PALA BAND OF MISSION INDIANS

Transportation Climate Vulnerability Assessment

Pala Band of Mission Indians

TRIBAL TRANSPORTATION CLIMATE ADAPTATION PROJECT | VOLUME 1-A

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Funded by:

Caltrans

ACKNOWLEDGEMENTS

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1. EXECUTIVE SUMMARY

Extreme climate conditions can heavily influence transportation systems and the people that depend on them. This report (Volume 1-A) describes the findings of a vulnerability assessment conducted for the Pala Band of Mission Indians as part of the Tribal Transportation Climate Adaptation Project funded by Caltrans. It outlines current and anticipated transportation-related impacts of more extreme wildfires, storms, flooding, and heat on Pala's valued social, cultural, economic, natural, and built assets, with a strong focus on protecting the health and safety of members, residents, employees, and visitors to the Pala Reservation.

Based on data gathering, technical guidance, and community input, the report concludes that changing climate exposures including wildfire, storms and flooding, and temperature extremes will pose transportation-related vulnerabilities for Pala (see Section 3 "Vulnerability Findings"). Figure 1 outlines the vulnerabilities that represent the highest risks, which are further summarized and mapped in Section 4 "Summary of Key Vulnerabilities." A subsequent transportation-focused adaptation plan will identify feasible strategies that can help Pala better address these vulnerabilities (Volume 1-B).

Impact category	Vulnerability	Relevant Climate Change Exposures
Health and safety	Limited access to critical health/emergency services and evacuation (+ increased demand)	Wildfire, Storms and Flooding, and Extreme Heat
Health and safety	Increased road dust	Extreme Heat
Economy	Increasing costs to tribal government of road repair	Storms and Flooding
Economy	Limited access to key economic drivers	Wildfire, and Storms and Flooding
Natural resources	Impacts to ecosystems including habitat fragmentation and loss of culturally important plant and wildlife species	Storms and Flooding

Figure 1: Summary of transportation impacts from climate change at Pala

2. INTRODUCTION

The Pala Transportation Climate Vulnerability Assessment is a joint project with the Jamul Indian Village, part of the Tribal Transportation Climate Change Adaptation Project funded by Caltrans. Although the transportation sector is a known source of greenhouse gas (GHG) emissions contributing to climate change, this report does not focus on reducing emissions. Rather, it examines the most significant transportation-related vulnerabilities resulting from changing climate conditions affecting the Pala Band. Subsequently a Transportation Climate Adaptation Plan will outline strategies to reduce transportation-related risks and build resilience.

California's Fourth National Climate Assessment indicates that climate change poses a major risk to transportation systems throughout the United States, with regional and local differences. Pala, like many tribes, is located in a rural and remote area and is particularly vulnerable to climate change impacts on its limited transportation systems and other community assets that depend on it.

Pala has taken forward steps in understanding the severity and likelihood of climate change exposures, impacts, and vulnerabilities, including conducting the 2019 Climate Change Vulnerability Assessment[1] and the 2020 Local Hazard Mitigation Plan Update.[2] These efforts revealed that wildfire, extreme storms, flooding, elevated temperature, and drought present the most significant risks. For example, the California Department of Public Health predicts that 40% more land in San Diego County will become vulnerable to 100 and/or 500-year flood events by 2100. And despite heavy precipitation events, increasing dryness and strong Santa Ana winds will exacerbate wildfires, particularly from September through May, according to the California Fourth Climate Assessment: San Diego Report.[3]

Pala initiated the current project to support its efforts to identify specific risks and solutions for roads and other transportation-dependent systems. By seeking out and compiling community input, available data, technical guidance, and relevant literature, this report outlines current and anticipated transportation-related impacts to Pala's valued social, cultural, economic, natural and built assets, with a focus on protecting the health and safety of residents and visitors to the Pala Reservation. Key vulnerabilities are detailed in Section 3 under three key climate change exposures known to result in transportation damage, disruption, and congestion:

- **Wildfire** – affecting access to health and emergency services; and affecting access to economic drivers.
- **Storms and Flooding** – affecting access to health and emergency services; increasing road repair costs; affecting access to economic drivers; and causing damage to ecosystems.
- **Extreme Heat** – Affecting access to health and emergency services; and causing increased road dust.

Purpose

The purpose of this vulnerability assessment is to identify, evaluate and prioritize climate change impact risks related to multimodal transportation infrastructure in and around the Pala Reservation.

Vulnerability to climate change is the degree to which geophysical, biological, and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. Based on the findings of this report, the project team next will complete an adaptation plan to identify, evaluate, and prioritize strategies and

[1] Pala Band of Mission Indians, *Pala Climate Change Vulnerability Assessment* (2019), http://ped.palatribe.com/climate-change/climate-change-vulnerability-assessment/
[2] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)
[3] State of California, *California Fourth Climate Assessment - San Diego Region Report* (2018), https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf

specific actions to proactively remedy priority climate-related vulnerabilities. Those actions will aim to improve Pala's ability to prevent damage and costs, where possible, and to recover and repair damage after climate disruptions, toward the goal of strengthening the overall resilience of Pala's transportation systems and community.

Pala is committed to integrating resulting climate resilience and adaptation strategies into relevant tribal operations, plans, and decisions. Through this process, Pala is planning for a resilient transportation system that supports the uninterrupted health, safety, and prosperity of all living things at Pala amid a changing climate.

Background

The Pala Band has jurisdiction over the federally recognized Pala Indian Reservation that was established in 1875. The Pala Indian Reservation is located on approximately 13,000 acres in northern San Diego County, roughly 30 miles east of the Pacific Ocean. The Pala Reservation sits next to the Palomar Mountain range that runs along 5,000 square miles of California desert.

The 12,772-acre Pala Indian Reservation is a rural community with over 900 residents, 2,000 employees, and an average of 8,500 visitors on a daily basis. Pala completed a comprehensive *Climate Change Vulnerability Assessment* in 2019, a *Transportation Safety Plan* in 2020, a *Flood Mitigation Plan* in 2020, and a *Local Hazard Mitigation Plan* (LHMP) update in 2020, all of which have been used to inform this assessment.

Pala is located in an area historically prone to some level of wildfire, inland flooding, and heat. Surface waters within the reservation portion of the Pala Basin are mostly non-perennial (intermittent or ephemeral), occurring during and right after storm events. The reservation incorporates portions of the San Luis Rey River Valley; the intersecting tributary valleys of Marion Canyon, Magee Creek, Trujillo Creek, Pala Creek, Castro Canyon Creek, Agua Tibia Creek, Frey Creek, and Gomez Creek; and surrounding mountainous terrain. Bubble-Up Creek is on the south side of the reservation. The ephemeral San Luis Rey River flows generally to the west through the reservation, from where it enters at the east-central boundary to its exit at the west-central boundary. Several ephemeral tributary creeks drain south and southwestward into this river, and one ephemeral creek drains north from Pala Mountain to the river.[1]

Pala is experiencing increasing traffic on roads through the reservation, as well as changes in climate, and has recognized the need for coordination with the County of San Diego and Caltrans on shared transportation assets. Caltrans in 2020 awarded funding to support this project.

Pala's Transportation Systems and Assets

California State Highway 76 runs through the Pala Reservation and is the primary road used to enter or exit the reservation, which is located seven miles east of Interstate 15. The Pala Reservation has limited points of entry and exit, and has little access to public transportation, except for a private shuttle bus service. Many of the roads on the reservation are not owned by the Tribe, but instead are the responsibility of the County or Caltrans, making coordination a critical component of planning. By focusing on Pala's transportation needs, this report is intended in part to support cooperation among Pala, the County, and Caltrans to prioritize capital improvement projects based on community needs.

Pala has approximately 500 homes and 120 government, nonprofit, and commercial buildings and facilities spread throughout the reservation. One of the businesses – the Pala Casino and Resort – is a major economic enterprise that regularly has a high concentration of visitors and employees onsite, most of whom come from outside the local area. Pala has only one public transit option (NCTD bus 388), no sidewalks or bike paths, and

limited EV infrastructure. Many of the most important roads are used to access critical community facilities and economic assets such as the Pala Administration Building, Pala Fire Station, and wastewater treatment plant and lift station.

The historic Pala swinging bridge

The Pala Reservation is surrounded by mountains, and a large share of Pala's lands are located within a floodplain, while also being in a high wildfire hazard area. Only three routes provide access to and egress from the reservation, two of which are along State Highway 76. These routes become congested with heavy automobile traffic on a daily basis. Many roads and bridges throughout the reservation are aged, in need of repair, and located too close to wetlands and unstable slopes. An abundance of native and invasive wildlife species, wildlands habitat, and cultural resources can be found throughout the reservation, including along most of the roadways. Figure 2 provides a mapped inventory of Pala's transportation assets including roads, bridges, crossings, highways, and destinations.

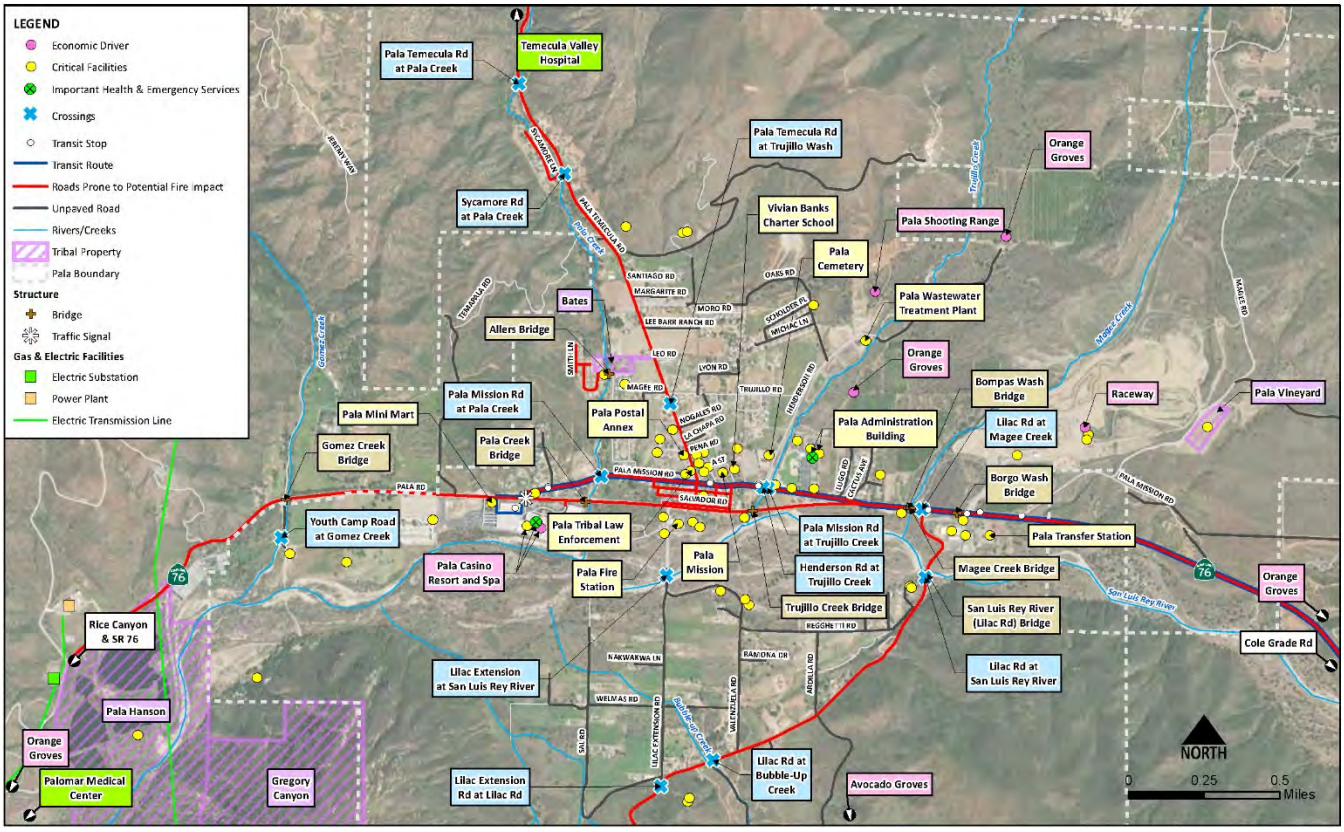

Figure 2: Mapped Inventory of Pala's Transportation Assets

Notes on Figure 2:

1) Annotation box colors coordinate with legend marker colors (*i.e.,* "Palomar Medical Center" is green and the legend marker to indicate "Health and Emergency Services" is also green.)
2) Sources: SanGIS Regional Warehouse (accessed July 2020), 2018 ACS 5-Year Estimates.

Figure 3 provides a full list of categorized transportation assets with community ranking of importance.[4] The relative importance of transportation assets was used to help determine the highest priority vulnerabilities in this assessment.

Transportation Assets	Importance Ranking
Roads	
Pala Temecula Road	High
Pala Mission Road	High
Lilac Road	High
Lilac Extension	High
Hwy 76 and Rice Canyon	High
Reghetti	Medium
Valenzuela	Medium
Moro Rd.	Medium
South Side Roads	Low
Cole Grade Road	Low
Highways	
Highway 76	High
Bridges	
Lilac Road Bridge	High
Allers Bridge	High
Trujillo Creek/Hwy 76	Medium
Pala Creek/Hwy 76	Medium
Magee Creek/Hwy 76	Medium
Gomez Creek/Hwy 76	Medium

Transportation Assets	Importance Ranking
Crossings	
Lilac Extension/SLR	High
Trujillo Creek/Pala Mission Road	High
Pala Creek/Pala Mission Road	High
Pala Creek/Pala Temecula Road	High
Sycamore	High
Lilac Road/Bubble Up Creek	High
Pala Rey Youth Camp/Gomez Creek	Low
Magee Creek/Lilac Road	Low
Trujillo Creek/Henderson Road	Low
Destinations	
Pala Administration Complex	High
Pala Casino	High
Pala Fire Department	High
Wastewater Treatment Plant	High
Pala Mini Mart	Medium
Pala Postal	Medium
Transfer Station	Medium
Vivian Banks School	Medium
Pala Mission	Low
Cemetery	Low
Shooting Range	Low
Tribal Law Enforcement (TLE)	Low
Pala Raceway	Low

Figure 3: Pala assets ranked by importance for climate hazard protection

[4] Pala community workshop, Dec. 7, 2020

3. VULNERABILITY ASSESSMENT APPROACH

The Pala Environmental Department (PED) led this assessment of potential transportation-related impacts of climate change on Pala, in collaboration with multiple tribal departments and with support from consultants at Prosper Sustainably and Kimley Horn. The assessment also incorporates input from Pala stakeholders, including community members, and partners Jamul Indian Village. The SB 1 Caltrans Adaptation Planning Grant program provided funding for this project.

3.1 Steps

Upon executing the Caltrans award, the PED executed all subcontracts. Prosper Sustainably assisted with overall project management, including facilitating regular project team meetings with PED, Jamul's environmental staff, and Kimley Horn. As detailed in the next section, the project team conducted initial public outreach and consulted with Pala's internal planning team. The project team compiled information from existing tribal reports, data, and other materials relevant to the assessment, with consideration and respect for traditional knowledge and any confidential or sensitive information, as well as publicly accessible climate and GIS data. Risks and vulnerabilities were analyzed using the evaluation criteria detailed in Section 2.3. The findings were presented to the planning team, which provided feedback that substantiated the ranked vulnerabilities presented in this report. The project team provided a draft of this report for review and input by the planning team as well as key stakeholders.

3.2 Community Engagement

Community engagement activities in this project included:

- Gathering community inputs through an online questionnaire (see Appendix A);
- Convening a community workshop on Dec. 7, 2020 (see input worksheet in Appendix B);
- Consulting with the Pala Environmental Department Advisory Group (PEDAG), comprised of staff from the Pala Casino, Pala Fire Department, Pala Utilities Department, Pala Learning Center, Pala GIS Specialist, Pala Tribal Services; and Pala community residents.
- Distributing the draft report for review and input by members of PEDAG, the Pala Executive Committee, and members of the Pala community.

Pala residents

3.3 Evaluation criteria

To determine the most significant vulnerabilities for Pala, the project team evaluated the severity and likelihood of the following climate risks:

- Climate exposure risk obtained from previous climate vulnerability and hazard analyses and new GIS models for temperature extremes, storms and flooding, and wildfire;
- Potential transportation-related impacts by climate exposure (see Figure 5), ranked and substantiated with input and information gathered from the Tribe and external sources; and
- Moderating factors including impacts to assets deemed most valuable (see Section 1.3), population sensitivity, and adaptive capacity or existing mitigation measures.

	Potential Transportation-Related Impacts Resulting from Climate Change	**Temperature Extremes**	**Storms and Flooding**	**Wildfire**
A.	Limited access to critical health/emergency services due to damage to roads			
B.	Increased demand for critical health/emergency services			
C.	Increase in accidents and collisions due to damage to roads			
D.	Limited access to key cultural sites on reservation due to damage to roads or bridges			
E.	Increase in costs to tribal government for repairing damaged roads			
F.	Limited access to key economic drivers (*e.g.,* tourism, agriculture, jobs) due to damage to roads			
G.	Limited access to key economic drivers (*e.g.,* tourism, agriculture, jobs) due to public transit problems associated with power outages or road damage			
H.	Limited access to evacuation and cooling/emergency centers in event of power outage due to increased congestion			
I .	Decrease in exercise due to limited use of active transportation (*e.g.,* biking or walking)			
J.	Increased demand to go to or deliver in water via roads			
K.	Limited access to go to or deliver in water via roads due to damage to roads			
L.	Increased demand to go to or delivery in food via roads			
M.	Limited access to go to or deliver in food via roads due to damage to roads			
N.	Impacts to ecosystems including habitat fragmentation and loss of culturally-important plant and wildlife species due to road or bridge damage and runoff			

Figure 4: Climate change impact evaluation criteria

To assess potential impact E., "Increased costs to tribal government for repairing damaged roads," Kimley Horn conducted a site visit, analyzed pavement conditions, and provided other cost estimate projections described in Appendix C.

These evaluation criteria were used to develop the findings outlined in the Section 3.2.2.5 under "Vulnerability Findings," which present Pala's key transportation-related impacts by climate exposure.

4 VULNERABILITY FINDINGS

As part of global climate-change trends, the regional climate is changing and affecting Pala's transportation systems and assets. Three key climate change exposures affecting transportation assets and systems on the Pala Reservation include: 1) wildfire; 2) storms and flooding; and 3) temperature extremes.[5] Vulnerabilities associated with each of these exposures are explained in Sections 3.1, 3.2, and 3.3. Respondents to the Pala community engagement survey[6] indicated that wildfire risk is the climate exposure that presents the greatest concern for Pala's transportation systems (Figure 5).

Climate Exposures	Concern about Impact	Perceived Threat to Transportation
Wildfires	1	1
Storms and flooding (including erosion and landslides)	2	2
Temperature extremes	3	3

Figure 5: Community survey exposure rankings

A key overarching concern voiced by the Pala community in the survey was the risk of isolation due to transportation problems during a climate event or other emergency (Figure 6).

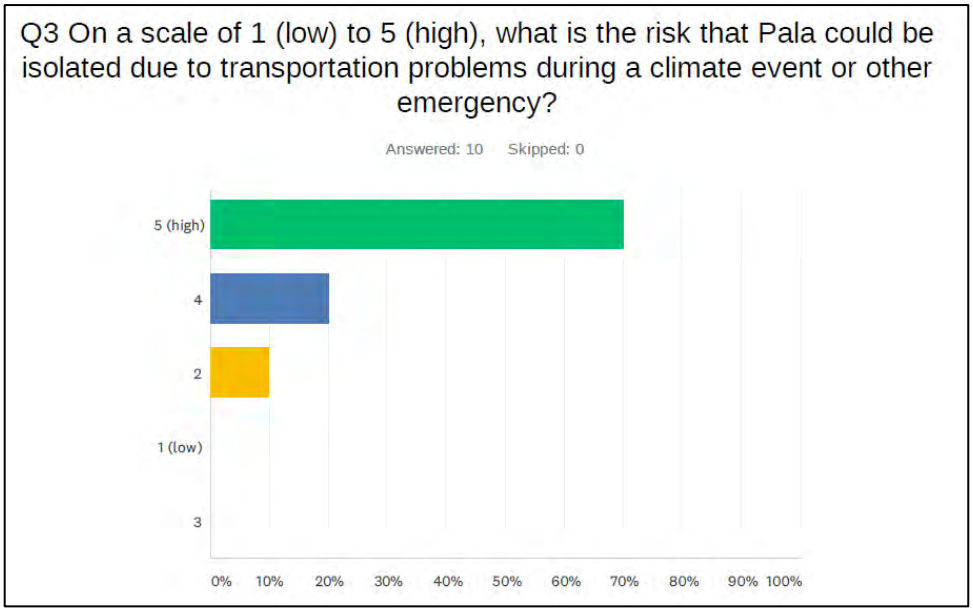

Figure 6: Community survey - isolation risk response

[5] While drought is a major climate change exposure for Pala, it was not deemed significant to Pala's transportation systems and assets. However, drought can make other climate impacts worse. Drier soils can result in larger and more intense wildfires. Higher temperatures can increase the impacts of drought, especially the effect of shrinking and swelling soils on roads and bridges. Lastly, large storms after a drought can result in more extreme flooding, as drier soils cannot immediately absorb floodwaters.

