5.2.1.4. Composite Fire Behavior Changes

Figure 5.10: projected changes in flame length under Case II compared to baseline

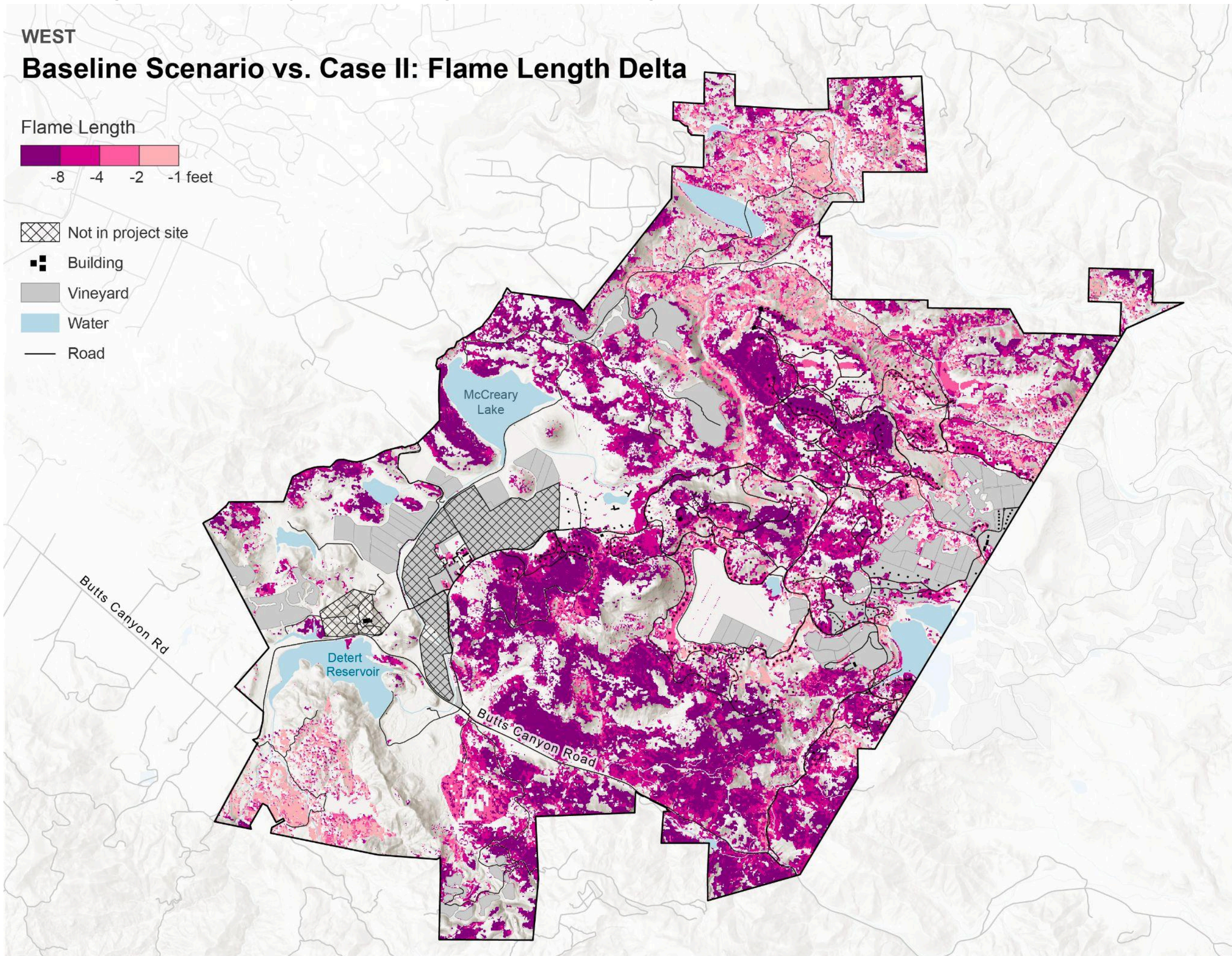


Table 5.8: Projected changes in key fire behavior indicators on the MGV project site[60]

