels about NAAQs standards for multiple hours. Table C-3 summarizes the maximum one-hour rolling average measured at each location.

TABLE C-3. MAXIMUM ONE-HOUR AVERAGE PM LEVELS

Trail Location	Maximum 1-Hour Average PM2.5 (µg/m3)	Maximum 1-Hour Average PM10 (µg/m3)
FR 152C	75	178
Broken Arrow Trailhead – UW	31	72
Broken Arrow Trailhead – DW	40	154
Dry Creek Road/Trailhead	16	20
Schnebly Hill Trailhead	15	37
Soldier Pass Trailhead	15	37

1 Forest Road 152C

The FR 152C experienced the highest recorded levels of PM as well as a strong correlation between vehicle activity and elevated levels of PM. Below are two examples showing PM levels before, during, and after vehicle activity at the trailhead entrance.

TABLE C-4. PM 2.5

Day	Total Average PM 2.5	Maximum Rolling 1-Hour Average	Peak PM 2.5
Friday	13	29	170
Saturday	20	53	382
Sunday	30	75	323

TABLE C-5. PM 10

Day	Total Average PM 10	Maximum Rolling 1-Hour Average	Peak PM 10
Friday	21	60	425
Saturday	37	103	792
Sunday	66	178	795

1 Friday – 03/17/2023

At 12:32 PM, PM measurements spiked when three different vehicles crossed through the intersection. Specifically, PM2.5 levels increased seven times ambient measurements and PM10 levels increased more than 12 times ambient measurements. See Figures C-1 through C-3 for video vehicle activity. Table C-6 summarizes the measured PM due to vehicle activity at the FR 152C on Friday.

TABLE C-6. MEASURED PM DUE TO VEHICLE ACTIVITY, FRIDAY – FR 152C

Elapsed Time [s]	PM2.5 [µg/m^3]	PM10 [µg/m^3]
12:27 PM	9	10
12:28 PM	9	10
12:29 PM	12	19
12:30 PM	10	13
12:31 PM	20	38
12:32 PM	72	170
12:33 PM	9	9
12:34 PM	10	10
12:35 PM	9	9
12:36 PM	9	9
12:37 PM	9	9