[6] Pala Band of Mission Indians, *Transportation Climate Adaptation Survey* (2020)

4.1 Wildfire

Changing climate conditions are driving more severe and frequent wildfires in the region. These changes are expected to adversely affect Pala's transportation systems, resulting in key vulnerabilities to Pala's health, safety, and economy, as described in this section. In addition, wildfires can make storms and flooding worse (see Section 3.2), and droughts and heat (see Section 3.3) can make wildfires more likely.

4.1.1 Climate Change and Wildfire Trends

The frequency of large forest fires in the western United States and Alaska has increased since the early 1980s and is projected to further increase in those regions as the climate warms.[7] Evidence also indicates that the fire season is getting longer in southern California.[8] Three of California's largest wildfires occurred in in San Diego County. According to the California Fourth Climate Assessment, the annual average area burned in San Diego County is expected to increase by up to 50% by the 2070 through 2099 time period.[9]

Wildfires are considered a high-risk exposure for the Pala Tribe, particularly in the Sycamore neighborhood. Pala's location currently is considered a fire hazard severity zone,[10] and 28.6% of the population of Pala's broader census tract currently occupies a very high wildfire risk zone.[11] Of the Tribe's 66 critical facilities, 45 are located in wildland urban interface (WUI) areas. These include the Pala Administration Building, which during emergencies is used for community sheltering.

The Pala Reservation landscape is characterized predominately by brush, desert shrubs, and tree groves, which are susceptible to wildfires. Tree mortality due to drought and pest infestations creates more fuel for wildfires. As a result, the area faces the possibility of large fires spanning several square miles. Until recently, large, high intensity fires occurred regularly but infrequently in the region due to the low frequency of natural ignition sources. As urbanization increased in the area, human-caused ignitions have increased dramatically.

From 1910 through 2019, at least 39 fires affected Pala. Recent fires have burned significant portions of Pala's lands and have forced evacuations at the Pala Casino Spa and Resort.[12] Major fires in 1997 (Pala Wildfire), 2004 (Warner Wildfire), and 2010 (Pala 5 Wildfire) burned more than 10,000 acres on the reservation.[13] Wildfire risks at Pala are increasing due to climate factors, including Southern California's

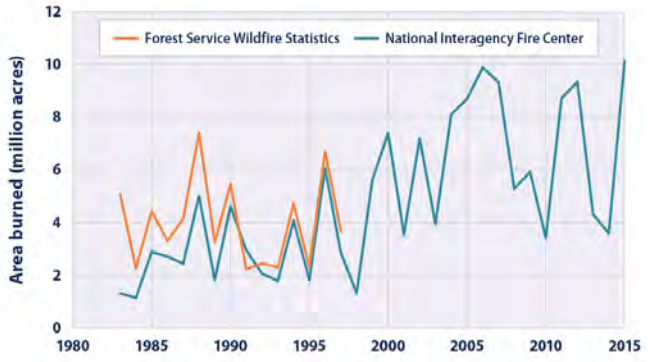

Figure 7: U.S. Wildfire Trends

[7] U.S. Global Change Research Program, "Droughts, floods, and wildfires," *Climate Science Special Report: Fourth National Climate Assessment, Volume I* (2018), https://science2017.globalchange.gov/chapter/8/
[8] State of California, *California Fourth Climate Change Assessment - Los Angeles Region Report* (2018), p. 53
[9] State of California, *California Fourth Climate Change Assessment - San Diego Region Report* (2018)
[10] California Department of Public Health, Office of Health Equity, *Climate Change and Health Profile Report - San Diego County* (2017), https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHPRs/CHPR073SanDiego_County2-23-17.pdf
[11] California Department of Public Health, Climate Change and Health Equity Section - CalBRACE Project, *Climate Change & Health Vulnerability Indicators for California (CCHVIz),* (2021), https://skylab.cdph.ca.gov/CCHVIz/
[12] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2016)
[13] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

intense Santa Ana winds,[14] increasing temperatures, and more severe drought conditions resulting in drier autumns and more dead vegetation fuel. In addition, high wildfire risks prompt San Diego Gas & Electric to implement Public Safety Power Shutoffs (PSPS), which may cause extended outages across the reservation.

Even more concerning, wildfires can lead to rapid erosion and flooding, especially during winter storms that are becoming more intense due to climate change. Where vegetation is destroyed by fire, heavy rainfall causes severe erosion and landslides in some locations. Without trees and other plants to retain the soil, stormwater erodes the land and carries soil and debris into nearby waterways, in some cases sending entire hillsides down into roads and waterways. Large rain events after wildfires have in the past caused extensive flooding and mudslides on the reservation.

4.1.2 Wildfire and Transportation Impacts

Wildfires and related smoke, ash, and PSPS events and other utility outages can cause short- and long-term transportation problems for Pala, affecting the Tribe's health, safety, and economic security, among other vital resources.

Fire debris-saturated flood waters following the 2007 Poomacha Wildfire.

Wildfire can directly damage roads, bridges, signs, streetlights, public transit, and other transportation infrastructure. Even the threat of wildfire can cause disruption, given the utility's PSPS protocols. Power outages disrupt streetlights and public transit, as well as access to information about the status of fire danger. As shown in the Caltrans diagram in Figure 8, wildfire also can destabilize nearby soil and groundcover and produce debris that can clog culverts during rainfall events.

Damage, disruption, or closure of transportation infrastructure can interrupt or impair mobility and accessibility to the reservation for residents, visitors, and service providers; it also affects wildlife by disrupting animals' regular migration and movement patterns across affected thoroughfares. Additional traffic and congestion may occur when residents and visitors are abruptly displaced due to dangerous air quality or evacuation orders. This factor causes increasing concerns, because Pala reports that congestion is already a regular problem at specific junctions (see Figure 10). In addition, egress routes are constrained on the Pala reservation, with bottlenecks and limited routes making it difficult for residents, workers, and visitors to evacuate the reservation or reach their homes. Most notably, Highway 76, the main route in and out of the reservation, traverses an area of high and very high wildfire risks.

Repairing roads, signs, electrical systems, culverts, and other infrastructure after a wildfire can be costly in terms of time and money. Pala depends on the County of San Diego and Caltrans to maintain paved highways that traverse the reservation. As a result, the County and Caltrans are responsible for repairing highways damaged by wildfire. Most of the roads maintained by the Pala General Services Department are unpaved and relatively impervious to the direct effects of wildfires. As a result, the assessment team determined that direct costs of road damage due to wildfire generally are nominal for Pala. More concerning and costly are the combined

[14] State of California, *California Fourth Climate Change Assessment - San Diego Region Report* (2018)

impacts of wildfire followed by heavy rains and flooding. Those combined effects are discussed further in Section 3.2, focusing on vulnerabilities due to storms and flooding.

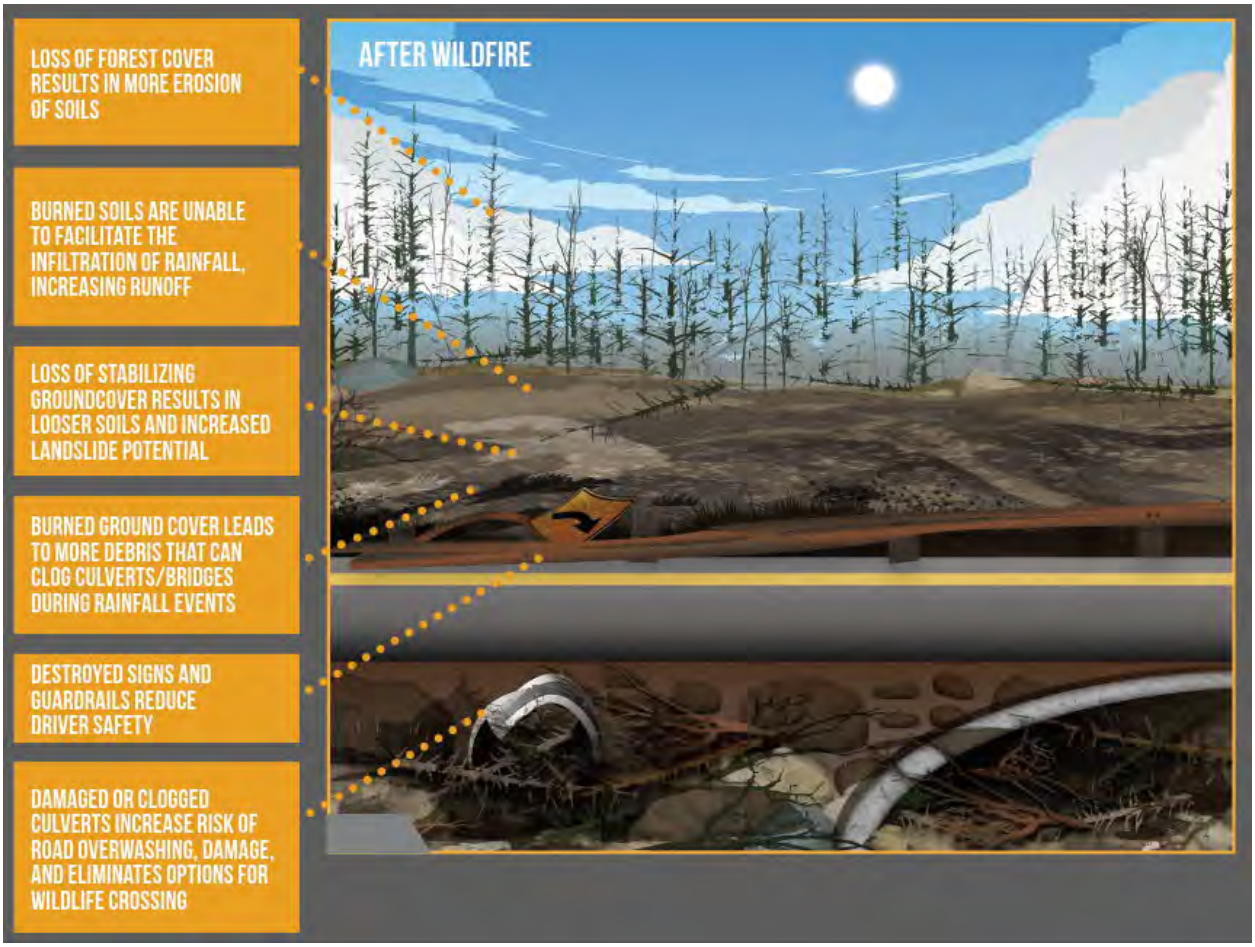

Figure 8: Post-wildfire flood risks (Caltrans, 2019)

4.1.2.1 Community Wildfire Observations

Pala survey respondents ranked wildfire as the highest climate exposure risk. Survey respondents indicated they had experienced road or bridge closures, traffic congestion, household displacement, and inability to enter or leave the reservation as a result of past wildfires (Figure 9). One respondent remarked ***"negative experiences will occur over and over again due to wildfires because of where Pala is located, what surrounds Pala, the condition of Pala's roads, and the limited access residents have to transportation in Pala***."[15]

During the 2014 drought, tribal members noted that the drought was killing trees, which could lead to greater wildfire risk and fuel loading.[16]

4.1.3 Pala's Key Wildfire-Related Transportation Vulnerabilities

As wildfires become more frequent and severe in the region, the two transportation-related impacts outlined in this section represent the most significant vulnerabilities to Pala resulting from wildfire:

[15] Pala Band of Mission Indians, *Transportation Climate Adaptation Survey* (2020)
[16] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

- Wildfire Vulnerability #1: Limited access to critical health and emergency services and evacuation (Impact to Health and Safety)
- Wildfire Vulnerability #2: Limited access to key economic assets and resources (Impact to Economy)

Figure 10 displays a projected wildfire hazard map for the year 2050[17] overlaid with Pala assets and spatial data relevant to wildfire-related transportation vulnerabilities.

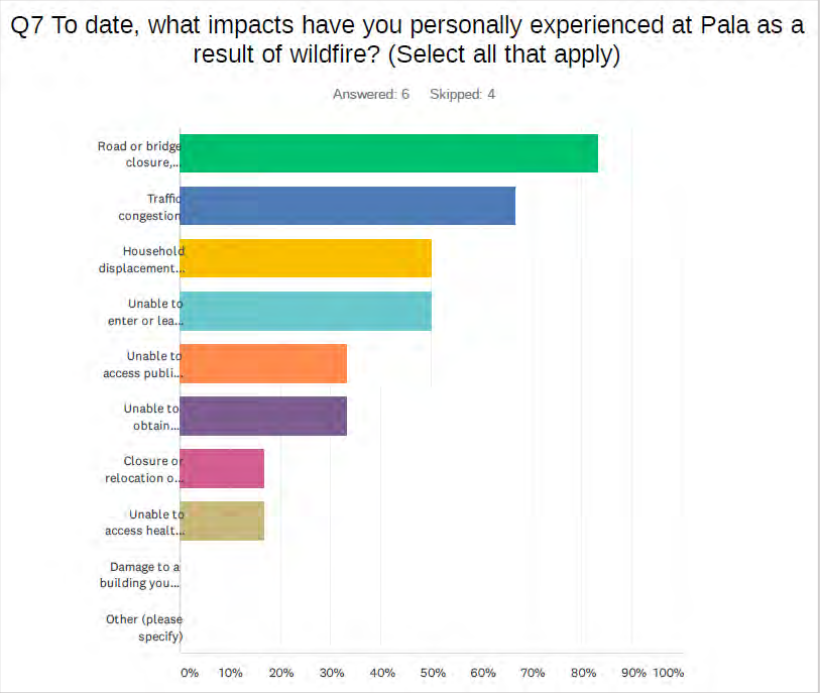

Figure 9: Survey responses on wildfire experiences

[17] California Department of Forestry and Fire Protection (CalFire), (accessed December 2020), https://frap.fire.ca.gov/mapping/gis-data

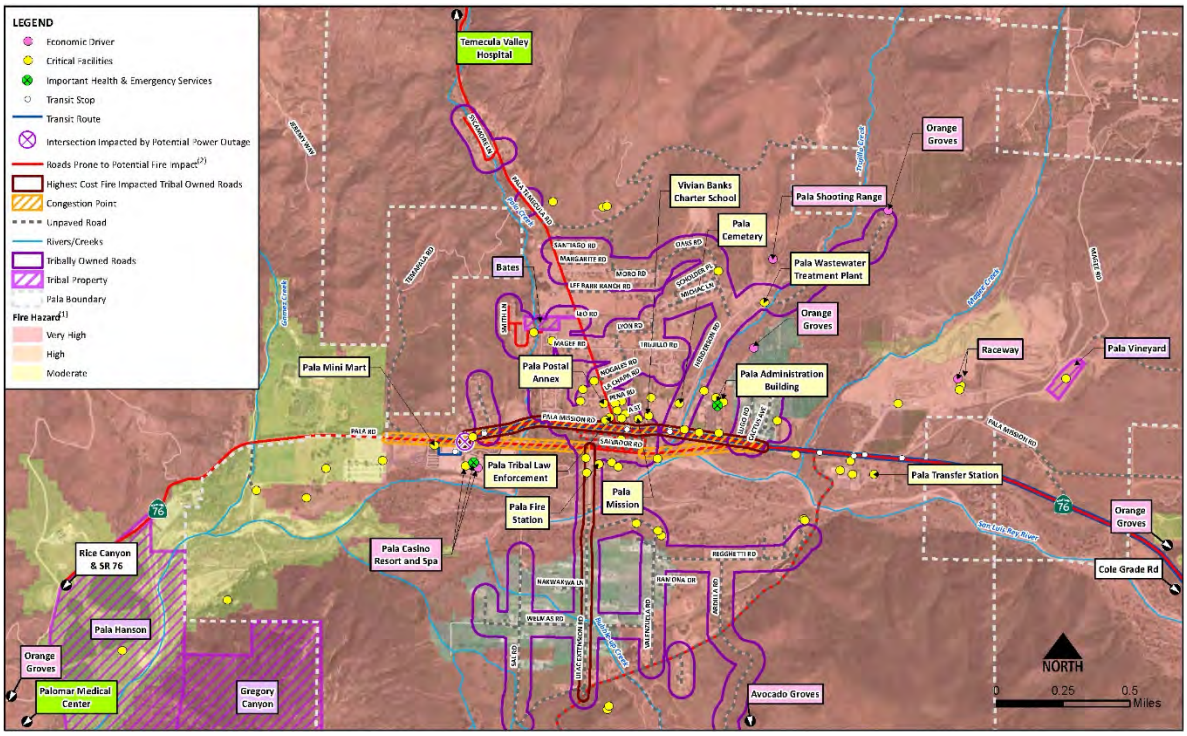

Figure 10: Wildfire Vulnerability Map

Notes on Figure 10:

1) Wildfire Risk: The number of dry spells is expected to stay roughly the same, but the average duration of dry spells is projected to increase by 45.5 days annually (average between a 33-day decrease and a 124-day increase in duration).
2) Data provided by Pala Band of Mission Indians.
3) Annotation box colors coordinate with legend marker colors (i.e., "Palomar Medical Center" is green and the legend marker to indicate "Health and Emergency Services" also is green.)
4) Sources: California Department of Forestry and Fire Protection, SanGIS Regional Warehouse (accessed July 2020), 2018 ACS 5-Year Estimates.

Wildfire Vulnerability #1: Limited access to critical health and emergency services and evacuation (Impact to Health and Safety)

Pala administrators are very concerned about the potential for wildfire to limit resident and visitor access to critical health and emergency services. During and after a wildfire on or near the reservation, Pala may experience road damage or closure, worsened congestion, and power outages, which can disrupt vehicle mobility to, from, and within the reservation, including personal cars, public transit, ambulances, fire trucks, police, and utility vehicles. These disruptions can cut off access to homes, businesses, and healthcare centers (*e.g.,* Temecula Valley Hospital or Palomar Medical Center) and impede medical or tribal, county, or state emergency response efforts. At the same time, Pala may experience an abrupt increase in demand for mobility during a fire event if residents or guests are displaced due to hazardous air quality or evacuation orders, or if significant numbers of individuals need medical attention due to traumatic injuries or respiratory problems,[18] exacerbated by existing traffic congestion and access constraints.

Why is this vulnerability significant to Pala?

[18] Tracking California website: https://www.trackingcalifornia.org/climate-change/wildfires

Recent fires have burned significant portions of Pala's lands and have forced evacuations at the Pala Casino Spa and Resort.[19] Tribal residents have voiced concerns about being "trapped" during disasters. Pala administration staff indicate that "being stuck is as much of a problem as being evacuated" and that "key people cannot get in." Figure 10 illustrates the following areas relevant to this vulnerability: important health and emergency services; roads prone to potential fire impact; intersections potentially affected by outages; transit stops and routes; and traffic congestion points.

Pala-area fires including the Pechanga Wildfire (2000) and the Poomacha Wildfire (2007) have threatened Pala residents and visitors. During the Poomacha Wildfire, approximately 400 Pala tribal members were first evacuated to the Pala Casino but later needed to be evacuated to the Pechanga Casino, which is operated by the Pechanga Band of Luiseño Indians in Temecula. Evacuees were sent to homes of relatives, as well as hotel rooms and RV spaces donated by Pechanga.

Case Study

Increasing California Fires and Evacuations

From 2017 to 2019, 11 large-scale wildfires in California each required the evacuation of 10,000 or more people. In most cases, local agencies and resources were overwhelmed by the speed and scale of the fires. In all, approximately 1.1 million people were ordered to evacuate. Analysis of the 11 wildfires showed the following key challenges: difficulties in communicating evacuation orders to residents; heavy traffic congestion due to masses of personal vehicles evacuating at the same time; limited assistance from transit agencies in evacuating residents; roadway and debris impediments; extremely limited public shelter space; and lack of formalized re-entry plans.

Although California has seen increasing incidence and severity in recent years, wildfires are a long-term phenomenon affecting the state. For example, many wildfires resulted from the drought of 2011 to 2017, one of the most notable being the 2016 Blue Cut Fire in Cajon Pass. The Blue Cut Fire jumped I-15 in Caltrans District 8 and destroyed 318 homes and other buildings, multiple vehicles, and highway infrastructure. The fire burned 36,274 acres near I-15 and Highway 138 north of San Bernardino, forcing road closures and eliminating access before it was contained. (Source: Western Riverside Council of Governments and San Bernardino Transportation Authority, *Climate Resilient Transportation Infrastructure Guidebook,* *https://wrcog.us/DocumentCenter/View/7230/Climate-Resilient-Transportation-Infrastructure-Guidebook*)

Pala has three access routes in and out of the reservation. Highway 76 is the main access road. Lilac Road is difficult to access, and Pala Temecula Road, the route to the closest hospital, is impassable during seasonal flooding when Pala Creek rises, preventing the most direct and quickest access to essential services. Additionally, the route to the nearest hospital, in Temecula, is a section of Temecula Parkway (California State Route 79) that is vulnerable to wildfires. These constraints limit or prevent residents and visitors from escaping danger or accessing healthcare services, and may delay or prevent rescue and recovery efforts. In extreme cases, air ambulance services for Pala residents and visitors are available from Mercy Air.

Congestion problems on Pala Road and Pala Mission Road present a challenge to allowing large numbers of vehicles to travel out of the reservation during an emergency, especially when there are many guests at the Pala Casino and Resort. Some guests arrive via public transit or private shuttles owned by Pala, which poses an additional threat to health and safety due to limited capacity. However, these vehicles also can be useful if needed to transport people quickly.