	Key Indicator	Projected Change: Baseline vs. Case I (DF)	Projected Change: Baseline vs. Case II (DF + MM)
East Scenario	Site-Wide Average Flame Length	-3%*	-50%*
	Site-Wide Average Rate of Spread	-3%*	-29%*
	Fraction of Site Supporting Direct Attack	+2%*	+32%*
	Torching Fraction of Site	-1%*	-26%*
West Scenario	Site-Wide Average Flame Length	-3%*	-50%*
	Site-Wide Average Rate of Spread	-3%*	-28%*
	Fraction of Site Supporting Direct Attack	+2%*	+31%*
	Torching Fraction of Site	-1%*	-26%*

60 Indicators marked with a (*) indicate a less risky and more resilient state than the current baseline.

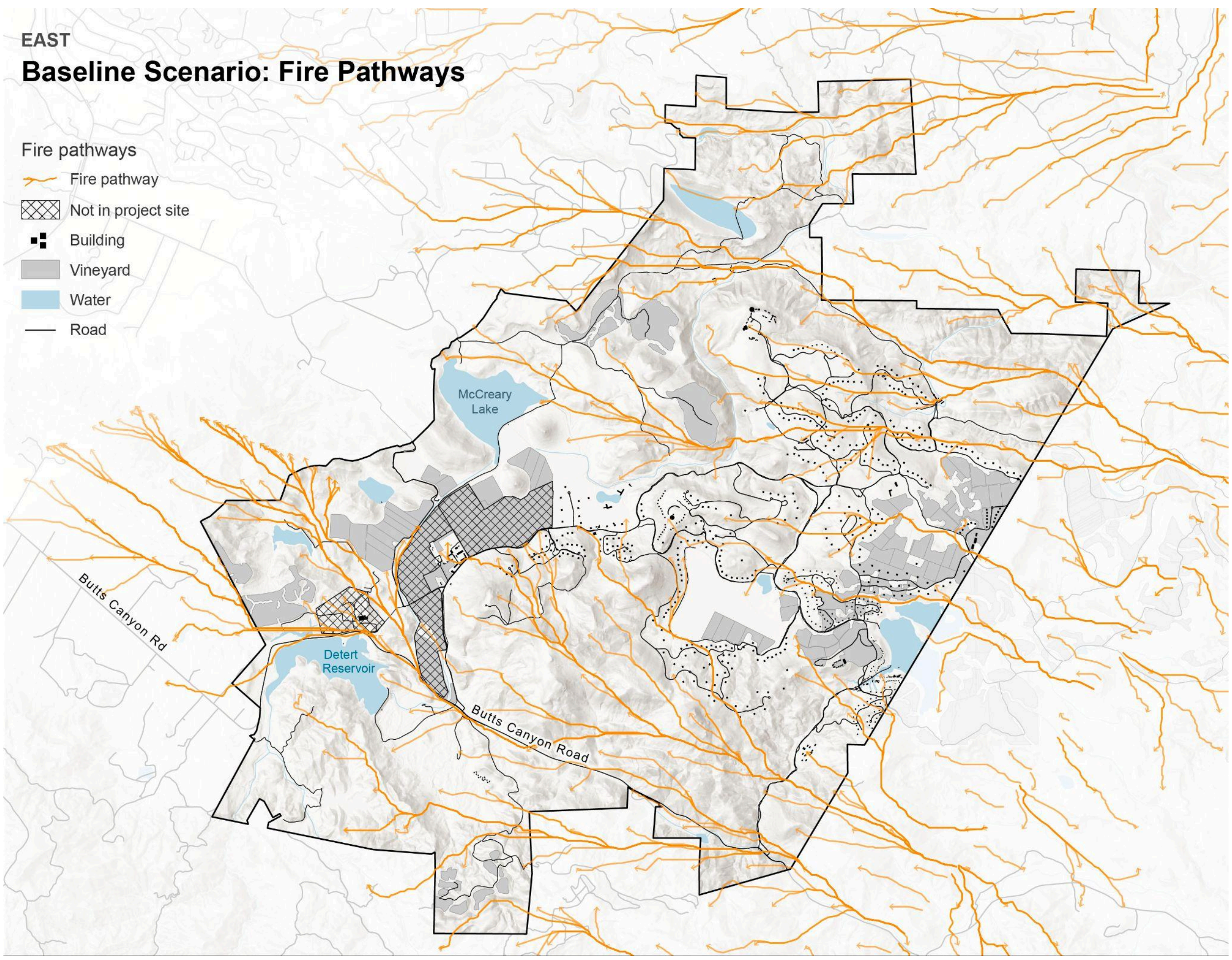
Table 5.8 shows the projected changes in key fire behavior indicators averaged across the MGV project site.