FIGURE C-1. NO VEHICLE ACTIVITY, FRIDAY 12:31:11 P.M. – FR152C

FIGURE C-2. MULTI-VEHICLE ACTIVITY, FRIDAY 12:31:54 P.M. – FR152C

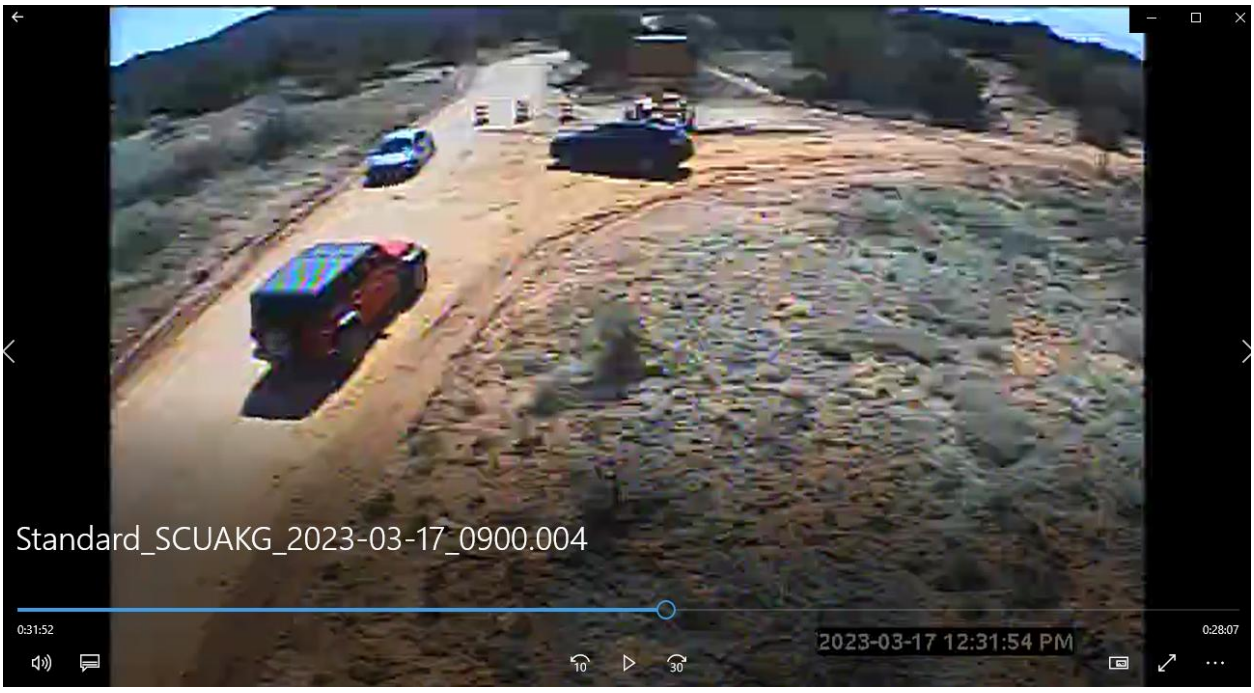


FIGURE C-3. NO VEHICLE ACTIVITY, FRIDAY 12:33:08 P.M. – FR 152C

2 Sunday – 03/19/2023

At 10:16 AM PM, PM measurements again spiked when a single OHV crossed through the trail intersection. Specifically, PM2.5 levels increased 12 times ambient measurements and PM10 levels increased more than 40 times ambient measurements before the vehicle activity. In this incident, there is a small delay between the OHV activity and the PM sensor measuring ambient levels. This is expected because PM disturbances from unpaved roads take time to disperse through the surrounding environment. See Figures C-4 through C-6 for video of vehicle activity. Table C-7 summarizes the measured PM due to vehicle activity at the FR 152C on Sunday.

TABLE C-7. MEASURED PM DUE TO VEHICLE ACTIVITY, SUNDAY – FR 152C

Elapsed Time [s]	PM2.5 [µg/m³]	PM10 [µg/m³]
10:14 AM	4	8
10:15 AM	2	3
10:16 AM	4	6
10:17 AM	70	148
10:18 AM	145	323
10:19 AM	5	11
10:20 AM	11	22
10:21 AM	27	58
10:22 AM	27	59
10:23 AM	3	5
10:24 AM	10	21

FIGURE C-4. NO VEHICLE ACTIVITY, SUNDAY 10:15:32 A.M. – FR152C

FIGURE C-5. PINK JEEP ACTIVITY, SUNDAY 10:16:52 A.M. – FR152C

FIGURE C-6. NO VEHICLE ACTIVITY, SUNDAY 10:19:22 A.M. – FR152C

This trend of a low ambient baseline PM level followed by a spike in PM measurements due to vehicle activity followed for much of the data.

2 Broken Arrow Trailhead

The Broken Arrow Trail consisted of significant vehicle and pedestrian traffic, and the beginning of the trailhead had a design that allowed for a comparison between upwind and downwind PM measurements. By taking measurements upwind (before the pollution source) and downwind (after the pollution source), it becomes possible to identify and characterize the source of pollution. Comparing PM concentrations between these two locations helps determine the contribution of a specific source to the overall PM levels.

As can be seen in Table C-8 and Table C-9, as Pink Jeeps enter the trailhead, the PM monitor upwind makes a measurement and one minute later, the downwind monitor spikes similarly to the upwind monitor. See Figures C-7 through C-10 for video of vehicle activity.

TABLE C-8. MEASURED PM DUE TO VEHICLE ACTIVITY, SUNDAY – BROKEN ARROW TRAILHEAD UPWIND

Elapsed Time [s]	PM2.5 [µg/m^3]	PM10 [µg/m^3]
10:04 AM	3	4
10:05 AM	6	10
10:06 AM	7	14
10:07 AM	40	94
10:08 AM	16	34
10:09 AM	14	32

10:10 AM	8	16
10:11 AM	8	15
10:12 AM	23	51
10:13 AM	5	7
10:14 AM	4	4

TABLE C-9. MEASURED PM DUE TO VEHICLE ACTIVITY, SUNDAY – BROKEN ARROW TRAILHEAD DOWNWIND

Elapsed Time [s]	PM2.5 [µg/m^3]	PM10 [µg/m^3]
10:04 AM	1	2
10:05 AM	10	44
10:06 AM	2	4
10:07 AM	27	117
10:08 AM	57	242
10:09 AM	18	97
10:10 AM	3	11
10:11 AM	49	215
10:12 AM	20	87
10:13 AM	1	4
10:14 AM	1	2