During a fire, many residents shelter in place, which may reduce dependence on roads to evacuate while increasing dependence on roads for mobility and emergency vehicle access within the community. Most of

[19] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2016)

Pala's residents live in neighborhoods in the northwest area of the reservation such as the Village, Allers, Moro Rd, Oaks, Remijillo, and Trujillo Rd neighborhoods.[20] The roads in these neighborhoods are located on either side of Pala Temecula Road and Pala Mission Road, which are key access points in and out of the reservation. Other critical roads for emergency access include California State Route 76, Lilac Road, and Lilac Extension.

Pala gets most of its power from SDG&E, with limited backup power for critical facilities, leaving the Tribe vulnerable to extended outages. As PSPS events continue plaguing California's utility system, extended outages could leave Pala residents without power or access to critical services. Lack of access to air conditioning, air filtration, and electricity-dependent medical equipment may cause additional health problems and create further transportation needs. The use of portable generators during outages also creates risks of carbon monoxide poisoning.[21] Power outages due to PSPS events and wildfires on and near the reservation could affect the operation of lights at intersections and contribute to increased congestion and accidents, exacerbating healthcare access concerns.

Wildfire and smoke create the risk of traumatic injury, illness, or even death. Prolonged exposure to wildfire smoke-related air pollutants, including particulate matter (PM), has been associated with a wide range of human health effects, including cardiovascular consequences, early deaths, low infant birth weight, and acute respiratory illness.

Of the Pala Tribe's 66 critical facilities, 45 are located in wildland urban interface areas. These include the Pala Administration Building, which is used for a community evacuation shelter.

Nearly one-third of Pala's population lives in a high-risk wildfire area. People with existing health conditions or disabilities may be at greatest risk of smoke-related respiratory illness or injury, and their conditions may affect their ability to evacuate quickly in an emergency. At Pala, 5% of the population is physically disabled.[22] People

Case Study

Karuk Tribe: Limited Evacuation Routes and Multiple Hazards

High intensity wildfire presents risk to travel throughout Karuk territory due to road closures directed by Forest Service and California Department of Forestry and Fire Protection (CalFire) during fire events, and from flooding and landslides in the immediate aftermath of high-intensity fires. Road closures during wildfire events cut off the community from the outside, potentially affecting escape routes and access to emergency services, food, and vital supplies. In the aftermath of high-intensity fires, erosion, flooding, and landslides may occur as increased sediment causes landslides onto roadways. Increased sediment and debris can block culverts, causing further flooding that can damage or destroy travel routes.

The increased likelihood of high-intensity wildfires due to climate change affects the Karuk Tribe transportation department in various ways. As multiple routes traverse the heavily forested Karuk territory, high-intensity fire events create short-term emergencies and road closures as well as long-term damage to facilities and infrastructure. Despite inadequate funding resources, the Karuk DOT must develop and adhere to multiyear monitoring and maintenance schedules directly associated with site-specific road and infrastructure stabilization, drainage, and debris removal during and after high-intensity fire events. (Source: Karuk Tribe Department of Transportation, *Karuk Tribe Climate Vulnerability Assessment: Assessing Vulnerabilities from the Increased Frequency of High Severity Fire,* Ch. 4 (2016), https://karuktribeclimatechangeprojects.com/chapter-4-high-severity-fire-and-vulnerabilities-to-program-capacity/)

[20] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2016)
[21] Pala Band of Mission Indians, *Pala Climate Change Vulnerability Assessment* (2019)
[22] Public Health Alliance of Southern California, *The California Healthy Places Index (HPI)* (Accessed 2018), https://healthyplacesindex.org/data-reports/

with chronic health conditions also may have difficulty accessing regular health services (*e.g.,* dialysis, ventilators) during a wildfire, placing them at additional risk. And vulnerable populations may lack access to personal vehicles or telecommunications to receive emergency notifications or call for help. These populations may require additional assistance during a wildfire.

Wildfire Vulnerability #2: Limited access to key economic assets and resources (Impact to Economy)

Pala is concerned that wildfire will limit access to the economic assets and resources that are vital to sustaining prosperity and livelihoods for tribal members, residents, and employees. Unlike natural disasters that occur over a few minutes or days (*e.g.,* tornadoes, earthquakes, and hurricanes), wildfires often last weeks or months. During and after a wildfire on or near the reservation, Pala may experience road damage or closures, worsened congestion, and power outages, which can disrupt vehicle mobility to, from, and within the reservation, including personal cars and supply or service vehicles necessary to sustain business operations. Wildfires can disrupt employment and earnings in natural resource management and tourism sectors, and reduce business sales and revenue throughout the reservation, which for Pala means less income for tribal government and tribal members.

Pala Casino and Resort

Why is this vulnerability significant to Pala?

As noted, recent fires have burned substantial portions of Pala's lands and have forced evacuations at the Pala Casino Spa and Resort. As the Tribe's primary economic driver, casino operations present its biggest economic vulnerability given the potential for significant losses. When employees and guests cannot access the casino, or when it must be closed or evacuated, the revenue losses to Pala can be as much as $500,000 per day, according to casino management. During the COVID-19 pandemic, the Pala Casino and Resort was closed for 32 days, leading to major economic losses for the Tribe.

Case Study

White Mountain Apache Tribe: Lost tourism income

The White Mountain Apache Tribe sells hunting permits on its reservation. In past years, permit sales have grossed as much as $975,000 for the tribe. Habitat damage, closure of burned areas, and aesthetic impacts from wildfires may reduce these revenues in coming years. The tribe also operates the Hon Dah Casino on the reservation. Closure of the casino due to the Rodeo-Chediski Fire in 2002 cost an estimated $3.3 million through September 2002. (Source: Arizona Department of Health Services, *Public Health Assessment – Rodeo-Chediski Fire* (2002), https://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/environmental-toxicology/rodeo_chedeski_assmnt.pdf)

Because the casino is a significant employment and economic center for the Tribe, Pala tribal members depend on it for their quality of life. Losing access to the benefits of the casino due to transportation disruption related to wildfires can have significant impacts on people and families.

In addition to the Pala Casino and Resort, Pala also operates other revenue-earning businesses. These include the Pala Raceway, a shooting range, a vineyard, and avocado and citrus groves. If access to the vineyard or groves were limited for any prolonged period of time, Pala would have difficulty mobilizing employees and needed agricultural supplies to sustain business operations, and also may encounter difficulty distributing crops in a timely manner, leading to substantial revenue losses. For example, Roberts Ranch annually produces crops that generate between $400,000 to $1.5 million in revenues, some portion of which may be threatened in emergency circumstances that impede access.

4.1.4 Existing Mitigation Measures

The following measures already are being implemented at Pala, demonstrating some level of resilience or capacity to adapt that can help mitigate these three impacts to transportation systems and infrastructure.

Strategy	Access to Health and Emergency Services	Costs to Tribal-owned Roads	Access to Economic Drivers
Evacuation routes and procedures for each direction	✓		
Tribal Law Enforcement weed abatement, controlled burns, and defensible space*		✓	✓
Air ambulance	✓		
Grading Lilac roads		✓	
Emergency communications and coordination with Caltrans	✓		
Alert app	✓		
Onsite emergency shelters (*e.g.,* Pala Casino)	✓		
Back-up power systems at Pala Casino and grant funding for solar + storage microgrids at Pala administration facilities	✓		✓
Water tanks that support most of reservation designed to withstand fires and flood	✓		✓
Wildfire education	✓	✓	✓
GIS of fire footprints	✓	✓	✓

Figure 11: Existing mitigation strategies for wildfire in relation to community concerns

*The Tribe intends to maintain 100 feet of defensible space around the Pala Casino Resort & Spa, but trees currently are growing in the San Luis Rey River floodway. The trees cannot be removed because they are part of habitat for a protected species in the area.

In addition to the mitigation strategies described in Figure 11, the Tribe's stream gage early warning system provides advance notice of potential for floods that occur after fires (see Section 3.2.3).

4.2 Storms and Flooding

Changing climate conditions are driving more severe storms and flooding at Pala. These changes are anticipated to adversely affect Pala's transportation systems, resulting in key vulnerabilities to Pala's health, safety, economy, and natural resources, as described in this section. In addition, storms and flooding can exacerbate wildfire impacts (see Section 3.1), and droughts can make flooding events more severe.

4.2.1 Climate Change and Storms and Flooding Trends

Extreme rainfall events are becoming increasingly frequent and severe in the United States as a result of climate change. Severe storms can trigger flash floods along smaller rivers and creeks, prolonged flooding along major rivers, and urban flooding, especially when exacerbated by sea level rise.[23] The EPA projects the number of 100-year floods in the contiguous United States will rise steadily for the remainder of the century under high emission scenarios.[24]

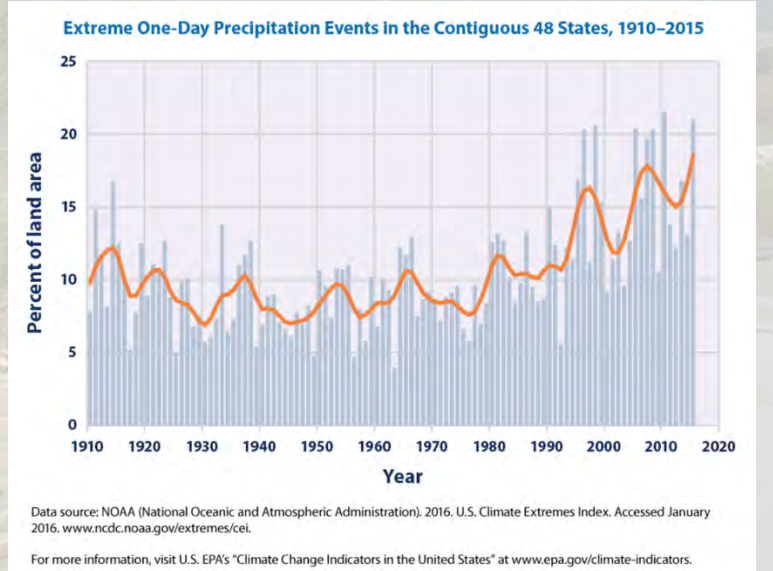

Figure 12: U.S. Extreme Precipitation Events

In San Diego County, the drying expected with increased drought intensity and longer seasonal dry periods is offset with a projected increase in the wettest days (see Figure 12) – a phenomenon known as "weather whiplash." As part of the trend, storms will be less frequent and occasionally stronger.[25] Greater drought conditions and lower soil moisture lead to flash floods in inland areas, as well as mudslides and landslides, especially in areas recently affected by wildfire. California Department of Public Health (CDPH) predicts that by 2100, 50% more land in San Diego County will become vulnerable to 100-year and 500-year flood events.

Flooding is a serious concern for Pala. Flooding events are common and associated with water drainage problems on the reservation. Minor flooding, often along Pala Temecula Road, occurs frequently during rainfall events, especially during winter months. Surveyed community members observe that less rainfall is happening in general.[26] However, according to Pala staff, rain events are becoming more intense on the reservation, causing flooding that rises and falls quickly.[27] The Pala Environmental Department tracks rainfall, water flows, and river and stream levels, as well as storm damage and flooding at multiple locations on the reservation.[28]

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[23] U.S. Global Change Research Program, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,* Ch. 4: "Impacts of Extreme Events on Human Health" (2016), https://health2016.globalchange.gov/extreme-events

[24] U.S. EPA, Multi-Model Framework for Quantitative Impacts Analysis: A Technical Report for the Fourth National Climate Assessment (2018), https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OAP&dirEntryId=335095

[25] California Energy Commission and California Natural Resources Agency, *San Diego County Ecosystems: The Ecological Impacts of Climate Change on a Biodiversity Hotspot, A Report for California's Fourth Climate Change Assessment* (2018), https://www.energy.ca.gov/sites/default/files/2019-12/Biodiversity_CCCA4-EXT-2018-010_ada_0.pdf

[26] Prosper Sustainably, *Pala Climate Vulnerability Experiences and Priorities Survey* (2018)

[27] Prosper Sustainably, Pala staff comments during 5/22 workshop (2018)

[28] Pala Environmental Department, 2017-2018 Log for Storm Events (2018)

Some hillsides within the reservation are vulnerable to landslides. Flooding is a regular occurrence, with six major flood events occurring between 1916 and 2014,[29] and with events in 1998, 2005, 2010, 2017, 2019, and 2020 flooding roads, causing property damage, and trapping residents. In addition to flooding, other storm-related hazards at Pala include strong wind events and thunderstorms.[30] One survey respondent remarked "(Floods are) more frequent than wildfire, but less scary."[31]

4.2.2 Storms, Flooding, and Transportation Impacts

Storms and related flooding, landslides and debris flow, erosion, runoff, and power outages can cause short- and long-term transportation problems, affecting the Tribe's health, safety, natural resources, and economic security, among other vital resources.

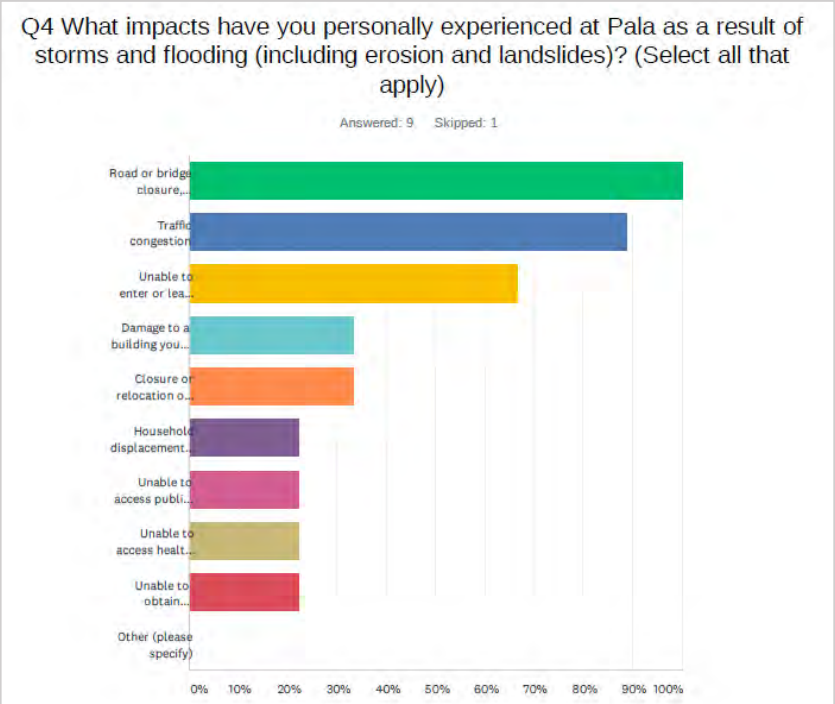

Figure 13: Survey responses on storm and flooding experiences

Storms and flooding can damage roads, culverts, bridges, signs, and other transportation infrastructure. Flooding can accelerate erosion, compromising transportation infrastructure. Downstream flooding can be exacerbated by past fires, and elevated flood risks can persist for several years after a fire (see Section 3.1.1). Repairing roads, signs, electrical systems, culverts and other infrastructure after a storm or flood can be costly in terms of time and money. Pala depends on the County of San Diego and Caltrans to maintain paved highways that traverse the reservation. As a result, the County and Caltrans are responsible for repairing highways damaged by storms and flooding. Anticipated storm and flood-related increases in Pala's road repair costs are discussed in Flooding Vulnerability #3 below.

Damage, disruption, or closure of transportation infrastructure can interrupt or impair mobility and accessibility to the reservation for residents, visitors, and service providers; it also affects wildlife by disrupting their regular migration and movement patterns across affected thoroughfares. Additional traffic and congestion may occur when residents and visitors are abruptly displaced due to flood danger or evacuation order. This factor causes increasing concerns, because congestion already is a regular problem at specific junctions (see Figure 14). In addition, egress routes are constrained on the Pala reservation, with bottlenecks and limited routes making it difficult for residents, workers, and visitors to evacuate the reservation or reach their homes.

Electrical equipment and other facilities also may become inundated, disrupting service to such infrastructure as traffic signals. If power infrastructure is damaged, outages can disrupt streetlights and public transit, as well as access to information about the status of road conditions and flood danger.

[29] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)
[30] Pala Band of Mission Indians, *2016 Hazard Mitigation Plan Update* (2016)
[31] Pala Band of Mission Indians, *Transportation Climate Adaptation Survey* (2020)

4.2.2.1 Community Storm and Flooding Observations

Pala survey respondents all reported experiencing road or bridge closures due to storms and flooding, as well as traffic congestion, obstructed routes, inability to enter or leave their homes, and building damage caused by storms and flooding (Figure 13). The survey indicated that storms and flooding-related transportation experiences most commonly resulted in consequences to natural resources and health.[32]

Several community members noted that they had been stuck at the casino or unable to get to work due to flooding. One respondent remarked that ***"it floods every year in Pala, making it difficult to get to and from homes, work, medical services, etc. In 2019, it took me almost two hours to get to work one day, and then we all had to leave early or we would've been stuck in Pala for the afternoon or evening. Every year I worry that my car won't make it to work, or home from work, due to flooding in Pala."***

Another respondent shared that ***"During heavy rainfall, there is the potential for two of the main roads accessing the reservation being flooded out and impassable."*** A respondent specifically pointed to Pala-Temecula Road near Sycamore as a place that had been washed out.

4.2.3 Pala's Key Storm and Flooding Transportation-related Vulnerabilities

As storms and flooding become more frequent and severe in the region, the four transportation-related impacts outlined in this section represent the most significant vulnerabilities to Pala resulting from storms and flooding:

- Storm and Flooding Vulnerability #1: Limited access to critical health and emergency services and evacuation routes (Impact to Health and Safety)
- Storm and Flooding Vulnerability #2: Limited access to key economic drivers (Impact to Economy)
- Storm and Flooding Vulnerability #3: Increase in costs to tribal government for repairing damaged roads (Impact to Economy)
- Storm and Flooding Vulnerability #4: Impacts to ecosystems (Impact to Natural Resources)

Figure 14 illustrates a projected storm and flooding hazard map for the year 2050[33] overlaid with Pala assets and spatial data relevant to Pala's storm and flooding-related transportation vulnerabilities.

[32] Pala Band of Mission Indians, *Transportation Climate Adaptation Survey* (2020)
[33] California Department of Forestry and Fire Protection (CalFire) (accessed December 2020), https://frap.fire.ca.gov/mapping/gis-data

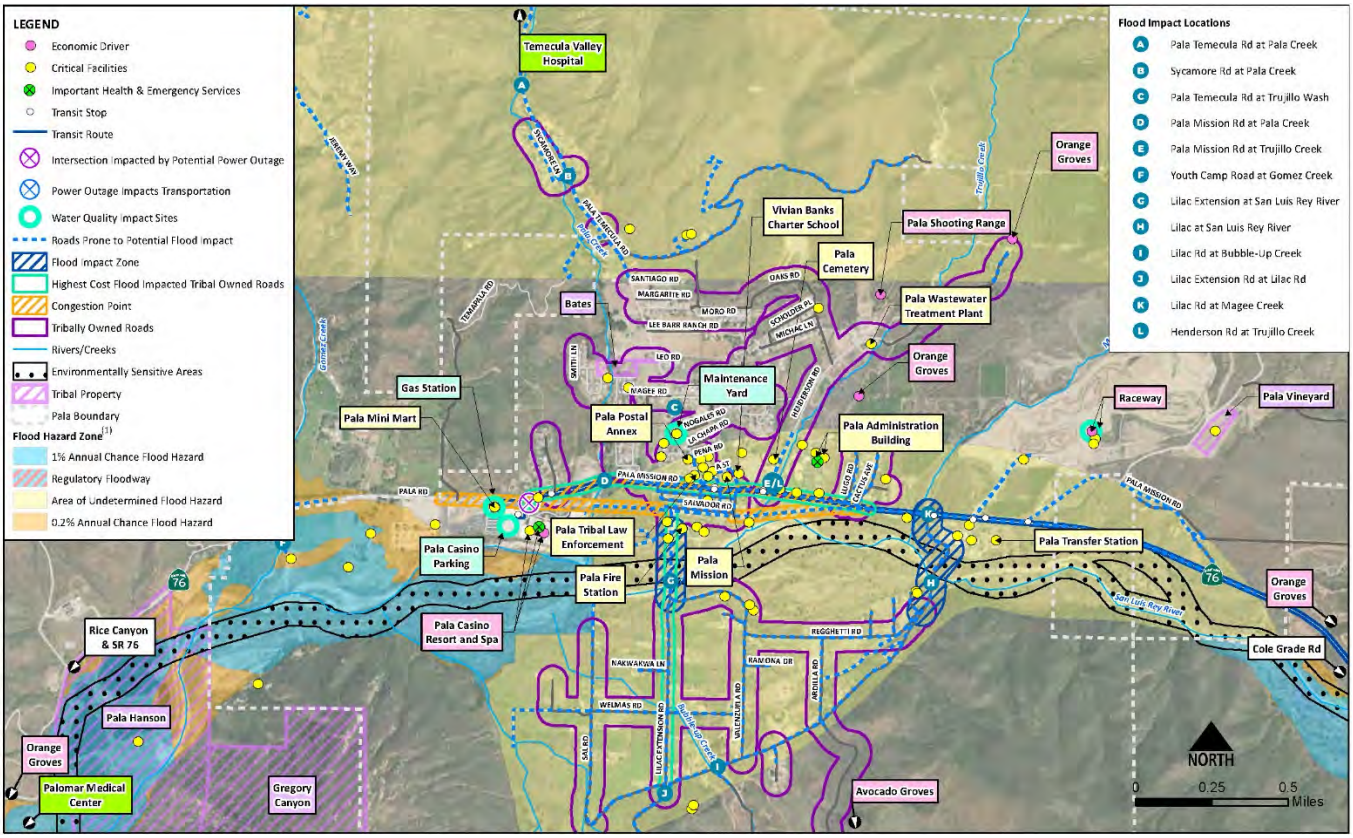

Figure 14: Storms and Flooding Vulnerability Map

Notes on Figure 14:

1) Flooding Risk: Total annual precipitation is projected to stay roughly the same, but it is expected over shorter periods of time due to the increasing duration of dry spells, which increases the risk of flooding.
2) Annotation box colors coordinate with legend marker colors (i.e., "Palomar Medical Center" is green and the legend marker to indicate "Health and Emergency Services" also is green.)
3) Sources: FEMA National Flood Hazard Zone Layer, California Energy Commission, SanGIS Regional Warehouse (accessed July 2020), 2018 ACS 5-Year Estimates.