5.2.1.5. Buildout of Future Phases of the Project

The addition of approximately 1,500 additional structures in the buildout of future phases of the project is not projected to substantially increase the fire behavior on the MGV site. The precise changes in fire behavior due to landscaping and the addition of buildings and other elements is dependent on the location of those features; however, continued adherence to the principles laid out in the WPP, including irrigation, defensible space around buildings, roadside clearance, and active landscape management throughout the site, are likely to keep flame length, rates of spread, and torching probabilities low around roads and buildings.

5.2.2. Analysis of Potential Fire Growth

Figure 5.11: Projected fire pathways modeled under the existing baseline conditions and an east wind event



While potential fire behavior models express the spatial differences characteristics of the fire across a heterogeneous landscape, fire growth modeling, and fire pathways modeling in particular, addresses fuel continuity and delineates the likely trajectories of fire growth. In this study, fire growth was modeled under the statistically-derived worst-reasonable case fire weather for the MGV project site. This fire activity may exceed the fire activity observed during the 2015 Valley Fire and the 2020 Hennessey Fire; however, those fires likely experienced slower growth rates on the MGV site because they burned under less-than-peak fire weather conditions. An ignition during a higher-severity day would likely have resulted in even more substantial consequences than the nearly 2,000 structures destroyed during the Valley Fire.