FIGURE C-7. NO VEHICLE ACTIVITY, SUNDAY 10:07:08 A.M. – BROKEN ARROW TRAILHEAD

FIGURE C-8. PINK JEEP ACTIVITY, SUNDAY 10:08:08 A.M. – BROKEN ARROW TRAILHEAD

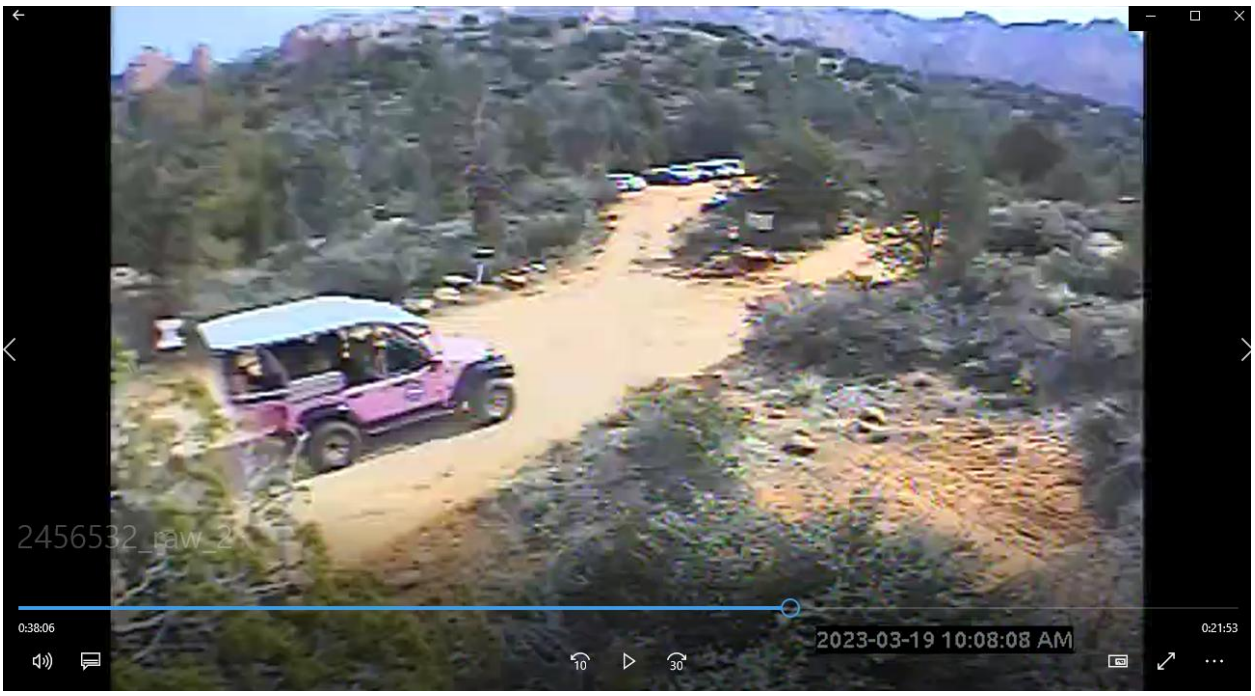


FIGURE C-9. DELAYED ACTIVITY, SUNDAY 10:08:16 A.M. – BROKEN ARROW TRAILHEAD

FIGURE C-10. PINK JEEP ACTIVITY, SUNDAY 10:09:06 A.M. – BROKEN ARROW TRAILHEAD

3 Day-to-Day Comparison

Based on the discussion above, a comparison amongst the trailheads for each day highlights the various environmental factors that contribute to rural PM concentrations. Specifically, it is likely that the dampness of the unpaved roads and amount of paved road leading to each trailhead influenced how vehicle activity contributed to PM concentration trends. For the day-by-day comparison and analysis, only PM2.5 concentrations are used due to their established human health impacts at lower concentrations and because PM2.5 is a percentage of PM10.

Figure C-11 and Figure C-12 show the total concentration averages for PM 2.5 and total vehicle activity, respectively, over each testing day.