Flooding Vulnerability #1: Limited access to critical health/emergency services and evacuation routes (Impact to Health and Safety)

As with wildfire, storms and flooding have the potential to constrain resident and visitor access to critical health and emergency services. During and after a flood on or near the reservation, Pala may experience road damage or closure, worsened congestion, and power outages, which can disrupt vehicle mobility to, from, and within the reservation, including personal cars, public transit, ambulances, fire trucks, police, and utility vehicles. These disruptions can cut off access to homes, businesses, and healthcare centers (*e.g.,* Temecula Valley Hospital or Palomar Medical Center) and impede medical or tribal, county or state emergency response efforts. At the same time, Pala may experience an abrupt increase in demand for mobility during a storm event if residents or guests are displaced due to flood danger or evacuation orders, or if significant numbers of individuals need medical attention,[34] exacerbated by existing traffic congestion and access constraints. Medical attention may be needed during or after a flood due to traumatic injuries (*e.g.,* drowning, being struck by objects, or electrocution), exposure to toxic materials, or mental health consequences associated with social impacts, stress, grief, and

[34] Tracking California website: https://www.trackingcalifornia.org/climate-change/wildfires

economic hardship.[35] Given limited public transit options available in Pala, roadway disruptions disproportionately affect those with mobility constraints.

Why is this vulnerability significant to Pala?

While minor flooding occurs frequently during rainfall events, the tribe has reported several events in recent years that have caused major damage on the reservation, including road closures at stream crossings, on Pala Temecula Road and Pala Mission Road, and repeated flooding in the Oaks neighborhood. Populations that live in areas adjacent to the San Luis Rey River, Pala Creek, Bubble Up Creek, and Trujillo Creek may be threatened during 100-year or 500-year storms, particularly areas within Pala's flood plain. There are three homes considered at risk of riverine flooding.[36]

Pala residents have been affected by riverine flooding, sheet flooding, flash flooding, and flooding due to lack of drainage infrastructure. Figure 14 details "Roads prone to Potential Flood Impact" and "Flood Impact Locations" (analyzed in Pala's current flood mitigation planning process). Some of these areas are on routes to important health and emergency services such as Temecula Valley Hospital and Palomar Medical Center, emergency shelters at the Pala Casino and Resort and the Pala Administration building, and Pala Tribal Law Enforcement station.

Flooding at Lilac Extension

Road disruptions due to flooding are also concerning because they can trap people in dangerous situations as occurred during floods in 1980, 1998, 2005, 2010, and 2019.[37] Road flooding occurs on Pala Temecula Road floods causing closures or causing vehicles to hydroplane.[38] Past flooding events have trapped Pala residents in their homes or on the reservation. During such floods, cars and emergency vehicles have been washed away. Pala Temecula Road frequently has been flooded, leading to hydroplaning incidents and road closures.[39] Examples of flood-related transportation impacts on the Pala reservation include:

- 1980: Major flooding on the reservation caused closure of all main roads, leaving most residents trapped.
- 1988: Again major flooding caused closure of all main roads, leaving most Pala residents trapped. Also, flood waters swept away a Pala fire engine during an emergency call.
- 1998: Serious flooding caused road closures that left some residents stranded on the reservation. Rapid runoff forced the San Louis Rey River out of its banks in Pauma Valley and closed numerous roads due to high water. Mud slides washed out or undermined bridges. Flooded intersections stranded several motorists who required emergency rescue.

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[35] U.S. Global Change Research Program, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,* Ch. 4: "Impacts of Extreme Events on Human Health" (2016), https://health2016.globalchange.gov/extreme-events

[36] Pala Band of Mission Indians, *Pala Climate Change Vulnerability Assessment* (2019)

[37] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

[39] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

[39] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

- 2005: Sustained rain brought major flooding on the reservation, closing roads and causing thousands of dollars in property damage and cleanup costs. The heavy rains resulted in mudslides throughout the area.
- 2019: In just 12 hours, between five and 10 inches of rain fell on Palomar Mountain. This led to flash flooding in Pala, causing road damage and trapping people in swift-moving flood waters. A car was stuck trying to cross the San Luis Rey River; the Oaks neighborhood flooded due to runoff from the shooting range area; and major flooding from Bubble Up Creek was reported at the corner of Welmas Road and Valenzuela, affecting a residence.[40]

Flooding has resulted in power outages (see "Power Outage Impacts Transportation" areas mapped on Figure 14), increasing the risk of traffic congestion (see "Congestion Points" mapped in Figure 14) as well as vehicles hydroplaning, getting trapped in high water, or colliding with other vehicles or structures. In some flooding events, auto accidents have blocked routes, exacerbating congestion and risks for other drivers. Congestion problems on Pala Road and Pala Mission Road present a challenge to allowing large numbers of vehicles to travel out of the reservation during an emergency, especially when there are many guests at the Pala Casino and Resort. Some guests arrive via public transit or private shuttles owned by Pala, which poses an additional threat to health and safety due to limited capacity. However, these vehicles also can be useful if needed to transport people quickly.

As shown in Figure 15, priorities for hazard mitigation planning at Pala include preventing road overtopping at low water crossings. Unpaved roads are particularly vulnerable – including Lilac Extension where it crosses the San Luis Rey River and Lilac Road where it crosses Bubble Up Creek. Other priorities include culverts at Pala Creek crossings on Pala Mission Road, Sycamore Lane, and Pala Temecula Road, as well as Trujillo Creek crossing at Pala Mission Road. Additional areas of concern include other crossings at Bubble Up Creek, Trujillo Creek, the San Luis Rey River, and Gomez Creek.

Stream Crossing	Structure(s)	Type	Hazard Mitigation Priority
San Luis Rey River	Lilac Extension	Unpaved road	✓
	Youth Camp Road and Entrance	Unpaved road	
Bubble Up Creek	Lilac Road	Unpaved road	✓
	Valenzuela and Welmas	Unpaved road	
Trujillo Creek - branch	Pala Temecula Rd., Robles Way	Paved road	
Trujillo Creek	Henderson Road at WWTP	Paved road	
	Pala Mission Road	Paved road, 3 culverts	✓
	Henderson Rd. by Pala Gym	Unpaved road, 2 culverts	
	Oaks Road and Michac Lane		
Pala Creek	Pala Mission Road	Paved road, 4 culverts	✓
	Sycamore Lane	Paved road, 4 culverts	✓
	Pala Temecula Road	Paved road, 3 culverts	✓
Gomez Creek	Youth Camp Road and Entrance	Unpaved road, 2 culverts	

Figure 15: Transportation flood hazard mitigation priorities

[40] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

Because healthcare facilities and public transit systems are limited on the Pala Reservation, disruption to transportation is a major safety risk during floods. However, Pala members have a strong history of coordination during disasters, which reduces the Tribe's vulnerability and increases the likelihood of positive outcomes.

Case Study

Thomas Fire Debris Flow and Flooding

Firefighters battling the Thomas Fire (Source: US Forest Service)

The Thomas Fire in Ventura and Santa Barbara counties started on Dec. 4, 2017, and burned 281,893 acres, followed by a storm and catastrophic debris flow event on January 9. Debris flows issued from numerous watersheds within the Santa Ynez and Topatopa Mountains, killing 23 people and causing severe damage to infrastructure. Of 558 damaged structures, 162 were considered destroyed. Of them, 79 had complete structural damage, and 41 were swept off their foundations. Debris accumulated in low sections of U.S. Highway 101, a major transportation corridor, rendering a 30-mile section through Montecito impassable for 13 days. Between January 9 and 22, first-responder personnel conducted search-and-rescue operations, provided life-safety and life-sustaining support. Before and during the event, approximately 1,300 individuals were evacuated and 700 sheltered in place. This case study demonstrates how critical transportation infrastructure is to protecting health and safety during a major flooding event. (Source: Multiple sources including NOAA/NWS, "Southern California's Thomas Fire and the Deadly Montecito Debris Flow: NWS Successes and Challenges in Providing Impact-Based Decision Support Services for Preparedness, Response, and Recovery," 5th Conference on Weather Warnings and Communications (June 13, 2019), https://ams.confex.com/ams/47BC5WxComm/webprogram/Paper358734.html)

Flooding Vulnerability #2: Limited access to key economic assets and resources (Impact to Economy)

Storms and flooding can also disrupt transportation systems and affect Pala's key economic drivers such as tourism and agriculture. While a storm may be brief, flooding related damage to transportation or power infrastructure can constrain personal or service vehicle mobility to, from, or within the reservation for weeks or even months. These events can significantly reduce tribal revenue, disrupt employment, and threaten Pala's economic stability.

Why is this vulnerability significant to Pala?

The map in Figure 16 illustrates "Economic Drivers" that may be vulnerable to disruption due to storm and flooding-related transportation impacts. Examples include the Pala Casino and Resort – the most significant economic driver on the reservation – as well as agricultural operations, the raceway, and the shooting range. Areas where vehicle access to these assets is threatened are displayed as "Roads prone to Potential Flood Impact;" "Flood Impact Locations;" "Intersections Impacted by Potential Power Outage;" "Transit Stop/Route" and "Congestion Points."

As described in Flooding Vulnerability #1, numerous floods have occurred in the past few decades that have disrupted important routes. Flooding occurs on Pala Mission Road, which leads to the Pala Casino and the Travers development.[41] When employees and visitors cannot access the casino, which could occur during

[41] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

flooding events, the losses to Pala could be as much as $500,000 per day, as experienced during COVID-19 lockdowns. If storms increase in intensity as expected with climate change, flooding could close vital roads for longer periods of time, costing millions in economic activity.

Because the casino is a significant economic center and source of employment for the Tribe, Pala members depend on it for their quality of life. Losing access to the benefits of the casino due to flooding can cause serious hardship for families.

Case Study

Regional Flooding Impacts on Tribal Economies

The Havasupai Tribe in Arizona experienced several severe floods from 2008 to 2010 that damaged trails, campgrounds, and recreational areas in Havasu Canyon, greatly reducing tourism revenue. Since then, the Havasupai have experienced repeated flood events, the latest in October 2010, and the recovery process has been difficult. Funding from the San Manuel Band of Mission Indians ($1 million), as well as federal and state agencies and non-profit organizations has helped in recovery efforts.[42]

Flooding Vulnerability #3: Increasing costs to Pala for repairing tribally owned roads damaged by storms and flooding (Impact to Economy)

Storms and flooding can damage roads and lead to transportation infrastructure costs including for repair and clean-up. Changes in precipitation can raise water levels in creeks, inundate travel lanes, wash out roadways, destabilize stream conditions, and raise stream channels, reducing the distance between a creek and a road. During storms, bridge scour removes sediment such as sand and gravel from around bridge abutments or piers, and can undermine roads and culverts, compromising the integrity of these structures. When creeks flow over roads, it can lead to debris buildup, erosion of embankments and road surfaces.

Flood mitigation efforts at Pala Resort & Casino

Additionally, precipitation levels affect soil moisture and groundwater conditions by affecting the stability of slopes and potentially causing landslides. Once saturated, soils become fragile and less able to support roads, causing settlement and premature road failure.[43] As roadways are exposed to a higher volume of water due to climate change, their pavement materials are susceptible to damage from excess moisture. The most common form of pavement damage due to water is

[42] Institute for Tribal Environmental Professionals, "Tribal climate change efforts in Arizona and New Mexico" (2011), https://www7.nau.edu/itep/main/tcc/docs/resources/SWTCCEffortsAZNM_12-14-11.pdf

[43] Sacramento Area Council of Governments and CivicSpark, *Sacramento Region Transportation Climate Adaptation Plan* (2015), https://www.sacog.org/sites/main/files/file-attachments/2015_sacramento_region_transportation_climate_adaptation_plan_1.pdf

stripping, where the layers of the road pull apart. Another potential source of damage occurs when water seeps into the pavement, either through voids or through cracks in the surface, then becomes trapped between two layers of asphalt; as traffic drives over it, the layers of asphalt shift. Erosion can be worsened by flooding, compromising road infrastructure.

Culverts are among the most important – and vulnerable – assets the Tribe has for dealing with heavy precipitation and flooding.[44] Flooding associated with clogged culverts causes and accelerates existing road distortion, alligator cracking, and erosion.

As discussed in Section 3.1.1, where vegetation is destroyed by fire, heavy rainfall causes severe erosion and landslides in some locations. Without trees and other plants to retain the soil, stormwater erodes the land and carries soil and debris into nearby waterways, in some cases sending entire hillsides down into roads and waterways. In this way, the effects of wildfires and flood conditions combine to intensify potential for damage to transportation infrastructure and increase repair costs to Pala.

Why is this vulnerability significant to Pala?

The Pala tribal government faces increasing and potentially overwhelming costs of repairing roads damaged by storms and floods. Figure 16 illustrates vulnerable areas, including roads estimated to cost the most to repair after being damaged by flooding. The map also highlights "Tribal Owned Roads," which represent those roads that Pala would be responsible for repairing, as opposed to road that are owned and maintained by the County of San Diego or Caltrans.

Lilac Road crosses a natural flood plain and is vulnerable to overflow from Bubble Up Creek and the San Luis Rey River

In San Diego County, some flooding events have caused millions of dollars of damage.[45] Examples include the 1916 Hatfield Flood, which destroyed the Sweetwater and Lower Otay Dams, causing 22 deaths. In the 1980 floods, the San Diego River at Mission Valley peaked at 27,000 cubic feet per second and caused $120 million in damage.

In 2005, sustained rain caused major flooding on the Pala Reservation, closing roads and causing thousands of dollars in property damage and cleanup costs. Heavy rains caused mudslides throughout the county. In 2017, Pala Temecula Road and Pala Mission Road in Pala were closed due to flooding and rocks in the roadway, costing $5,000 in repairs. In 2019, flash flooding occurred in Pala with road damage and swift water rescues. Approximately $40,000 in damage was reported.

In 2020 Pala Creek overtopped culverts, forcing closure of Pala Temecula Road and depositing a large amount of sediment on the road. As a community member recalled, ***"The bottom of Pala-Temecula Road got washed out***

[44] CalTrans, *Climate Change Vulnerability Assessment – Summary Report - District 11* (2019), https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/2019-climate-change-vulnerability-assessments/ada-remediated/d11-summary-report_a11y.pdf

[45] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

near Sycamore but was quickly repaired." Pala Mission Road also was closed due to flooding. Lilac Extension Road was closed at its crossing with the San Luis Rey River and part of the road was washed away. Lilac Road at Bubble Up Creek flooded, and Rice Canyon Road was closed in both directions near Highway 76 due to mudslides and rockfalls.

Consultants Kimley-Horn used two methods to estimate future costs of road repairs to Pala-owned roads related to storms and flooding. First, they conducted a site visit to assess existing road conditions using the PASER method. The team conducted visual observations to evaluate current patterns of cracking, surface degradation, roadway distortions, and erosion. Kimley-Horn assigned relative cost estimate based on current condition and whether the road was vulnerable to each of the projected exposures analyzed in this report, including storms and flooding. This analysis suggests that some roads would be more costly to repair than others, such as Lilac Road and Lilac Extension. (See Appendix C)

Case Study

Rising Costs of Road Repair from Flooding and Climate Change

Nationally, the total annual damages from temperature- and precipitation-related damages to paved roads are estimated at up to $20 billion under RCP8.5 in 2090. Inland flooding, projected to increase over the coming century, threatens approximately 2,500 to 4,600 bridges in the United States and is anticipated to result in average annual damages of $1.2 to $1.4 billion each year by 2050.[46]

In 2020, the Federal Highway Administration allocated emergency road and bridge repair funds to numerous relief efforts for California floods. This included $47.5 million to repair roads and bridges from multiple floods that occurred from 2016 to 2018.[47] Highway 41 is one of three roadways that enter Yosemite Valley. At one point following heavy precipitation events in 2017, both Highway 41 and Big Oak Flat were closed at the same time due to storm damage. Caltrans workers responding to the washout noticed that the northbound lane was sinking and eventually a five-foot- hole in the roadway opened. Water had eroded the roadbed under part of Highway 41, so it needed to be excavated and rebuilt. Repairs cost more than $1 million. The 100-year storm depths are expected to increase in the northern segment of Highway 41 by about 5% to 10%, by 2025, making the impacts of future flooding even greater.[48]

Kimley-Horn also estimated Pala's road repair costs using a factored value projected by the California's Fourth Climate Change Assessment (See Appendix C). This analysis suggests that climate change induced increases in inland flooding over the next 50 years will result in $1.8 million in additional costs through 2050. However, statewide conditions aren't well represented in Pala; in general, on a per-capita basis, Pala's roads likely represent substantially higher costs and vulnerabilities for the Tribe than equivalent transportation assets do for the state of California. Accordingly, the assessment team considers this estimate to be a *de-minimis* estimate.

Increased capital costs will divert scarce funds from other priorities. Coordination with Caltrans and other funding sources will be vital to maintaining transportation corridors in Pala.

[46] U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (2018), https://toolkit.climate.gov/reports/impacts-risks-and-adaptation-united-states-fourth-national-climate-assessment-volume-ii

[47] Federal Highway Administration Emergency Relief Program, https://www.fhwa.dot.gov/programadmin/erelief.cfm

[48] California Department of Transportation (CalTrans), *Climate Change Vulnerability Assessment – Summary Report - District 6* (2019), https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/2019-climate-change-vulnerability-assessments/d6-technical-report-a11y.pdf

Flooding Vulnerability #4: Impacts to ecosystems (Impact to Natural Resources)

The Pala community has prioritized impacts to ecosystems including habitat fragmentation and loss of culturally important plant and wildlife species due to road or bridge damage and runoff.

Why is this vulnerability significant to Pala?

Pala's wildlife depends on healthy, large, and connected habitats to roam, breed, and hunt. Climate-related changes are adding pressure to ecosystems already stressed by habitat loss and fragmentation, pollution, disease, population growth, and other human-related impacts.[49] Roads and other transportation infrastructure can impede climate-induced migration of wildlife. Severe storms and landslides can result in habitat shifts, loss of soil-stabilizing streamside vegetation, and accelerated erosion. Aquatic habitats also can become contaminated by runoff. Storms and flooding can also weaken and remove vegetation and soil leading to downed trees, erosion, and mudslides.

Pala habitat for endangered and threatened species

Pala is home to several federally endangered or threatened species. These include least Bell's vireo, southwest willow flycatcher, coastal California gnatcatcher, Quino checkerspot butterfly[24], and the arroyo toad. Other species of importance to Pala include golden eagle, coyote, bobcat, and mountain lion. Roadside and nearby trees and vegetation can be lost due to flooding, erosion, and fire. As the risks of wildfire and flooding increase due to climate change, vegetation loss can worsen erosion and flooding of roads, and affect the survival of plants and wildlife.[50]

Figure 16 illustrates areas related to this vulnerability, including roads prone to significant stormwater runoff near environmentally sensitive areas, and road crossings vulnerable to floods. As habitat areas change, connectivity is important, and such major highways as Highway 76 could impede species migrations. Other highways and roads can similarly affect habitat connectivity, while unpaved roads can shed sediment into waterways, especially during floods. Without mitigation efforts, habitat loss, fragmentation, and other barriers caused by habitat conversion and road development will decrease the ability of natural communities to adapt to a changing climate. Because roads are highly prohibitive barriers to many species' movement, they have a negative impact on a population's ability to adapt to shifting resource availability, especially in the face of climate change. The most frequently cited recommendation for protecting biodiversity in the face of climate change is improved connectivity among wildlife habitats on a landscape scale.