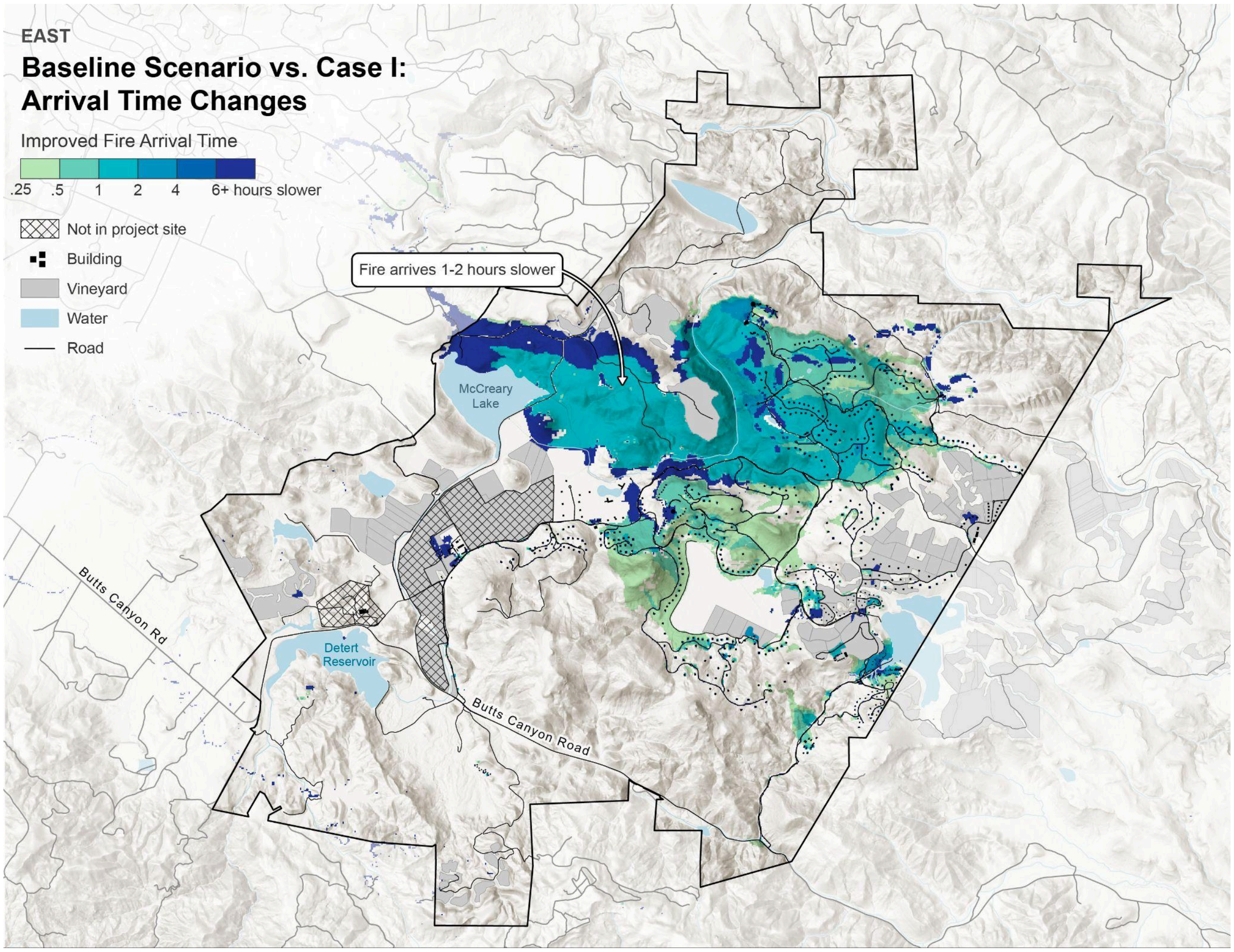
In this section, we include figures and results for the east to west fire scenario. The west to east scenario results in similar outcomes, and can be found in Appendix W.1.

5.2.2.1. Case I: Design Features

DF elements are marginally beneficial in interrupting fire spread: together, these features are projected to increase fire arrival time to the existing and proposed buildings on the eastern portion of MGV site by approximately 20-30 minutes, providing additional time for evacuation and firefighter ingress. While the increase in fire arrival time is not insignificant, it is unlikely to be sufficient to facilitate a complete evacuation or the sufficient ingress of local and regional firefighting resources. In many cases, the DF features are too small or too isolated to be broadly effective in interrupting the corridors of most rapid fire spread.

Although the modeling again shows a reduction of fire risk under Case I (design features alone), following the approach for ignitions and fire behavior above, this study again considers the highly stochastic nature of severe wildfire events, and evaluates fire pathways considering Case II (design features + mitigation measures), laid out in Table 1.1 in Section 1 above.