FIGURE C-11. TOTAL AVERAGE PM2.5 CONCENTRATION

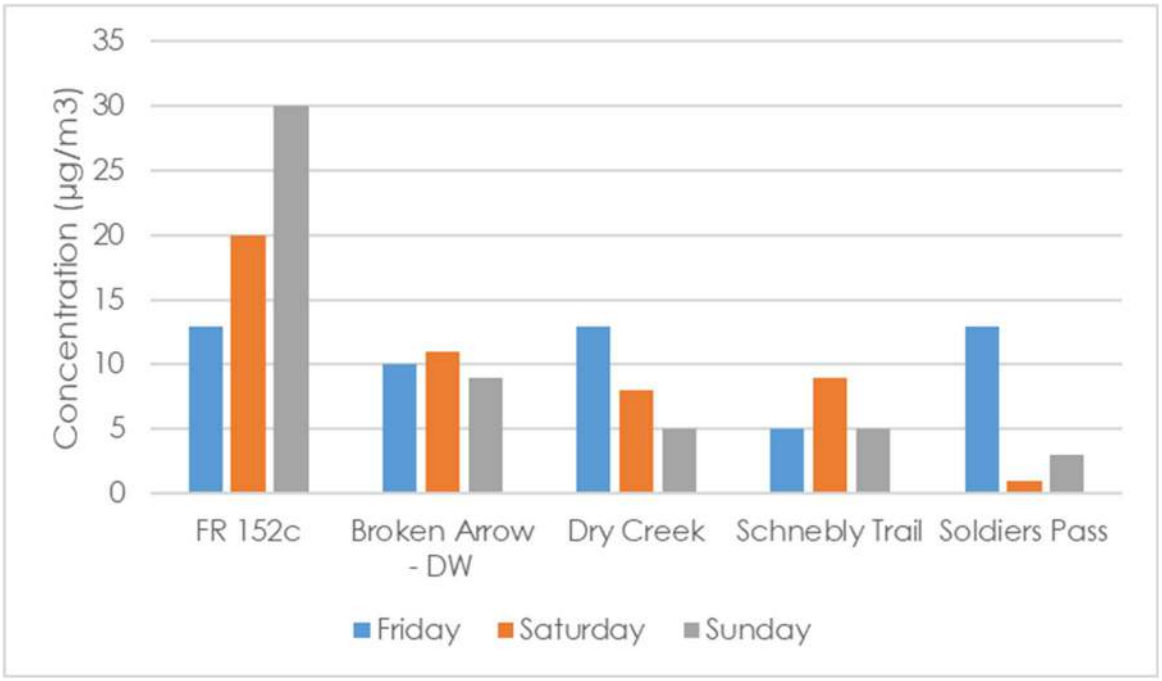


FIGURE C-12. TOTAL VEHICLE ACTIVITY

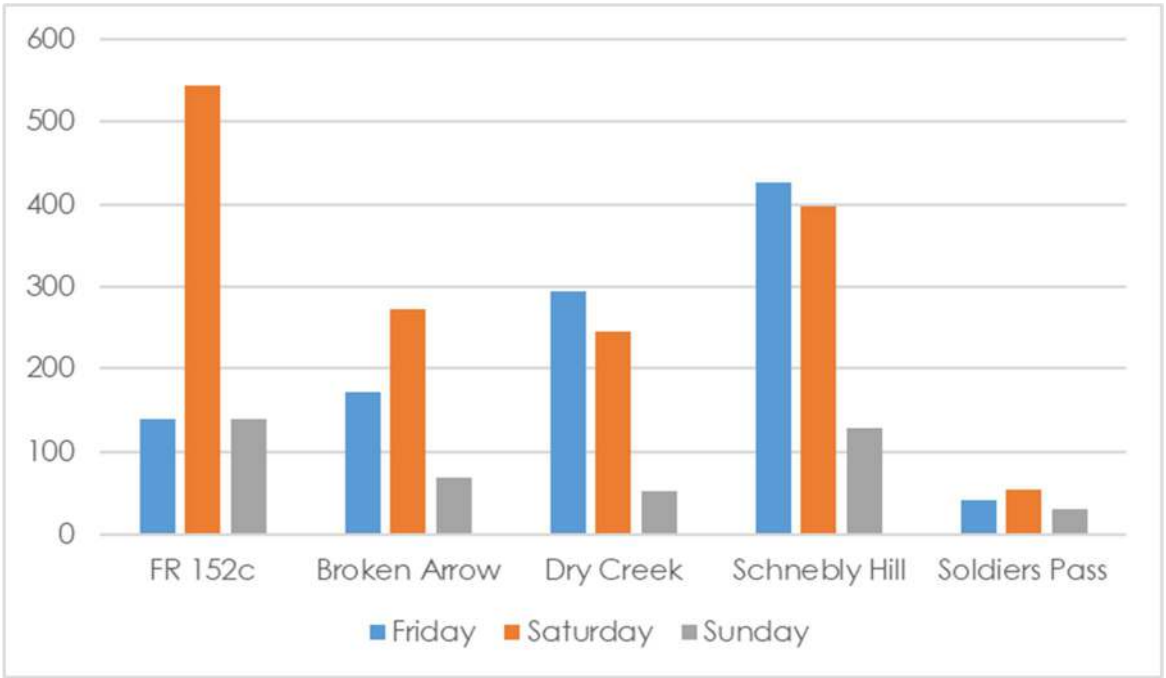


Figure C-13 and Figure C-14 show the maximum rolling one-hour