[49] California Natural Resources Agency, *Safeguarding California: Reducing Climate Risk, An update to the 2009 California Climate Adaptation Strategy* (2014), http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf

[50] Pala Band of Mission Indians, *Climate Change Vulnerability Assessment* (2019)

Case Study

Improving Wildlife Connectivity and Reducing Flood Risks with Wildlife Crossings

The South Coast Missing Linkages Project identifies the need to preserve and enhance the wildlife corridor between the Sierra Madre and Santa Monica mountain ranges, in light of existing land use pressures and in the context of climate change. The California Essential Habitat Connectivity Project, commissioned by Caltrans and the California Department of Fish and Wildlife with the support of the Federal Highway Administration, also prioritizes protection of this corridor. The proposed project is located in Agoura Hills in northwestern Los Angeles County. Highway 101, which runs east and west through this area from the LA Basin to Ventura, is the largest barrier to mountain lions and other wildlife moving between large blocks of native habitat in the Santa Monica Mountains to the south and the Simi Hills, and the Los Padres National Forest beyond, to the north. The physical and topographical characteristics of the Liberty Canyon area make this site an ideal location for a sustainable wildlife crossing along Highway 101. (Source: Santa Monica Mountains Conservancy, Liberty Canyon Wildlife Crossing project, https://smmc.ca.gov/liberty-canyon-wildlife-corridor/)

Liberty Canyon wildlife crossing project – design concept (Resource Conservation District of the Santa Monica Mountains)

4.2.4 Existing Mitigation Measures

Several measures are being implemented at Pala, as part of efforts to improve resilience and adaptive capacity mitigate climate impacts on transportation systems and infrastructure.[51] For example, a detention basin in the Morro areas helps prevent flooding, and Pala has completed structural projects with flood mitigation measures. Allers Development Retaining Wall was built to protect the Allers Development from flooding, landslides, and erosion from rain events. For Pala Casino Resort & Spa, Pala worked to mitigate risk by building a retaining wall along the river. In addition, many of the roads on the reservation have been retrofitted with culverts.

Culverts on Pala Creek passing under Pala Temecula Road are vulnerable to clogging during every rainstorm, causing flooding that makes the road impassable

Pala Environmental Department discovered that Trujillo Creek jumped out of its banks in recent years, redirecting substantial flow through the shooting range and Oaks neighborhood, and across Pala Temecula Road. In coordination with the County of San Diego, repairs are planned to alleviate some (but not all) flooding on Pala Temecula Road. Pala Environmental Department is working to develop a flood model of Trujillo Creek, which is expected to help in efforts to persuade the County to correctly resize the culverts on Pala Mission Road – or to build a bridge across Trujillo Creek.

[51] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

The bridge on Lilac Road floods, causing a build-up of sand and debris. This bridge is the County's responsibility to maintain, but it poses a risk to the reservation. However, a gate can be closed to block off the Lilac Extension over the San Luis Rey River, just past the fire station. Highway 76 and Pala Temecula Road are the primary routes used to enter or exit the reservation. San Diego County, with partial funding from the Tribe, installed several culverts along Pala Temecula Road to avoid flooding, which has closed the road in the past.

> *"Efforts to mitigate Pala Temecula Road flooding require coordinati on with the County of San Diego. Trujillo Creek has jumped its banks in recent years, redirecting substantial flow through the shooting range, Oaks neighborhood, and across Pala Temecula Road. Repairing the creek banks is expected to alleviate some but not all flooding on Pala Temecula Road. Pala Environmental Department is working on developing a flood model of the creek, which PED hopes will help persuade the County to correctly resize the culverts on Pala Mission Road – or build a bridge across Trujillo Creek."*[52]

Strategy	Access to Health and Emergency Services	Costs to Tribal-owned Roads	Access to Economic Drivers	Impacts to Ecosystems
Stream gage early warning system	✓	✓	✓	✓
Habitat preservation planning				✓
Air ambulance	✓			
Lilac extension gate	✓	✓		
Alert app	✓			
Onsite emergency shelters	✓			
Back-up power systems on Casino	✓		✓	
Water tanks that support most of reservation designed to withstand fires	✓		✓	
Flood mitigation planning	✓	✓	✓	✓
Pala Temecula Road culvert replacements	✓	✓	✓	✓
Old Highway 76 bridge retrofit		✓		
Allers Development and Casino Retaining Wall	✓	✓	✓	
Morro detention basin	✓	✓		
Debris removal	✓	✓	✓	✓

Figure 16: Existing mitigation strategies for flooding in relation to community concerns

[52] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

Case Study

Pala Stream Gage Early Warning System

Pala's flood and stream gage program has developed to the point where potential flooding is well monitored. The Tribe maintains three gages that measure rain levels and height of the water in creeks: on Pala Creek (where Pala Temecula Road crosses over Pala Creek), Trujillo Creek (where Henderson Road crosses over Trujillo Creek), and on the San Luis Rey River (at the Lilac Bridge). Each gage measures precipitation and/or stream height, logs the data, and then uses a radio repeater system to relay the data to the County of San Diego's flood warning department. From there, the data feeds into a real-time software system that allows Tribal emergency managers to view all of the gages and their measurements. Pala also can set alarms to warn them about impending flood conditions (*i.e.,* sending a notification when a gage measures a certain amount of water within 30 minutes. The same notifications trigger alarms on Fire Station and Environmental Department monitoring systems). Pala's current stream gage network is useful for determining the level of localized flooding, but since all of the gages are in the Pala Valley, they do not provide much warning time to the Tribe or casino operators in the event of a large flood.[53]

[53] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

4.3 Extreme Heat

Changing climate conditions are driving more severe and frequent temperature extremes at Pala. These changes are anticipated to adversely affect Pala's transportation systems, resulting in two key vulnerabilities to Pala's health, and safety, as described in this section. In addition, temperature can exacerbate wildfire impacts (see Section 3.1) and droughts conditions, which can make flooding events more severe (see Section 3.2).

4.3.1 Climate Change and Extreme Heat Trends

According to the 2017 Climate Science Special Report (CSSR), temperatures in the United States are projected to increase 2.8 to 7.3 degrees Fahrenheit on average by the period between 2071 and 2100.[54] The U.S. Southwest, where Pala is located, is particularly prone to heat waves.[55] The California Department of Public Health estimates that San Diego County will experience a 5 to 6 degree average temperature increase in January by 2100, along with a 5 to 10 degree increase in July. Heat waves have been historically infrequent in San Diego County; however, climate change is projected to significantly increase the frequency of heat waves.[56]

Heat extremes are considered a high-risk exposure for the Pala Tribe. The Tribe experienced 18 heat-related events between 1997 and 2014.[57] Several tribal members who responded to the survey for this assessment said they were concerned about temperature extremes. Cal-adapt, a climate adaptation tool developed by the State of California, projects that days over 99.9 degrees will increase by 750% by the 2070 to 2099 period.[58] That means Pala residents will experience extreme heat 1 out of every 10 days.

Average maximum temperatures on the Pala Reservation are projected to increase from an observed baseline of 75.8°F to upwards o f 79.7 by 2050 and 84.5°F by 2099. According to CalAdapt, the extreme heat threshold for the Pala Reservation is 103.9°F, and the Pala Reservation experienced an average of four extreme heat days per year during the baseline period (1961 through 1990). According to projections, the Pala Reservation could experience up to 46 extreme heat days under a high emissions scenario by the period 2070 through 2099, which means more than 13% of the entire year could consist of extreme heat days in the future.[59]

Figure 17: Pala Extreme Heat Days Trend (1950-2100)

[54] U.S. Global Change Research Program, "Temperature Changes in the United States," *Climate Science Special Report: Fourth National Climate Assessment, Volume I* (2018), https://science2017.globalchange.gov/chapter/6/

[55] U.S. Environmental Protection Agency (EPA), *Climate Impacts in the Southwest* (2018), https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-southwest_.html

[56] County of San Diego, "Climate Change Vulnerability, Resiliency, and Adaptation," *Climate Action Plan,* https://www.sandiegocounty.gov/content/dam/sdc/pds/advance/cap/publicreviewdocuments/CAPfilespublicreview/Chapter%204%20Climate%20Change%20Vulnerability%2C%20Resiliency%2C%20and%20Adaptation.pdf

[57] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2016)

[58] U.C. Berkeley, Geospatial Innovation Facility, Cal-Adapt research tool (2018), http://cal-adapt.org

[59] Pala Band of Mission Indians, *Hazard Mitigation Plan*

4.3.2 Extreme Heat and Transportation Impacts

Extreme heat and related power outages, low soil moisture, and air quality impacts can cause short- and long-term transportation problems. These impacts only become worse during evacuation, as Pala has limited egress and depends on Caltrans for road maintenance of primary evacuation routes.

Changes in temperature, precipitation, and moisture, including changes in frost penetration, freeze-thaw cycles, wet-dry cycles, and groundwater levels, threaten all parts of the pavement system, as well as soil and rock slopes, causing impacts such as rutting and cracking, smoothness deterioration, roadway deformation, and destabilized rock and soil slopes.

Extreme temperatures can affect the integrity of roads, bridges, and roadway vegetation. Based on a report completed by the United States Department of Transportation, the risk of asphalt pavement softening is expected to increase when temperatures remain over 100° F without cooling at night, particularly in areas with heavy truck traffic.[60] Extreme temperatures may lead to increased pavement distress, such as rutting and cracking in asphalt concrete pavements. Prolonged exposure to extreme heat can exacerbate roadway degradation, as asphalt and concrete can deform at a faster rate under high temperatures, resulting in unsafe road conditions for motorists.[61]

When temperatures exceed the design, placement, or performance thresholds of existing pavement (*e.g.,* binder specifications for performance graded asphalt binders), the Tribe may need to increase its use of punchout or continuously reinforced concrete for its paved roads and other surfaces.

Additionally, temperature may affect expansion-contraction allowances for bridge joints. Bridges experience expansion and contraction as temperatures fluctuate, affecting the way expansion joints absorb movement and vibration over time.[62]

Right-of-way landscaping and vegetation must be able to survive longer periods of high temperatures. Hardened and parched soils contribute to flooding when rain finally falls. This is more likely to happen when vegetation along the rights of way are not adapted to higher temperatures.

Recent results suggest that asphalt decline from heat could cost $150 million in Phoenix under high GHG emissions scenarios by 2100.[63] Without successful adaptation of roadway materials for high temperatures (*i.e.,* asphalt and pavement), researchers estimate that the median total cost to California for the 2040 to 2070 period will be between about $1 billion for RCP 4.5 to $1.25 billion for RCP 8.5.[64]

As temperatures increase, Pala Environmental Department staff note declining levels of important habitats including chaparral, native grasslands, wetlands, riparian, and upland habitats, and increasing levels of non-native grasslands. Loss of habitat can lead to bare soils and an increase in dust. This can combine with road dust, which can become toxic as temperatures rise and tires and road materials break down more easily. Additionally, as congestion increases, vehicle brake dust can increase, contributing heavy metals to road dust. In addition to

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[60] U.S. Department of Transportation, Transportation and Climate Change Clearinghouse (2012)

[61] Federal Transit Administration, *Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation* (2011)

[62] Caltrans and Humboldt County Association of Governments, *District 1 Climate Change Vulnerability Assessment and Pilot Studies: FHWA Climate Resilience Pilot Final Report* (2014)

[63] *Nature Climate Change,* "Increased costs to US pavement infrastructure from future temperature rise," 7, 704 (2017)

[64] State of California, *California's Fourth Climate Change Assessment: Statewide Summary Report* (2018), https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf

affecting air quality, this dust can run off into streams and creeks during storms, affecting aquatic wildlife and water quality, and potentially affecting groundwater resources.

Rising temperatures can cause physical and mental health effects for people who depend on roads and public transit. Such impacts include decreased comfort, transit and cars overheating, and network delays. Mental, behavioral, and cognitive disorders can be triggered or exacerbated by heat waves, particularly for populations with existing mental health conditions.[65] Studies have linked extreme heat with increases in aggressive behavior, alcohol and drug use, violence, and crime.[66]

Heat also compromises worker and public safety. Temperature extremes cause vehicles to overheat and tires to shred, while buckled roadway joints can send vehicles airborne. Increased cooling needed to alleviate passenger discomfort and cargo overheating can cause mechanical failures and reduced service, as well as greater greenhouse gas emissions.[67] Biking and walking becomes more strenuous during extreme heat days, posing health risks and a possible deterrent for biking and walking. During periods of extreme heat, maintenance and construction is forced to stop or slow down due to health risk exposures for workers, and because many materials for transportation infrastructure cannot be properly installed above certain temperatures. [68]

4.3.2.1 Community Extreme Heat Observations

In general, few community members report negative experiences from rising temperatures and extreme heat directly, although heat can create greater risks for wildfire. For example, one respondent remarked "***I see the potential to have negative experiences with our outdoor workers as well as our elders when considering heat, drought, and transportation at Pala.***" However, Pala ranked Temperature extremes as the least concerning of all three exposures evaluated in this report and also determined this exposure would have the lowest perceived threat to transportation (see Figure 18).[69]

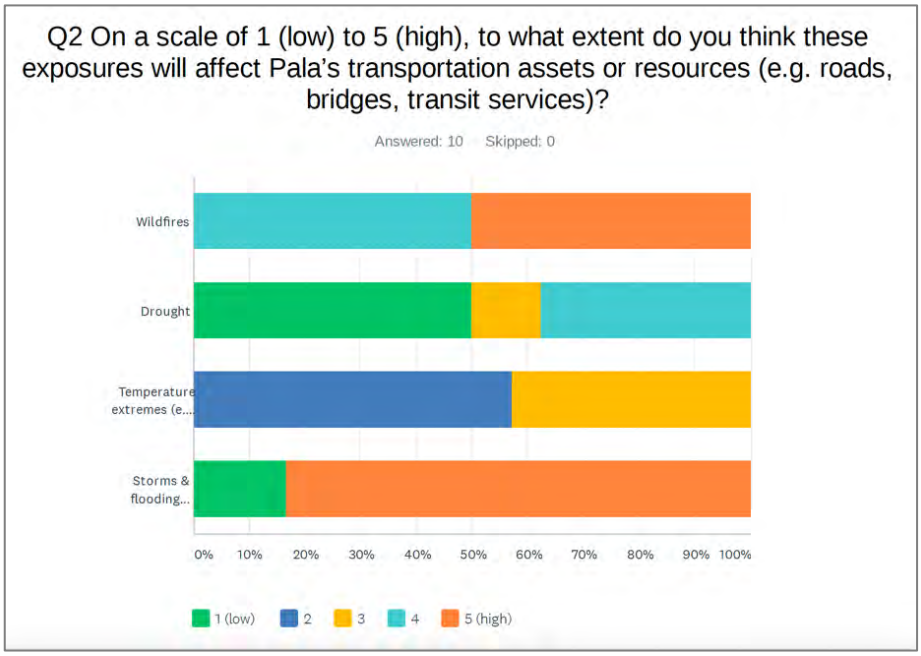

Figure 18: Survey Responses on Effect of Temperature on Transportation Assets

[65] *American Journal of Epidemiology,* "Examining the Association Between Apparent Temperature and Mental Health-Related Emergency Room Visits in California," 187, 726-735 (2018)

[66] U.S. Global Change Research Program, Chapter 8: "Mental Health and Wellbeing," *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (2016), https://health2016.globalchange.gov/mental-health-and-well-being

[67] U.S. Global Change Research Program, Chapter 12: "Transportation," *Fourth National Climate Assessment* (2018), https://nca2018.globalchange.gov/chapter/12/#fn:84

[68] Sacramento Area Council of Governments and CivicSpark, *2015 Sacramento Region Transportation Climate Adaptation Plan* (2015), https://www.sacog.org/sites/main/files/file-attachments/2015_sacramento_region_transportation_climate_adaptation_plan_1.pdf

[69] Pala Band of Mission Indians, *Transportation Climate Adaptation Survey* (2020)

4.3.3 Pala's Key Transportation-Related Vulnerabilities from Extreme Heat

As temperature extremes, particularly heat, become more frequent and severe in the region, the transportation-related impacts below present the most significant vulnerabilities to Pala resulting from heat.

- Extreme Heat Vulnerability #1: Limited access to critical health and emergency services and evacuation (Impact to Health and Safety)
- Extreme Heat Vulnerability #2: Increased road dust due to high heat and drought (Impact to Health and Safety)

Figure 19 displays a projected extreme hazard map for the year 2050[70] overlaid with Pala assets and spatial data relevant to Pala's extreme heat-related transportation vulnerabilities.

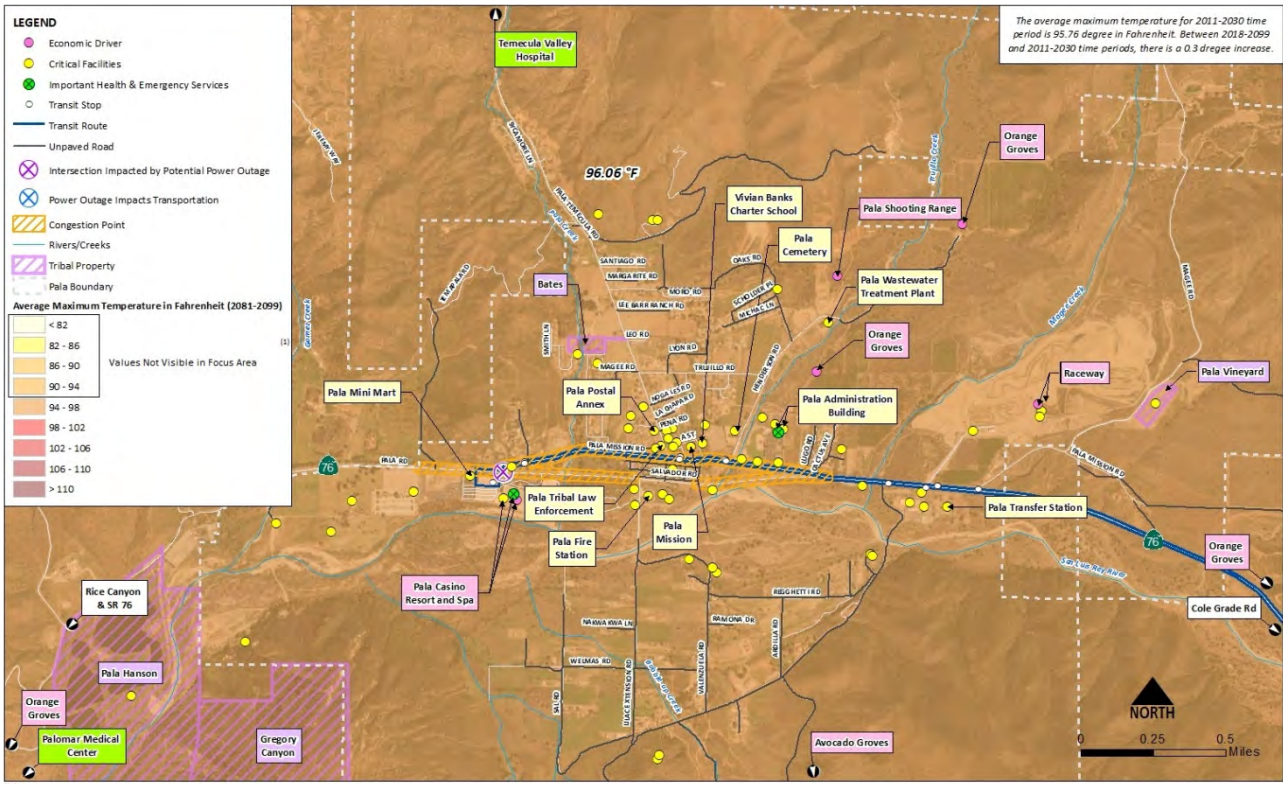

Figure 19: Pala Extreme Heat Vulnerabilities

Notes on Figure 19:

1) The hottest days of the year are projected to increase by 2-10 degrees (average of 10.5 degrees) by mid-century, compared to averages from 1961 to 1990. The number of days with temperatures over 90 degrees is projected to increase by 23 to 48 days (an average of 35.5 days) by mid-century, compared to averages from 1961 to 1990.
2) Annotation box colors coordinate with legend marker colors (i.e., "Palomar Medical Center" is green and the legend marker indicating "Health and Emergency Services" is also green.)
3) Number of annual health heat events in 2081 to 2099 period is projected to be 5.5.
4) Sources: Climate Explorer (accessed December 2020), California Energy Commission, SAN GIS Regional Warehouse (accessed July 2020), 2018 ACS 5-Year Estimates.

[70] California Department of Forestry and Fire Protection (CalFire) (accessed December 2020)

Extreme Heat Vulnerability #1: Limited access to critical health and emergency services and evacuation (Impact to Health and Safety)

Concerns about resident and visitor access to health and emergency services and evacuation was a high priority for Pala for each of the climate exposures evaluate, including extreme heat. While Pala did not feel that heat damage to roadways was a particular concern, power outages during heat events are not uncommon at Pala, which can disrupt transportation systems. At the same time, heat can increase the need for mobility to access health services for those that are vulnerable to heat related health impacts or whom depend upon electric medical equipment. For example, significant increases in the number of extreme heat days can lead to severe health impacts for people on the reservation, such as heat stroke and other related illness, especially for vulnerable populations such as the elderly, young, outdoor workers, and impoverished households. Increased heat also intensifies photochemical reactions that produce ground level ozone, a key component of smog. Ozone and smog irritate the human respiratory system and can contribute to and exacerbate respiratory diseases.

Why is this vulnerability significant to Pala?

Figure 19 illustrates areas related to this vulnerability, including road intersections vulnerable to power outages, public transit systems, congestion points, and health and emergency services facilities that Pala residents and visitors need to access in extreme heat conditions.