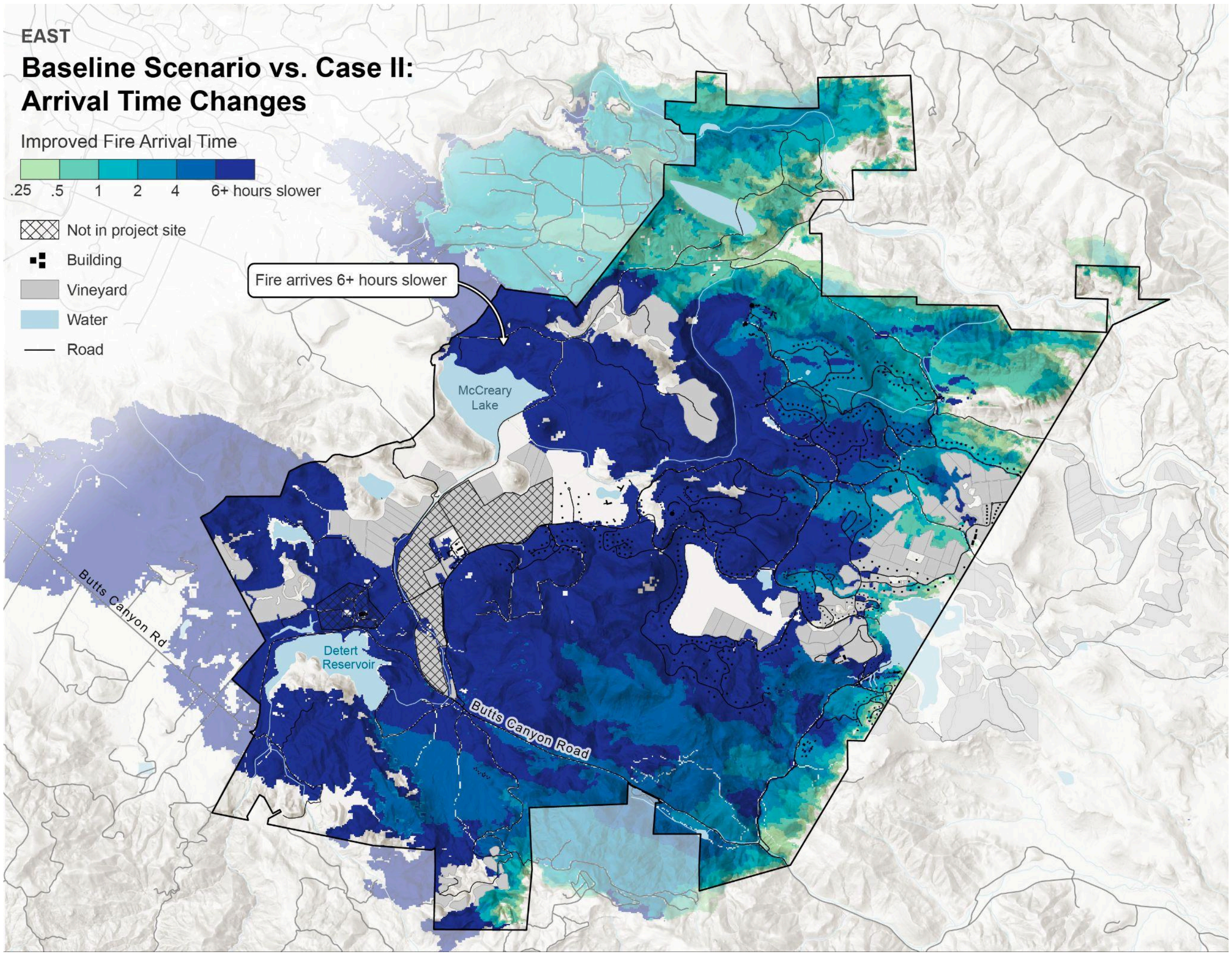
Figure 5.12: Projected fire arrival time increases resulting from the Case I risk reduction activities.



5.2.2.2. Case II: Design Features and Mitigation Measures

Fires spreading across the site in the presence of the Case II risk reduction activities are likely to spread much more slowly and encounter more fragmented fuels than under the baseline case. Decreased spread rates are projected to provide firefighters an average of approximately two hours, and in many cases upwards of four to five hours, to reach the existing and proposed structures on the MGV site. The benefits of slower fire spread are also likely to extend to the nearby communities of Middletown and Hidden Valley Lake, as shown in Figure 5.13.