averages for PM 2.5 average vehicle activity per hour, respectively, over each testing day.

FIGURE C-13. MAXIMUM ROLLING 1-HOUR AVERAGE PM2.5 CONCENTRATION

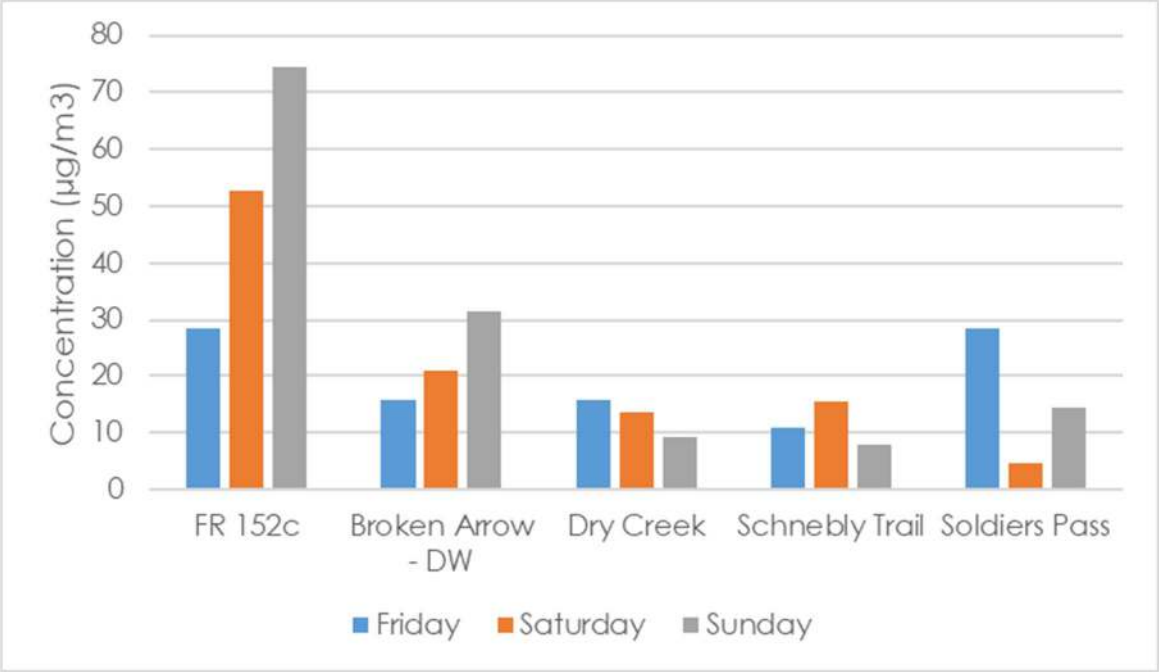
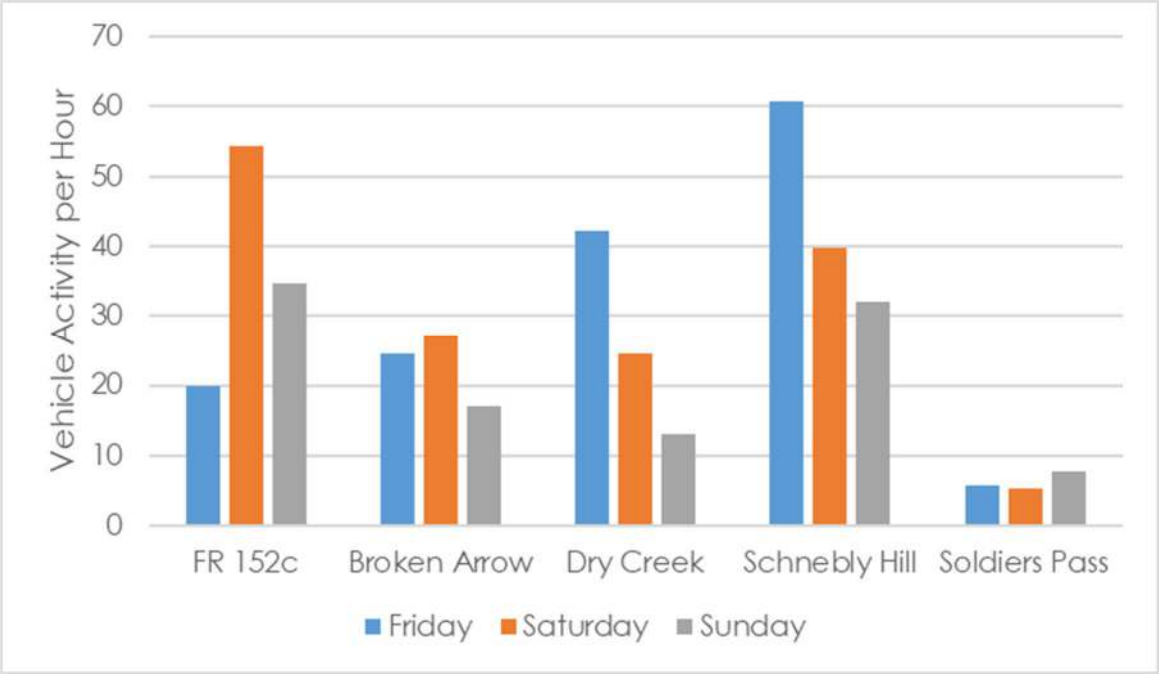