Pala residents likely will experience five or more extreme heat events per year by 2099. One of the longest and most severe heat waves on record was reported in mid-August of 2020. Temperatures of 105 degrees F were reported in Pala, lasting approximately 10 days. The event strained communities across the state, which were enduring rolling brownouts as utilities dealt with extreme heat and related wildfire events. Pala members reported no major outages during this time,[71] but as temperatures rise, the impacts on Pala could also rise. Given that during most extreme heat events most Pala community members shelter in place, and that only half have air conditioning, risks of health issues from heat exposure are increasing.

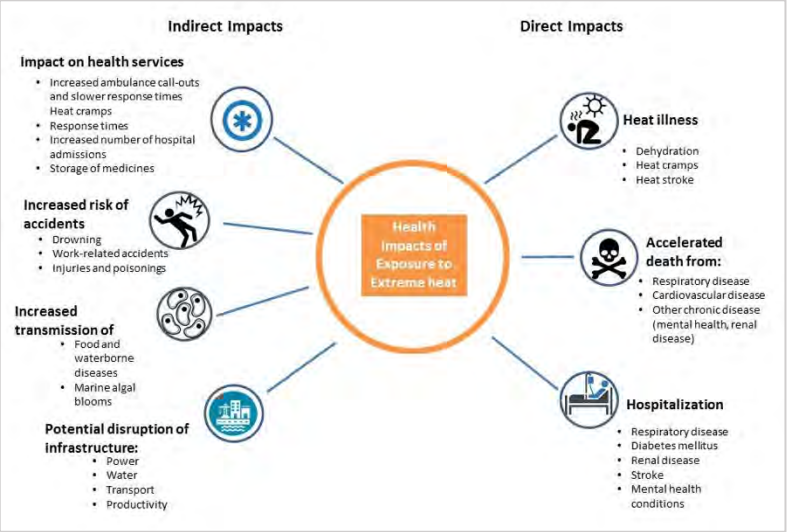

Figure 20: Extreme Heat Health Impacts

Source: World Health Organization Climate Change Heat and Health Fact Sheet, https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health

Projections for increased heat mean that Pala residents will be exposed to even higher levels of ozone. As a result, Pala residents may experience more cases of decreased lung function, respiratory symptoms, hospitalizations for cardiopulmonary causes, emergency room visits for asthma, and premature death. As temperatures rise, the need for additional healthcare facilities will also rise and with dependence on facilities outside Pala the traffic will also increase.

These rising risks translate into transportation vulnerabilities to the degree high heat events lead to increased needs for Pala residents and visitors to use roadways, public transit systems, and air ambulances to reach

[71] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

cooling centers or to obtain critical health and safety services. These risks are further exacerbated by PSPS events and other power outages that result in part from higher temperatures and wildfire risks. Power outages can increase roadway usage as residents evacuate or seek medical attention, and outages also increase road congestion by disabling traffic signals.

At greatest risk in the Pala community are elders (over 65), children, outdoor workers, and people living in poverty.[72] Pala has a lower Urban Heat Island Index than most other California communities, meaning it has less local heat-producing manmade surfaces. Pala also has a higher percentage of area covered by tree canopy (6.8%) than 65% of California communities, meaning that the community has some well-shaded areas that can help reduce vulnerability to heat.[73]

Case Study

California Extreme Heat and Health Impacts

Ozone is a problem in San Diego County. The U.S. Centers for Disease Control (CDC) reports that residents of San Diego County were exposed to 32 days of unhealthy levels of ozone in 2014.[74] According to CDPH, San Diego County already has almost 6 times more days when ozone concentration is above standard than the rest of the state.[75] The EPA's Air Quality Index indicates that ozone was the main air pollutant in San Diego County for 238 days in 2017.[76] High heat can directly affect health and lead to higher ozone levels, which can cause and exacerbate health issues. For example, the July 2006 heat wave in California, which exhibited unprecedented magnitude and unusually high humidity levels,[77] resulted in at least 600 excess deaths,[78] more than 1,200 excess hospitalizations for cardiovascular and other diseases,[79] and 16,000 excess emergency-department visits.[80]

Extreme Heat Vulnerability #2: Increased road dust due to high heat and drought (Impact to Health and Safety)

Road dust from paved roads, or fugitive dust, contributes to airborne particulate matter (PM) emissions throughout California. Drought may increase the potential for wind erosion to cause soil dust to become airborne, and there is evidence from past trends showing regional increases in dust activity due to drought cycles. Intense dust storms are also associated with impaired visibility, which can cause road traffic accidents resulting in injury and death. As the climate warms, and droughts increase, the potential for airborne dust increases.[81] In the United States, dust exposure has been linked to increased incidence in respiratory disease,

[72] Pala Band of Mission Indians*, Climate Change Vulnerability Assessment* (2019)
[73] Public Health Alliance of Southern California, *California Healthy Places Index* (HPI) (2018)
[74] U.S. Centers for Disease Control (CDC), National Environmental Public Health Tracking, https://ephtracking.cdc.gov/InfoByLocation/(2018)
[75] California Department of Public Health, *Climate Change & Health Vulnerability Indicators for California*, https://discovery.cdph.ca.gov/ohe/CCHVIz/
[76] U.S. EPA, Outdoor Air Quality Data (2018), https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report
[77] *Journal of Climate,* "2006 heat wave over California and Nevada: Signal of an increasing trend," 22(23), 6181–6203 (2009) https://doi.org/10.1175/2009JCLI2465.1
[78] *Environmental Research,* "Estimating the mortality effect of the July 2006 California heat wave," 109(5), 614–619 (2009)
[79] *Journal of Applied Meteorology and Climatology,* "Impact of recent heat waves on human health in California," 53(1), 3-19 (2014), https://doi.org/10.1175/JAMC-D-13-0130.1
[80] *Environmental Health Perspectives,* "2006 California heat wave: Impacts on hospitalizations and emergency department visits," 117(1), 61–67 (2009), https://doi.org/10.1289/ehp.11594
[81] *GeoHealth*, "Characterizing the Role of Wind and Dust in Traffic Accidents in California," 3, 328-336 (2019)

including asthma , acute bronchitis, and pneumonia.[82] Dust particles can also carry heavy metals (*i.e.*, Pb, Mn, Fe, Cu, Co, and others), polycyclic aromatic hydrocarbons, and other carcinogens, which create a health burden on cardiovascular, respiratory, and cancer diseases,[83] and consequently increased risk for Valley fever.

Why is this vulnerability significant to Pala?

Figure 19 illustrates unpaved roads at Pala that tend to generate increased road dust due to climate change impacts, including locations where Pala residents and visitors likely will encounter road dust with higher frequency and severity.

Prolonged low average annual rainfall rates and high temperatures at Pala are expected to exacerbate low soil moisture levels and road dust in the future. Road dust contributes to poor air quality both on paved and unpaved roads, and can increase with traffic and drought. Poor air quality conditions have been reported in every year on record for the air basin that contains the Pala Reservation and its assets. In addition, projected higher temperatures and more frequent high heat days projected for the future likely will continue affecting air quality in the area.

Case Study

Fugitive Dust, Climate Change, and Accidents

Fugitive dust accounts for 80 percent of PM10 and 48% of PM2.5 in the South Coast Air Basin – the Pala's region.[84] Rainfall can reduce the concentration of particulate matter from road dust for a period of up to two days. During prolonged periods of drought, the region could experience increased concentrations of resuspended road particulates, which have negative respiratory impacts.[85] By 2050, concentrations of PM2.5 road dust are predicted to increase by about 47% in the San Joaquin Valley, due to changes in climate as well as population distribution.[86]

Dust-caused traffic accidents can be large and deadly. For example, a dust storm in California's San Joaquin Valley in late November 1991 resulted in near zero visibility, which led to 164 vehicular accidents in 33 collisions with 151 injuries and 17 deaths.[87] A combination of heat waves, dust storms, and changing weather patterns also led to a six-fold increase in Valley Fever (a disease caused by a fungus that is found in the soil) in California between 2000 and 2011, with more than 75% of the cases reported in the San Joaquin Valley.[88]

Additionally, in some arid regions including the U.S. Southwest, the spores of the *Coccidioides immitis* fungus are carried on dust. Inhaling these spores causes Coccidioidomycosis, also known as cocci or "Valley fever." Valley fever is characterized by coughing, chest pain and fever, as well as headaches, joint pain and rash.[89] Cases of

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[82] U.S. Global Change Research Program, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,* Ch. 4: "Impacts of Extreme Events on Human Health" (2016), https://health2016.globalchange.gov/extreme-events

[83] *Environmental Science Technology,* "Heavy metal contents of road-deposited sediment along the urban–rural gradient around Beijing and its potential contribution to runoff pollution," 45, 7120-7127 (2011)

[84] *Reconciling Urban Fugitive Dust Emissions Inventory and Ambient Source Contribution Estimates: Summary of Current Knowledge and Needed Research,* DRI Document No. 6110.4F (2000)

[85] *San Diego Summary Report – California's Fourth Climate Change Assessment* (2018)

[86] California Air Resources Board, *Climate Change Impact on Air Quality in California* (2010)

[87] *Bulletin of the American Meteorological Society,* "An observational study of the 'Interstate 5' dust storm case," 77(4), 693– 720 (1996)

[88] *American Journal of Public Health,* "Climate Change, Public Health, and Policy: A California Case Study," (2018)

[89] Public Health Institute, Center for Climate Change & Health, *Infectious Disease, Climate Change and Health* (2016), http://climatehealthconnect.org/wp-content/uploads/2016/09/InfectiousDisease.pdf

Valley fever in the U.S. have risen about 15% each year from 1998 to 2011. More recently, cases in California have risen from 840 in 2000 to more than 7,500 in 2018. In 2018, 273 cases were reported in San Diego County alone.[90] Although the reasons for this increase are unclear, drought conditions exacerbated by climate change may contribute to higher dust levels, and consequently increased risk for Valley fever; people are most likely to acquire Valley fever in areas where the fungus spores become airborne and are inhaled during windy, dusty conditions.[91]

Blowing dust and sand, exacerbated by drought, high heat, and increasingly fierce Santa Ana winds, also create other transportation-related impacts on public health and safety. In 2003, a three-day Santa Ana wind event toppled trees, power poles, and large trucks on highways, forcing the closures of Interstate Highways 8, 10, and 15 for several hours. Blowing dust and sand reduced visibility to zero, causing the closure of Interstate 215. The Pala Reservation is located in Wind Zone 1, which experiences winds up to 130 miles per hour. Such winds combined with increased dust can lead to dangerous driving conditions.[92]

4.3.4 Existing Mitigation Measures

Pala has implemented the following measures at Pala as part of efforts to improve resilience and adaptive capacity to mitigate extreme heat impacts on transportation systems and infrastructure.

Strategy	Access to Health and Emergency Services	Increased Road Dust
Watering unpaved roads		✓
Onsite cooling centers	✓	
Large scale solar	✓	
Air ambulance	✓	
Alert app	✓	
Back-up power systems on Casino	✓	

Figure 21: Existing mitigation strategies for extreme heat in relation to community concerns

[90] California Department of Public Health, *Epidemiologic Summary of Valley Fever (Coccidioidomycosis) in California* (2019), https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/VFEpiSum2019Dashboard.aspx
[91] State of California, *California's Fourth Climate Change Assessment: Los Angeles Region Report* (2018)
[92] Pala Band of Mission Indians, *Hazard Mitigation Plan Update* (2020)

5 SUMMARY OF KEY VULNERABILITIES

In Section 3, Pala's eight vulnerabilities were described under the relevant exposure (two for Wildfire, four for Storms and Flooding, and two for Extreme Heat), where some vulnerabilities applied to more than one exposure. Figure 22 summarizes Pala's key vulnerabilities.

Impact category	Vulnerability	Relevant Climate Change Exposures
Health and safety	Limited access to critical health/emergency services and evacuation (+ increased demand)	Wildfire, Storms and Flooding, and Extreme Heat
Health and safety	Increased road dust	Extreme Heat
Economy	Increasing costs to tribal government of road repair	Storms and Flooding
Economy	Limited access to key economic drivers	Wildfire, and Storms and Flooding
Natural resources	Impacts to ecosystems including habitat fragmentation and loss of culturally important plant and wildlife species	Storms and Flooding

Figure 22: Summary of transportation impacts from climate change at Pala

A significant part of this analysis relied upon spatial data. Figure 23 below provides a map that combines the most significant spatial vulnerability information across the three climate exposures evaluated. This map helps to visualize vulnerable corridors and assets on roadways and crossings that are critical for mobility and accessibility on the Pala Reservation. If addressed with the right adaptation strategies, Pala can help greatly diminish risks and losses associated with its key vulnerabilities and strengthen Pala's transportation and community resilience ahead of worsening climate impacts.

For example, there are only four routes to get in and out of the reservation, two of which are along State Highway 76. These routes become congested with heavy automobile traffic on a daily basis. Highway 76 is the main access road. Lilac Road is difficult to access, and Pala Temecula Road, the route to the closest hospital, is often impassable during extreme events. These route constraints may limit or prevent residents and visitors from escaping danger or accessing healthcare services, and may delay or prevent rescue and recovery efforts. Vulnerable portions of Lilac Road and Lilac Extension are sites that produce several risks, including stream crossings and culverts in areas that are prone to flooding and damage.

Based on this analysis in this report, Pala determined that its highest ranked vulnerabilities are as follows:

1. Limited access to critical health/emergency services and evacuation (+ increased demand) due to storms and flooding
2. Limited access to critical health/emergency services and evacuation (+ increased demand) due to wildfire
3. Limited access to key economic drivers due to storms and flooding
4. Limited access to key economic drivers due to wildfire

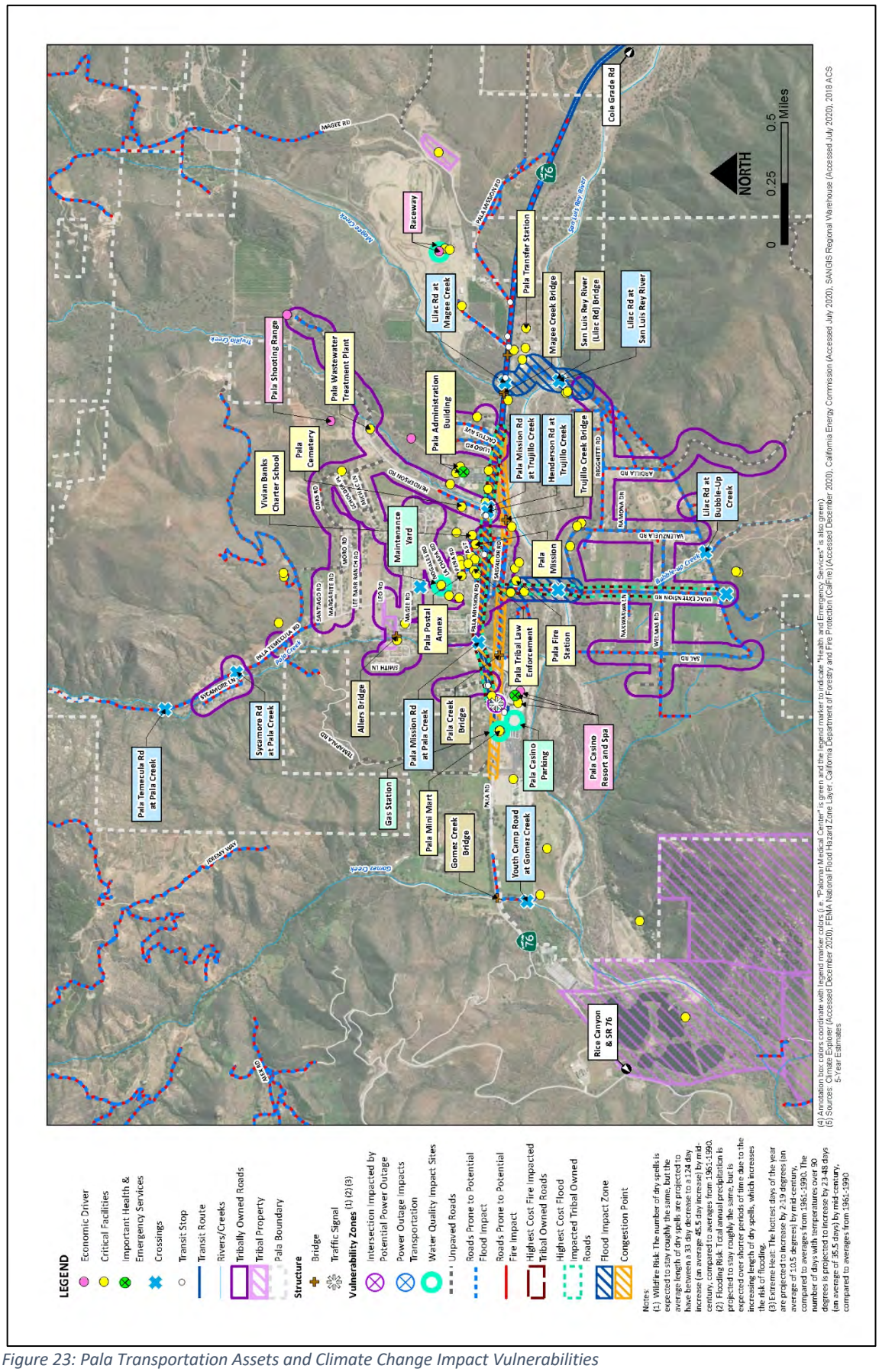


Figure 23: Pala Transportation Assets and Climate Change Impact Vulnerabilities

6 CONCLUSION

Assessments of climate change impacts and transportation vulnerabilities have yielded three primary outcomes.

First, by gathering and assessing community inputs, the assessment showed that climate impacts on transportation represent substantial concerns to Pala tribal members as well as administration and staff. Concerns focus on the many ways that increasing frequency and severity of wildfires, flooding, and extreme heat may affect mobility and accessibility among Pala residents and visitors and their ability to obtain critical health services, evacuate the area if necessary, and simply go about their normal daily patterns of commuting and transit for economic and other purposes. Many concerns focus on economic impacts – both for individual Pala residents who may incur costs or losses due to disruption of transportation infrastructure, and for the Tribe as a whole as road repairs and mitigation for wildfire, flood, and extreme heat impacts demand a higher share of the Tribe's total budget. Tribal members and staff also are concerned about how climate-related impacts to transportation can affect ecosystems in and around the Pala Reservation – specifically involving disruption to wildlife crossings and habitat.

Second, the assessment results show that when wildfire, flooding, and extreme heat are analyzed separately, flood-related impacts emerge as the most likely and frequent transportation problem, while transportation impacts resulting from a major wildfire are understood to present the most potential to be catastrophic to health, safety, and economic security. Flood damage is a clear and present danger on the Pala Reservation, with ample evidence to indicate that much of Pala's transportation infrastructure is both vulnerable to flood risk and critical to the Tribe's health, safety, ecological wellbeing and economic security. Additionally, flooding risks and damage are exacerbated by the other two key climate impacts assessed in this process; namely extreme heat, which increases the risk of wildfire that puts transportation at risk of greater damage during storms and flooding. In this way, the forces of climate change are compounded to create greater risks and costs for Pala.

Third, the assessment produced specific outcomes that will serve efforts to prioritize mitigation measures at Pala. This assessment provides clear guidance about specific transportation vulnerabilities that Pala should address in efforts to prioritize future investments. To the degree some key upgrades can avoid future damage, such upgrades will be well spent, yielding long-term savings for the Tribe, and reducing the impacts of climate change on residents and visitors to the Pala Reservation.

For next steps in adaptation planning, the project team recommends developing an adaptation plan to determine the most cost-effective mitigation measures to address the vulnerabilities presented in this report.

7 APPENDICES

Appendix A: Community Questionnaire

Appendix B: PEDAG Workshop Community Input Form

Appendix C: Kimley-Horn Pavement Assessment and Cost Estimates

Appendix A: Community Questionnaire

Appendix A includes the electronic questionnaire that was distributed to community members as part of the transportation climate change vulnerability assessment.

Welcome

Climate change is expected to cause disruptions that increase the need for safe, resilient and efficient transportation systems. The Pala Band of Mission Indians has received a Caltrans grant award to conduct a Tribal Transportation Climate Adaptation Project to help Pala adapt its transportation resources and assets to prepare for the impacts of climate change. Please complete the following survey by December 30, 2020 to help us better understand the Pala community's transportation experiences and priorities. Your responses may be anonymously quoted in related reports.

This survey is expected to take around 10-15 minutes.

1. On a scale of 1 (low) to 5 (high), how concerned are you about the following climate change exposures at Pala?

	1 (low)	2	3	4	5 (high)
Storms & flooding (including erosion and landslides)	○	○	○	○	○
Wildfires	○	○	○	○	○
Temperature extremes (e.g. heat)	○	○	○	○	○
Drought	○	○	○	○	○

2. On a scale of 1 (low) to 5 (high), to what extent do you think these exposures will affect Pala's transportation assets or resources (e.g. roads, bridges, transit services)?

	1 (low)	2	3	4	5 (high)
Storms & flooding (including erosion and landslides)	○	○	○	○	○
Wildfires	○	○	○	○	○
Temperature extremes (e.g. heat)	○	○	○	○	○
Drought	○	○	○	○	○

3. On a scale of 1 (low) to 5 (high), what is the risk that Pala could be isolated due to transportation problems during a climate event or other emergency?