Figure 5.13: Projected fire arrival time increases resulting from the Case II risk reduction activities.



5.2.2.3. Fire Growth Indicators

Table 5.9: Key indicators reflecting the changes attributable to the Case I and Case II risk reduction activities compared to the baseline[61]

	Key Indicator	Projected Change: Baseline vs. Case I (DF)	Projected Change: Baseline vs. Case II (DF + MM)
East Scenario	Change in Fire Arrival Time at Existing and Proposed Buildings	+5%*	+19%*
	Number of Existing and Proposed Buildings Along Fire Pathway	-13%*	-54%*
West Scenario	Arrival Time at Existing and Proposed Buildings	+3%*	+35%*
	Number of Existing and Proposed Buildings Along Fire Pathway	-15%*	-70%*

Under the existing baseline conditions, fires that ignite on the site or spread onto the site from the surrounding area are projected to spread quickly and exhibit characteristics that would make suppression difficult. On average, a fire igniting on the site in the baseline case could exceed 100 acres within one hour and approach 1,000 acres within three hours. Fire pathways analysis suggests that there are several existing corridors where fuel, topography, and wind are likely to align during high-severity fire weather days to produce fast-moving runs across the MGV project site and may affect down-wind communities, such as Hidden Valley Lake and Middletown. Correspondingly, potential fire behavior analysis indicates that these fires are likely to be resistant to control. Modeling suggests that only approximately 38% of the site is currently available to ground-based firefighters to directly engage the fire and that at least 50% of the site is likely to support torching or other forms of canopy fire activity.[62] Under baseline conditions, successful fire suppression would likely require indirect line construction,[63] aircraft, or heavy equipment.

[61] Elements marked with an asterisks (*) are less risky and more resilient than the existing baseline.
[62] See Appendix W.1.
[63] Ground-based firefighters can either engage in direct line construction, where the a fireline is dug directly adjacent to the edge of the active flaming front, typically using chainsaws or handtools, or indirect line construction, where crews and dozers create control features far from the fire front (100s-1000s of meters) and then engage in strategic firing operations to light controlled burns that remove fuel between the control feature and the main fire front. Indirect line is more complex to implement and can be less effective at controlling the fire than direct line construction.

The combined (DF+MM) risk reduction activities presented in the WPP are predicted to be highly effective at facilitating successful suppression on the site. Lower rates of spread, attributable to active landscape management, roadside clearance, and defensible space, and the placement of non-burnable features, such as roads and golf courses, would work together to limit the capacity for fire growth on the site. On average, fires are projected to be at least 38% smaller after the WPP risk reduction activities are implemented (DF+MM), and the area available to ground-based firefighters is projected to increase by more than 80%.[64]

The proposed DF+MM activities are particularly effective in reducing fire intensity near key transportation corridors and structures on the site. Flame length adjacent to existing and proposed roads is projected to decrease by approximately 36%, while flame length adjacent to existing and proposed structures is projected to decrease by 68%.[65] Although roadside ignitions are a common source of wildland fires that may increase with additional population, the reduced fuel conditions adjacent to the roadways throughout the site and the increased capacity for firefighters to quickly respond to those fires reduce the likelihood that they will become large and damaging wildfires that could affect structures on or adjacent to the MGV site.

Fire pathways analysis indicates that slower growth rates and strategically-placed non-burnable features, such as roadways and golf courses, are likely to benefit communities to the west of the project site, including Middletown and Hidden Valley Lake, by limiting rapid growth towards these communities under an east wind scenario. Even without firefighter intervention on the MGV site, fire is projected to reach these communities more than 100 minutes later under the modeled weather scenarios after the DF+MM risk reduction activities are implemented compared to the existing baseline.[66] With efficient emergency management, this increase in arrival time can provide substantially more time for safe evacuation and for defense of structures in these communities. Moreover, decreased fire intensity on the MGV project site is likely to facilitate safe and effective firefighting on the site, enabling firefighters to interrupt residual fire pathways and reduce the likelihood that the fires will continue to spread into adjacent communities.