FIGURE C-14. AVERAGE VEHICLE ACTIVITY PER HOUR



Comparing the data side-by-side creates two distinct conclusions based on two environmental factors. The first conclusion is FR 152C and Broken Arrow show a strong correlation between PM concentrations and the drying of the road dirt between Friday and Sunday. The second is that Dry Creek and Schnebly Hill show a stronger correlation between vehicle activity and PM concentrations. This is likely due to the amount of paved road leading up to each trailhead. FR 152C and Broken Arrow have at least 200 feet of unpaved road leading up to the trailhead,

whereas Dry Creek and Schnebly Hill have paved roads leading up to the trailheads. This may allude that the reduced amount of unpaved road at the trailheads influences whether the silt loading or vehicle activity dominates the PM concentrations.

11 Discussion

PM10 levels had maximum 1-hour concentrations of over 75 µg/m3 and PM2.5 levels had maximum 1-hour concentrations of over 178 µg/m3. While 24-hour averages for both PM10 and PM2.5 were below the federal guidelines for human health impacts, exposure to PM levels above the federal guidelines has the potential to trigger acute health conditions in highly sensitive and sensitive individuals, even over exposure periods of less than 24 hours. Elevated levels of PM were measured at the FR 152C and Broken Arrow trails. However, only FR 152C Trail, on Sunday, had PM10 and PM2.5 exposure above the federal guidelines for more than one single hour. All other trailheads only exceeded federal guidelines for human health impacts for significantly less than the established 24-hour average.

There are two important caveats to the correlation between PM pollution and vehicle activity, as well as the severity of PM pollution as a result of vehicle disturbances.

Firstly, a recent rain event can effectively reduce particulate matter (PM) levels from vehicles on unpaved roads. Rainwater wets the road surface, suppressing PM generation and suspension. It acts as a binding agent, making particles cohesive and less likely to become airborne. Raindrops capture and settle airborne PM through increased gravitational force. Additionally, rainwater infiltrates and stabilizes the road surface, reducing loose materials and minimizing PM emissions. Since there was a rain event in the City of Sedona the day before measurements were taken, the combined effects significantly lowered PM levels, improving air quality and reducing human exposure to harmful particulate matter. The data shows an increase in both average and peak particulate levels as the unpaved roads began to lose moisture between Friday and Sunday across all trails. A follow-up field visit in the summer when ground moisture would be extremely low may show increased levels of PM as vehicles create ground disturbances.

Secondly, all PM concentrations were also measured only at the trailheads, where person activity only lasts a few minutes in any single geographic area. Since PM pollution dilutes as it travels, it is inconclusive to say if there is a health impact of PM on residents near the trails or for persons using the trails. Further study should include PM monitors at property lines near the five different trails to achieve an understanding on how OHV and on-road vehicle activity is directly affecting residents, where persons are likely to be stationary and experience one-hour and 24-hour PM exposure.