- ○ 1 (low)
- ○ 2
- ○ 3
- ○ 4
- ○ 5 (high)

4. What impacts have you personally experienced at Pala as a result of storms and flooding (including erosion and landslides)? (Select all that apply)

- [ ] Traffic congestion
- [ ] Damage to a building you live in, work in, or own
- [ ] Road or bridge closure, obstruction, or damage
- [ ] Closure or relocation of a business or service you use
- [ ] Household displacement or evacuation
- [ ] Unable to enter or leave home or reservation
- [ ] Unable to access public transportation
- [ ] Unable to access health or emergency services
- [ ] Unable to obtain essential supplies (including food and water)
- [ ] Other (please specify)

5. On a scale of 1 (low) to 5 (high), to what extent have these storm and flooding transportation experiences resulted in:

	1 (low)	2	3	4	5 (high)
Health consequences	○	○	○	○	○
Disturbances to cultural practices	○	○	○	○	○
Natural resource impacts	○	○	○	○	○
Economic hardships	○	○	○	○	○

6. Please share stories, observations, and experiences associated with storm and flooding events and transportation at Pala.

7. To date, what impacts have you personally experienced at Pala as a result of wildfire? (Select all that apply)

- [ ] Traffic congestion
- [ ] Damage to a building you live in, work in, or own
- [ ] Road or bridge closure, obstruction, or damage
- [ ] Closure or relocation of a business or service you use
- [ ] Household displacement or evacuation
- [ ] Unable to enter or leave home or reservation
- [ ] Unable to access public transportation
- [ ] Unable to access health or emergency services
- [ ] Unable to obtain essential supplies (including food and water)
- [ ] Other (please specify)

8. On a scale of 1 (low) to 5 (high), to what extent have these wildfire transportation experiences resulted in:

	1 (low)	2	3	4	5 (high)
Health consequences	○	○	○	○	○
Disturbances to cultural practices	○	○	○	○	○
Natural resource impacts	○	○	○	○	○
Economic hardships	○	○	○	○	○

9. Please share stories, observations, and experiences associated with wildfire events and transportation at Pala.

10. Please share stories, observations, and experiences associated with heat or drought and transportation at Pala.

11. Besides climate changes, what other factors have resulted in transportation challenges at Pala?

12. On a scale of 1 (low) to 5 (high), to what extent do you feel Pala is well prepared to respond to and recover from climate-related impacts to transportation?

- 1 (low)
- 2
- 3
- 4
- 5 (high)

13. In your opinion, what are the largest obstacles to transportation adaptation planning?

- Lack of funds
- Lack of knowledge about risks
- Lack of time
- Lack of motivation or interest
- No obstacles
- Other (please specify)

14. What ideas or concerns do you have about strategies that can help Pala adapt its transportation assets and resources?

15. What actions can Pala take to help you become a more resilient home/community?

16. Please rank the following potential strategies to adapt transportation assets and resources to prepare for climate changes.

Flood mitigation plans and projects (e.g. drainage, green infrastructure)

Road improvements (e.g. remediation and expansion)

Re-routing traffic

Public transit services

Evacuation plans

Background

17. What is your gender

- Male
- Female
- Non-binary
- Prefer not to answer

18. What is your age range?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

19. Which of the following applies to you?

- Pala tribal member
- Pala resident
- Pala employee
- Other

20. In which area of the reservation do you live/work?

- South of the San Luis Rey River
- North of the San Luis Rey River and west of Pala Temecula Road
- North of the San Luis Rey River and east of Pala Temecula Road

21. Do you have any disabilities that inhibit your mobility?

22. During climate disasters and other emergencies, I'd prefer to be alerted via the following communication devices:

- [ ] I have no devices
- [ ] Mobile telephone
- [ ] Landline telephone
- [ ] Internet based telephone
- [ ] Social media
- [ ] Pala website
- [ ] Email
- [ ] Radio
- [ ] Other (explain)

23. Would you be willing to be contacted by staff to be interviewed, attend a workshop, or share photos? If so, please include your name and preferred email address or phone number.

Appendix B: PEDAG Workshop Community Input Form

Community Input Form

WORKSHOP #1

1. **CRITICAL TRANSPORTATION ASSETS:** Please rank the Tribe's transportation assets in terms of importance to the Tribe to protect from possible exposures resulting from climate change (high, medium, or low)

Transportation Assets	Category	Importance Ranking
Highway – State Route 76	Transportation	
Pala Road	Transportation	
Pala Temecula Road	Transportation	
Bridge	Transportation	
Public transit stations	Transportation	
Bicycle Lanes	Transportation	
Sidewalks	Transportation	
Trails	Transportation	
SDG&E Facilities	Gas & Electric	
Southern CA Tribal Chairman Association	Destination	
Pala Casino & Spa	Destination	
Vivian Banks Charter	Destination	
Mission San Antonio De Pala	Destination	
Pala Tribal Hall	Destination	
Agua Tibia	Destination	
Pala Reservation Fire Stations	Destination	
Others?		
Others?		
Others?		

2. **CLIMATE CHANGE EXPOSURE**: Please provide any feedback on the climate change exposures anticipated to affect your Tribe and corresponding rankings (high, medium, or low)

Exposures	Risk Level Ranking
Storms and Flooding	High
Wildfire	High
Temperature Extremes	High
Drought*	High

The following table is to be used for questions 3 and 4.

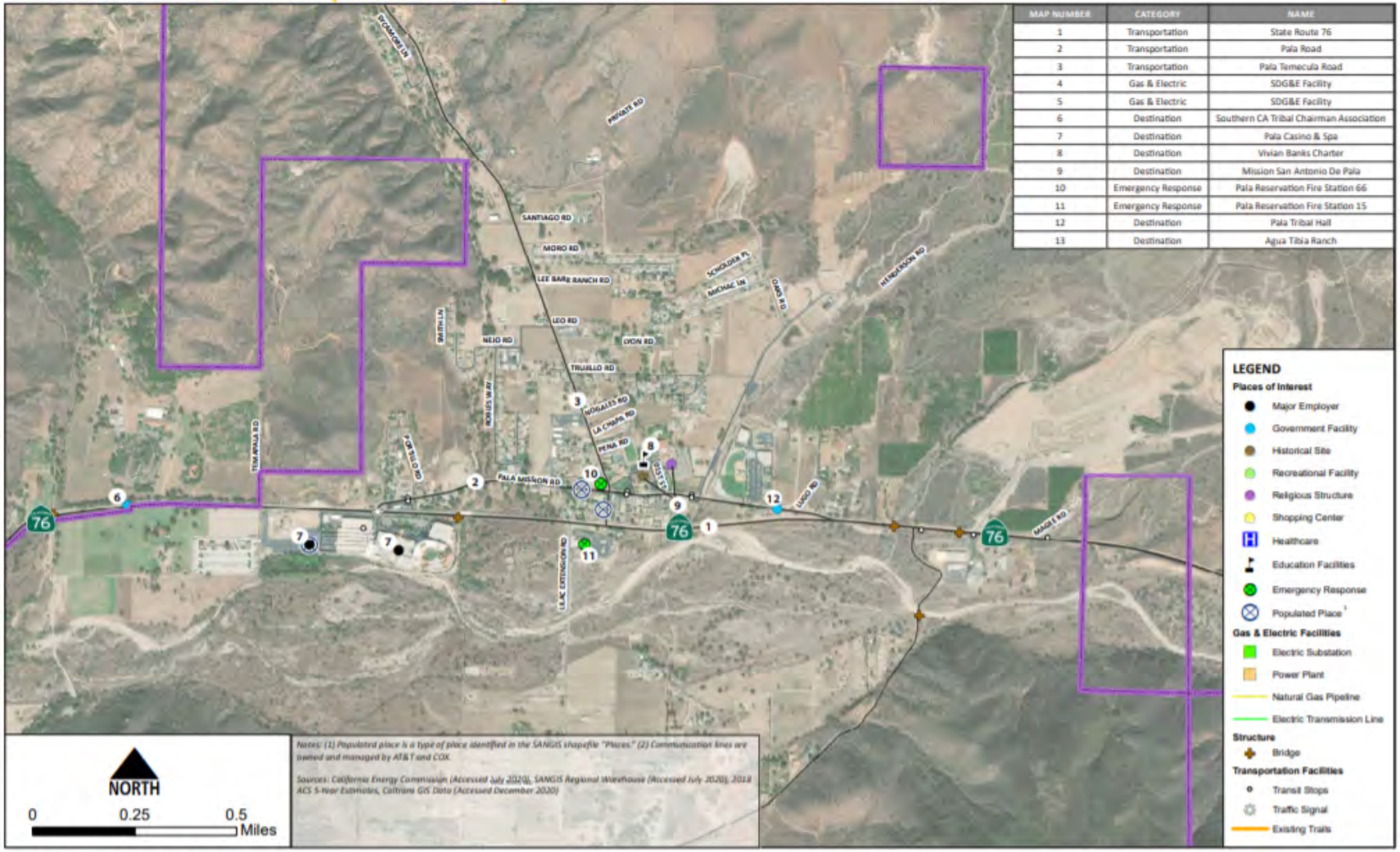
	Potential Transportation-Related Impacts Resulting from Climate Change	**Temperature Extremes**	**Storms and Flooding**	**Wildfire**
A.	Limited access to critical health/emergency services due to damage to roads			
B.	Increased demand for critical health/emergency services			
C.	Increase in accidents and collisions due to damage to roads			
D.	Limited access to key cultural sites on reservation due to damage to roads or bridges			
E.	Increase in costs to tribal government of road repair due to damage to roads			
F.	Limited access to key economic drivers (e.g. tourism, agriculture, jobs) due to damage to roads			
G.	Limited access to key economic drivers (e.g. tourism, agriculture, jobs) due to public transit problems associated with power outages or road damage			
H.	Limited access to evacuation and cooling/emergency centers in event of			

	power outage due to increased congestion			
I .	Decrease in exercise due to limited use of active transportation (e.g. biking or walking)			
J.	Increased demand to go to or deliver in water via roads			
K.	Limited access to go to or deliver in water via roads due to damage to roads			
L.	Increased demand to go to or delivery in food via roads			
M.	Limited access to go to or deliver in food via roads due to damage to roads			
N.	Others ?			
O.	Others ?			
P.	Others ?			

3. **VULNERABILITY EVALUATION CRITERIA:** The table above outlines potential transportation-related impacts resulting from climate change that will be used to assess the Tribe's vulnerability. Would you change, remove or add any potential impacts?

4. **MAPPING CONCERNS**: Please a) mark "x" by the three biggest transportation-related impacts resulting from each climate change exposure in the table above, and b) use the corresponding letter to label the assets/areas on the three group exposure maps that are most impacted. For easier viewing, maps are attached in the following pages.

INFRASTRUCTURE - PALA (FOCUS AREA)



MAP NUMBER	CATEGORY	NAME
1	Transportation	State Route 76
2	Transportation	Pala Road
3	Transportation	Pala Temecula Road
4	Gas & Electric	SDG&E Facility
5	Gas & Electric	SDG&E Facility
6	Destination	Southern CA Tribal Chairman Association
7	Destination	Pala Casino & Spa
8	Destination	Vivian Banks Charter
9	Destination	Mission San Antonio De Pala
10	Emergency Response	Pala Reservation Fire Station 66
11	Emergency Response	Pala Reservation Fire Station 15
12	Destination	Pala Tribal Hall
13	Destination	Agua Tibia Ranch

Notes: (1) Populated place is a type of place identified in the SANGIS shapefile "Places." (2) Communication lines are owned and managed by AT&T and COX.

Sources: California Energy Commission (Accessed July 2020), SANGIS Regional Warehouse (Accessed July 2020), 2018 ACS 5-Year Estimates, Caltrans GIS Data (Accessed December 2020)

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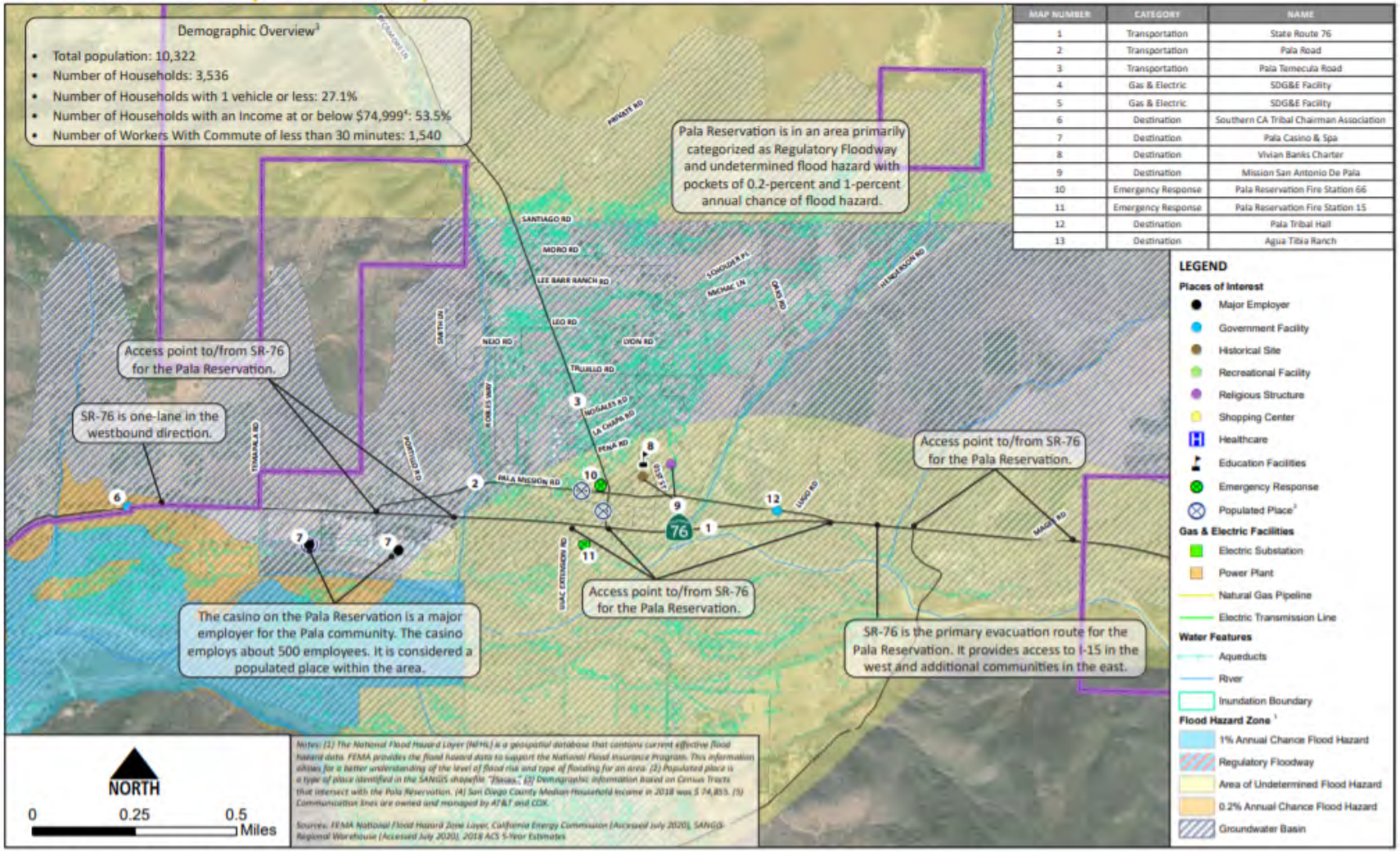
Appendix B-4

FLOOD RISK - PALA (FOCUS AREA)



MAP NUMBER	CATEGORY	NAME
1	Transportation	State Route 76
2	Transportation	Pala Road
3	Transportation	Pala Temecula Road
4	Gas & Electric	SDG&E Facility
5	Gas & Electric	SDG&E Facility
6	Destination	Southern CA Tribal Chairman Association
7	Destination	Pala Casino & Spa
8	Destination	Vivian Banks Charter
9	Destination	Mission San Antonio De Pala
10	Emergency Response	Pala Reservation Fire Station 66
11	Emergency Response	Pala Reservation Fire Station 15
12	Destination	Pala Tribal Hall
13	Destination	Agua Tibia Ranch

Notes: (1) The National Flood Hazard Layer (NFHL) is a geospatial database that contains current effective flood hazard data. FEMA provides the flood hazard data to support the National Flood Insurance Program. This information allows for a better understanding of the level of flood risk and type of flooding for an area. (2) Populated place is a type of place identified in the SANGIS shapefile "Places." (3) Demographic information based on Census Tracts that intersect with the Pala Reservation. (4) San Diego County Median Household Income in 2018 was $ 74,855. (5) Communication lines are owned and managed by AT&T and CDX.

Sources: FEMA National Flood Hazard Zone Layer, California Energy Commission (Accessed July 2020), SANGIS Regional Warehouse (Accessed July 2020), 2018 ACS 5-Year Estimates

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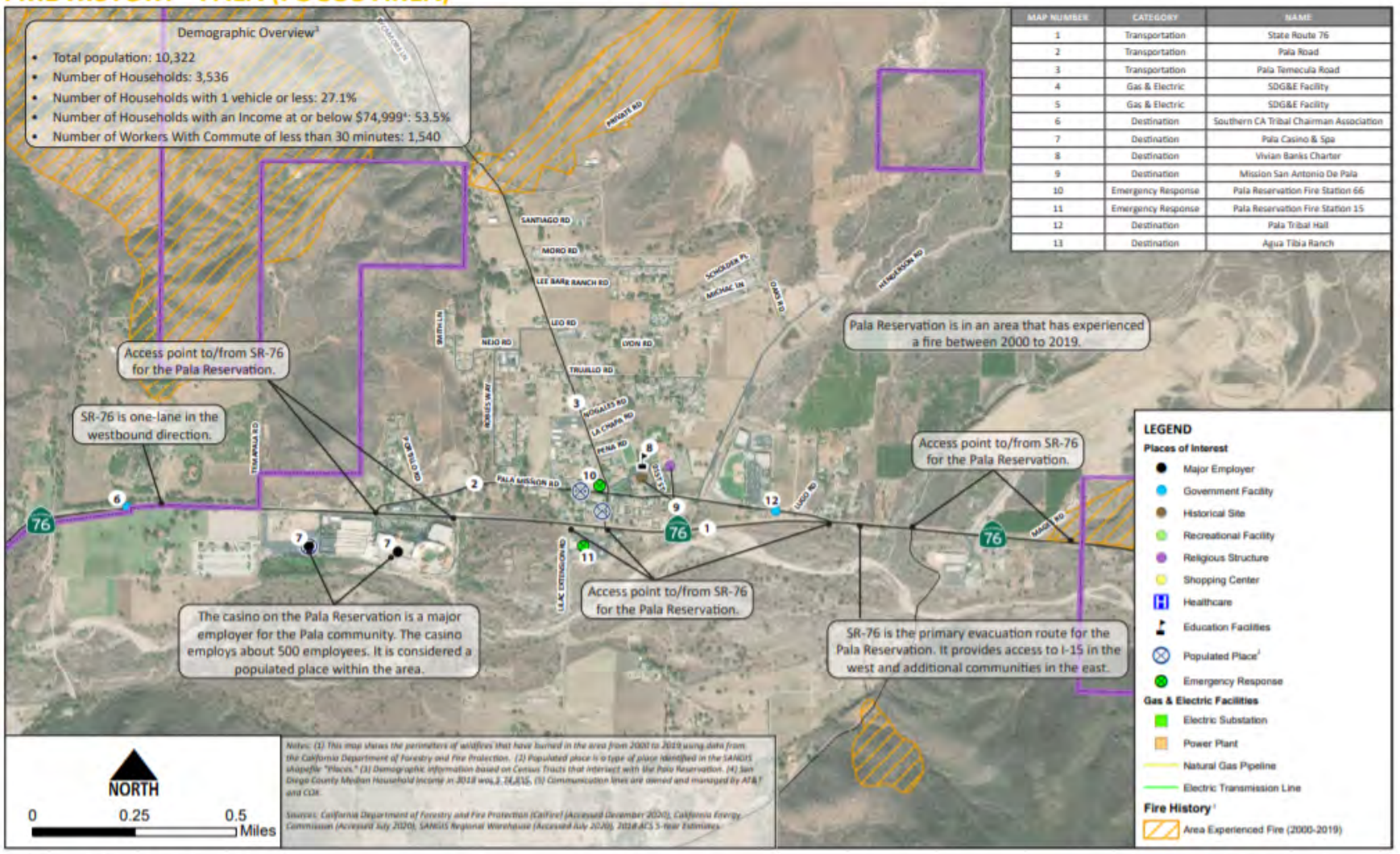
FIRE HISTORY - PALA (FOCUS AREA)



MAP NUMBER	CATEGORY	NAME
1	Transportation	State Route 76
2	Transportation	Pala Road
3	Transportation	Pala Temecula Road
4	Gas & Electric	SDG&E Facility
5	Gas & Electric	SDG&E Facility
6	Destination	Southern CA Tribal Chairman Association
7	Destination	Pala Casino & Spa
8	Destination	Vivian Banks Charter
9	Destination	Mission San Antonio De Pala
10	Emergency Response	Pala Reservation Fire Station 66
11	Emergency Response	Pala Reservation Fire Station 15
12	Destination	Pala Tribal Hall
13	Destination	Agua Tibia Ranch

Notes: (1) This map shows the perimeters of wildfires that have burned in the area from 2000 to 2019 using data from the California Department of Forestry and Fire Protection. (2) Populated place is a type of place identified in the SANGIS shapefile "Places." (3) Demographic information based on Census Tracts that intersect with the Pala Reservation. (4) San Diego County Median Household Income in 2018 was $ 74,755. (5) Communication lines are owned and managed by AT&T and CUI.

Sources: California Department of Forestry and Fire Protection (CalFire) (Accessed December 2020), California Energy Commission (Accessed July 2020), SANGIS Regional Warehouse (Accessed July 2020), 2018 ACS 5-Year Estimates.

Appendix C:
Kimley-Horn Pavement Assessment and Cost Estimates

Kimley-Horn consultants conducted a site visit of the Pala Reservation on March 15, 2021, which was used to evaluate Pala's existing transportation systems and road conditions. Photos from the visit help to document road conditions and are provided below.

The existing road conditions were investigated using the PASER Method. The PASER method is a visual observation tool that assesses surface defects. Surface deformations, cracks, patches and potholes of existing roadways in order to establish a condition based on a scale of 1-10. The PASER Rating Scale establishes a baseline for the rating scale accompanied by descriptions and example photos for the qualitative assessment of the surface condition of the road. In addition to indicating the surface condition of the road, the PASER Rating includes a recommendation for the needed maintenance or repair. (Source: Northwest Wisconsin Regional Planning Commission, *PASER Manual* (2013), https://interpro.wisc.edu/tic/documents/paser-manual-asphalt-pubpas01/)

The estimated cost of road repair in Pala and the surrounding areas due to increased wildfire frequency, inland flooding, and temperature increases in the next 50 years is predicted to be about $11 million with direct costs related to Pala owned road repairs around $1.9 million. The cost estimate is based on a factored value projected by *California's Fourth Climate Change Assessment*. Based on this assessment of the exposure on the existing roadways, the most critical roads prone to damage from all the exposures included Lilac Road and Lilac Extension.

	Direct Economic Costs to Climate Change[1]	Relative to Pala Focus Area[2]	Pala Direct Costs Factor[4]
	(billion)	(million)	(million)
Changes in Temperature	1	0.37	0.06
Wildfire Frequency[5]	0.18	0.07	0.01
Inland Flooding	42	10.6	1.80
Totals Cost	**43.2**	**11.0**	**1.9**

Notes:

1. Estimates from *California's Fourth Climate Change Assessment*

2. Factor applied to downscale impacts of climate change specific to the Pala Focus Area. Estimates created from ratio of population density.

3. Population density factor = 0.0000002531.

4. Dollar impact of Pala owned roads to all other owned roads in Focus Area. Factor equal to 17 percent.

5. Value interpolated from costs to rise 18 percent.

FIELD INPUT						Evaluation Summary						
						PASER Rating*	Cost**	Exposure			Cost**	Impacts***
Segment ID	Logical Street Name	# of Lanes/Width	Owner	Existing Surface Cover	Additional Notes	(#)	($)	Wildfire	Heat	Flooding	($)	
1	**Pala Mission Road @ Lilac Ext. Entrance**	No shoulder, 2-lane, fire lane	Tribe	**Paved**	Firestation, Fire Hazard Warning for Reservation	**7**	$$	X	X	X	$$	A, B, C, G, H, I
2	**Lilac Ext. @ San Luis Ray**	No shoulder, 1-lane	Tribe	**Unpaved**		**5**	$$$	X	X	X	$$$	A, B, C, D, G, H, I
3	**Lilac Ext. @ Lilac Road**	No shoulder, 1-lane	Tribe	**Unpaved**	Steep grade	**3**	$$$$	X	X		$$$$	A, C, D, G, H
4	**Lilac Road @ Bubble Up Creek**	No shoulder, 1-lane	County	**Unpaved**		**3**	$$$$	X	X	X	$$$$	A, B, C, D, I
5	**Lilac Road @ Ardilla Road**	No shoulder, 2-lane, 2 car passable	County	**Unpaved**		**5**	$$$	X	X		$$$	A, C, D
6	**Lilac Road @ Regghetti Road**	No shoulder, 2-lane, >5%, difficult to pass to cars	County	**Unpaved**		**4**	$$$	X	X		$$$	A, C, D
7	**Lilac Road @ San Luis Ray**	No shoulder, 2-lane, 2 car passable	County	**Unpaved/Paved**		**5**	$$$	X	X	X	$$$	A, B, C, D, I
8	**Pala Mission Road @ Lilac Road Entrance**	No shoulder, 2-lane, 2 car passable	County	**Paved**		**4**	$$$	X	X	X	$$$	A, B, C, I
9	**Magee Road @ Pala Mission Road**	No shoulder, 2-lane, 2 car passable	County	**Paved**	Alternative exit route	**6**	$$	X	X		$$	A, C, E,
10	**Pala Mission Road @ Pala Creek**	No shoulder, 2-lane, 2 car passable	County	**Paved**		**7**	$$	X	X	X	$$	A, B, C, E, F

11	**Pala Temecula Road @ Trujillo Wash**	Shoulder, 2-lane, 2 car passable	County	**Paved**		**6**	$$	X	X	X	$$	A, B, C, E, F
12	**Pala Temecula Road @ Santiago Road**	Shoulder, 2-lane, 2 car passable	County	**Paved**		**5**	$$$	X	X		$$$	A, C, E
13	**Pala Temecula Road @ Pala Creek**	Small shoulder, 3 lane, 2 car passable	County	**Paved**		**5**	$$$	X	X	X	$$$	A, B, C, E, F
14	**Pala Mission Road @ Trujillo**	Shoulder, 2-lane, 2 car passable	County	**Paved**		**5**	$$$	X	X	X	$$$	A, B, C, E, F
15	**Pala Mission @ Culvert and Camp Access**	Shoulder, 2-lane, 2 car passable	State	**Paved**		**7**	$$	X	X	X	$$	A, B, C, E, F

Notes:

*See attachment with PASER Rating Scale
**See attachment with Order of Magnitude Ranking associated with the PASER scale
***See Ranking Impacts Table Attachment

Asphalt pavement distress

PASER uses visual inspection to evaluate pavement surface conditions The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is

There are four major categories of common asphalt pavement surface extremely important in selecting an appropriate maintenance or rehabilitation technique.

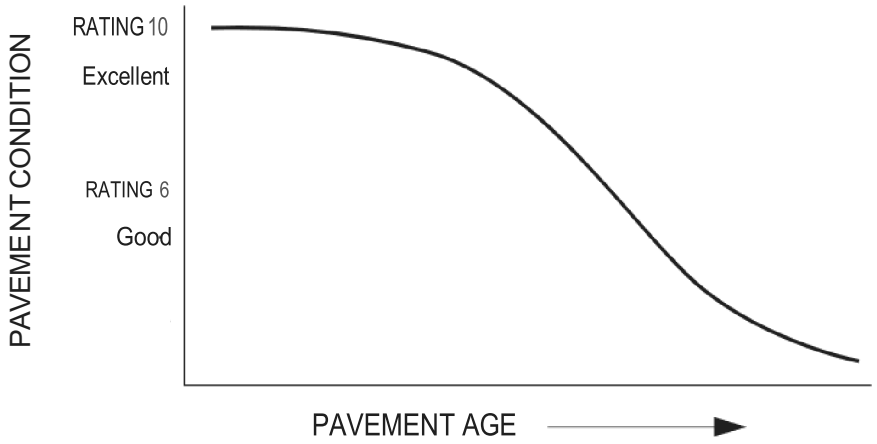
Sudacede*ec*s

Rave4ng. hushing, polishing.

surface deformation
Rutting. distortion—rippling and shoving, settling, Prost heave.

Transverse, reflection, slippage, longitudinal, block, and alligator cracks.

Patches and potholes

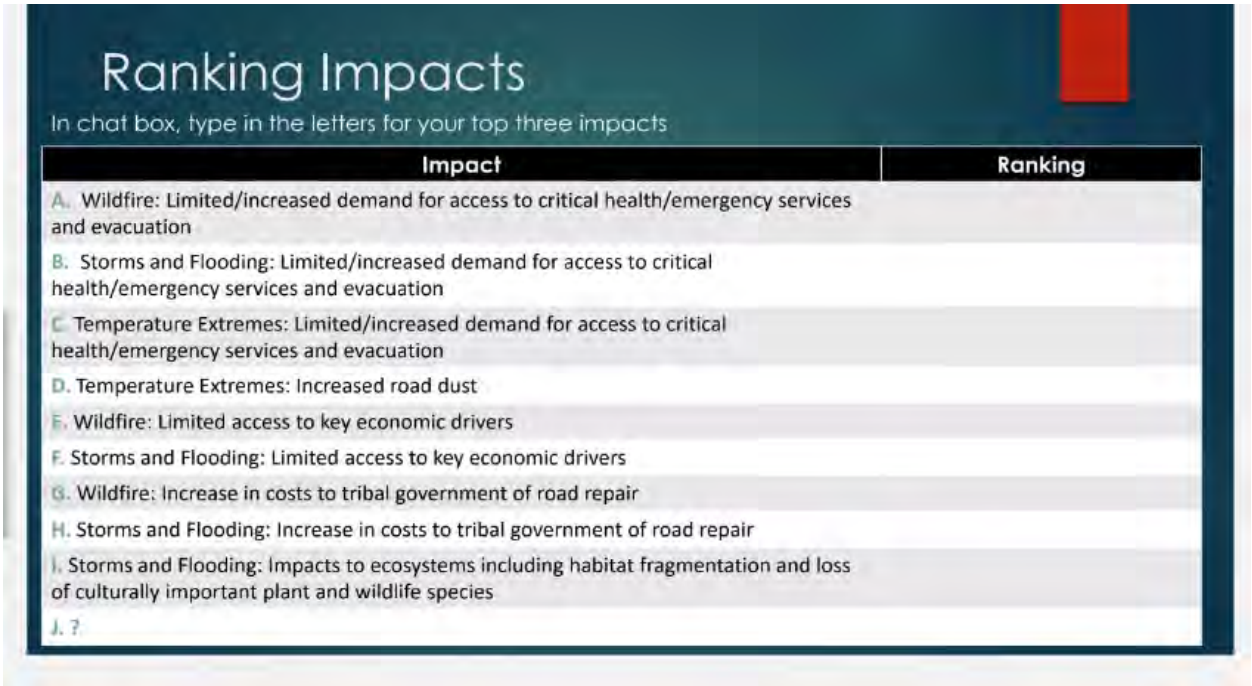


In addition to indicating the surface condition of a road, a given rating also includes a recommendation for needed maintenance or repair. This feature of the rating system

facilitates its use and enhances its value as a tool in ongoing

RATINGS ARE RELATED TO NEEDED MAINTENANCE OR REPAIR

Rating 9 & 10	No maintenance required
Rating 8	Little or no maintenance
Rating 7	Routine maintenance, cracksealing and minor patching
Rating 5 & 6	Preservative treatments (sealcoating)
Rating 3 & 4	Structural improvement and leveling (overlay or recycling)
Rating 1 & 2	**Reconstruction**


Ranking Impacts
In chat box, type in the letters for your top three impacts
Impact
Ranking
A. Wildfire: Limited/increased demand for access to critical health/emergency services and evacuation
B. Storms and Flooding: Limited/increased demand for access to critical health/emergency services and evacuation
C. Temperature Extremes: Limited/increased demand for access to critical health/emergency services and evacuation
D. Temperature Extremes: Increased road dust
E. Wildfire: Limited access to key economic drivers
F. Storms and Flooding: Limited access to key economic drivers
G. Wildfire: Increase in costs to tribal government of road repair
H. Storms and Flooding: Increase in costs to tribal government of road repair
I. Storms and Flooding: Impacts to ecosystems including habitat fragmentation and loss of culturally important plant and wildlife species
J. ?

Magnitude Cost

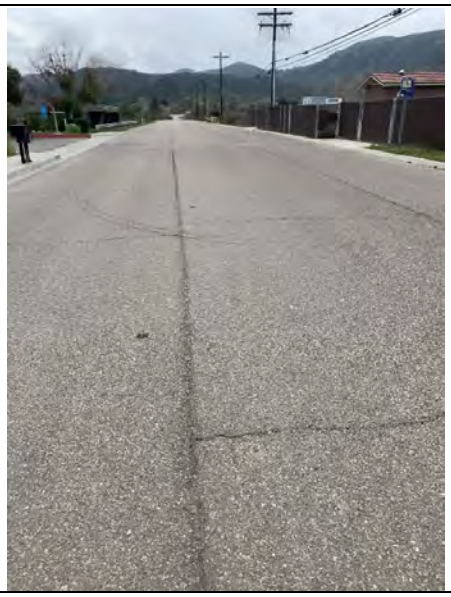
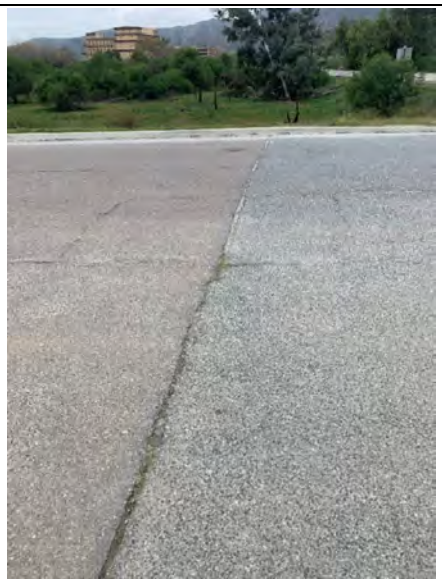
Order

Rating system

	30 **Excellent**	None.	New construction.
	9 **Excellent**	None.	Recent overlay. Like new.
$	8 **Very Good**	No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40' or greater) All cracks sealed or tight (open less than !/4“).	Recent sealcoat or new cold mix. Little or no maintenance required.
$$	7 Good	Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open !/4”) due to reflection or paving joints. Transverse cracks (open !/4”) spaced 10' or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging. Maintain with routine crack filling.
$$	6 Good	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open !/4”—!/2“). Transverse cracks (open !/4”— !/z”), some spaced less than 10'. First sign of block cracking. Sight to moderate flushing or polishing.	Shows sipns of aging. Sound structural condition. Could extend life with sealcoat.
$$$	5 Fair	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open !/z” or more) show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition. Needs sealcoat or thin non-structural overlay (less than 2”)
$$$	4 Fair	Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (!/z” deep or less).	Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2” or more).
$$$$	3 **Poor**	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (greater than !/7” but less than 2 " deep). Occasional potholes.	Needs patching and repair prior to major overlay. Milling and removal of deterioration extends the life of overlay.
$$$$ $$$$$	2 1 **Failed**	Alligator cracking (over 25 % of surface). Severe rutting or distortions (2” or more deep). Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair. Pulverization of old Failed. Needs total reconstruction.

* Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types.

Alligator cracking (over 25% of surface) Severe rutting or distortions (2″ or more deep) Extensive patching in poor condition. Potholes.
Severe distress with extensive loss of surface integrity.
Alligator cracking (over 25% of surface) Severe rutting or distortions (2” or more deep) Extensive patching in poor condition. Potholes. Severe distress with extensive loss of surface integrity.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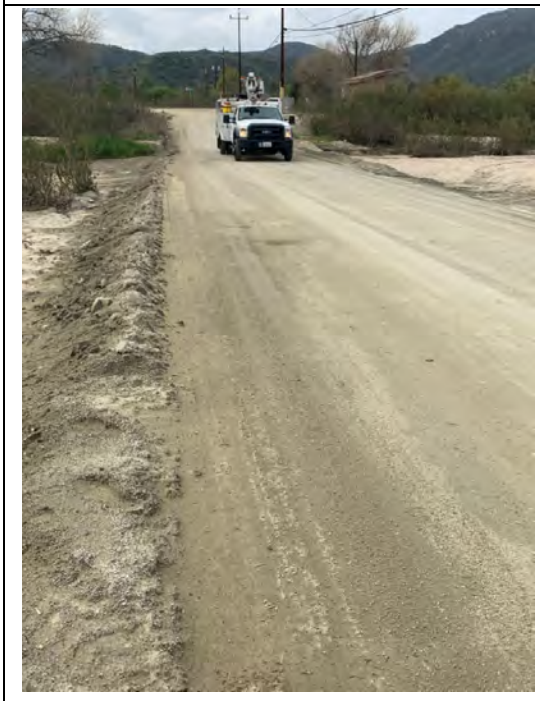
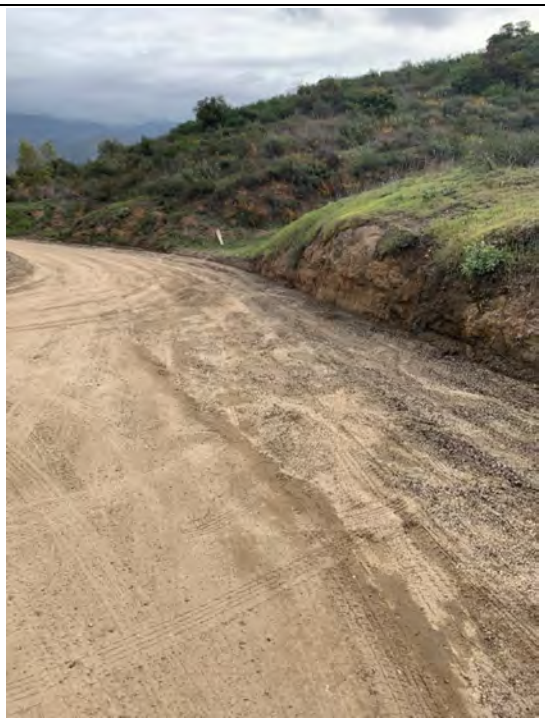
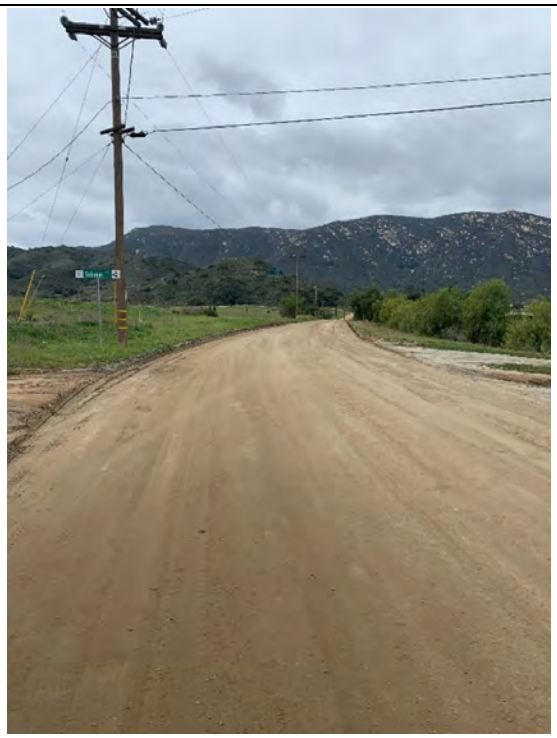
	
2 – Lilac Extension @ San Luis Ray	2 – Lilac Extension @ San Luis Ray

	
3 – Lilac Extension @ Lilac Road	3 – Lilac Extension @ Lilac Road
	
4 – Lilac @ Bubble Up Creek	4 – Lilac @ Bubble Up Creek



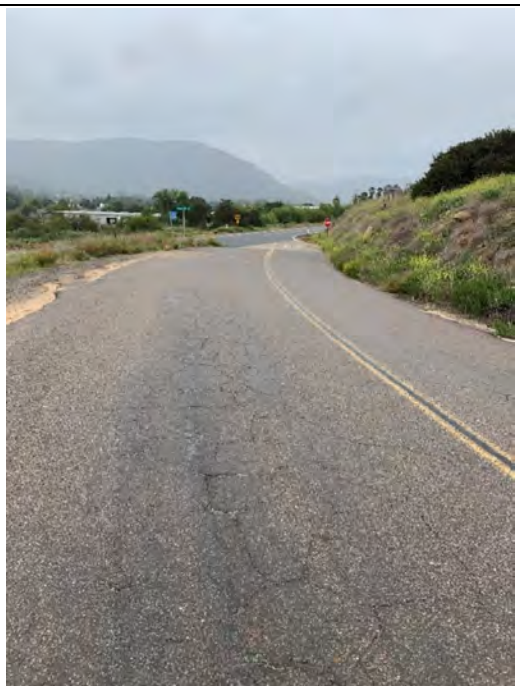
5 – Lilac @ Ardilla

5 – Lilac @ Ardilla

6 – Lilac @ Regghetti

6 – Lilac @ Regghetti

	
7 – Lilac @ San Luis Ray	7 – Lilac @ San Luis Ray
	
8 – Pala Mission Road @ Lilac Entrance	8 – Pala Mission Road @ Lilac Entrance

	
9 – Magee Road @ Pala Mission Road	9 – Magee Road @ Pala Mission Road
	
10 – Pala Mission Road @ Pala Creek	10 – Pala Mission Road @ Pala Creek

	
11 – Pala Temecula Road @ Trujillo Wash	11 – Pala Temecula Road @ Trujillo Wash
	
12 – Pala Temecula Road @ Santiago Road	12 – Pala Temecula Road @ Santiago Road

	
13 – Pala Temecula Road @ Pala Creek	13 – Pala Temecula Road @ Pala Creek
	
14 – Pala Mission Road @ Trujillo	14 – Pala Mission Road @ Trujillo

	
15 – Pala Mission @ Culvert and Camp Access	15 – Pala Mission @ Culvert and Camp Access