Although Case I alone results in a moderate reduction of wildfire risk on the site, considering the highly stochastic nature of severe wildfire events, this analysis retains a determination that a project of this magnitude should implement the full suite of mitigation measures laid out in Table 1.1 in Section 1 above. The models for fire behavior and fire pathways both demonstrate far greater reductions in intensity of wildfire behavior under Case II than Case I. Taken together, the various DF and MM activities are projected to result in smaller, less intense fires, along with a more rapid response and improved working conditions for firefighters. These factors work together to create a higher likelihood of controlling fires that ignite on the site or spread from the surrounding areas.

[64] See Appendix W.1. Section 2.2.2
[65] See Appendix W.1. Sections 2.2.2
[66] See Appendix W.1. Section 2.3.2.

5.2.2.3. Buildout of Future Phases of the Project

The buildout of future phases of the project is not projected to substantially change the exposure of buildings on the site to unmitigated fire pathways. Continued adherence to the WPP, including roadside clearance, active landscape management, the addition of non-burnable landscape elements, such as golf courses and polo fields, and defensible space around buildings, is projected to interrupt fire pathways to buildings constructed in Phase I of the MGV project as well as those built in future phases. As shown in Figure 5.12, fire growth benefits are likely to extend to the vast majority of the site area. The exact magnitude of the benefits afforded by these risk reduction activities will depend on the location of buildings constructed during the buildout of future phases of the project.

5.3. Community Susceptibility to Wildfire

Susceptibility of a community to wildfire is influenced by the resilience of structures and nearby landscapes to ignition and fire spread. It is also influenced by the capacity of firefighters to detect and respond to new fires quickly.

In the context of a wildfire risk assessment that is determining risk people, property, and environment both on-site and off-site, the concept of community susceptibility takes on two roles:

1. The susceptibility of anyone living, working, or recreating on-site; and
2. The susceptibility of surrounding communities off-site

As noted in Section 4.3., design features and mitigation measures are for the built environment on-site, not the built environment of surrounding communities off-site, and thus impacts to community susceptibility from these built-environment interventions would primarily accrue on-site. Impacts to the susceptibility of off-site built communities from Case I and Case II is indirect. Impacts to susceptibility of the on-site built community will positively influence off-site ignition likelihood and wildfire intensity, but not off-site community susceptibility. This is due to the fact that any change in susceptibility of on-site structures to wildfire would only alter ignitions off-site due to potential ember cast, and fire intensity off-site due to potential to alter fire intensity onsite from structure fires. Therefore, in Section 5.3, we primarily discuss community susceptibility to wildfire as it relates to the on-site community.

5.3.1. Design of the Built Environment

Through the devastation of recent megafires, fire professionals, architects, and community planners have learned how structures ignite and cause the tragic decimation of communities throughout the United States, including communities such as Paradise and Lahaina.[67,68,69] The need to rebuild communities after devastating wildfires, coupled with California's housing demand, has driven scientists and fire professionals to use evidence from the devastation of recent wildfires and develop guidelines for designing resilient communities.[70,71] These approaches to fire smart design can be much more effective when implemented as part of the community design and development process than when applied retroactively to existing communities.

While existing communities have the opportunity to retrofit their structures and remove or reduce vegetation on individual properties to reduce their individual risk, they cannot alter the fundamental design and topology of the structures, roads, and other elements of their community. In particular, existing communities cannot space out existing homes from one another to reduce the chance of radiant heat from structures from igniting other structures.[72,73,74] Additionally, some residents may be resistant or unable to remove vegetation near their homes, near their neighbors' homes, or adjacent to evacuation routes. Home retrofits also come with significant costs that are prohibitive for most people and are not often required by law.[75] Taken together, there are significant barriers to implementing even the simplest, least expensive measures, such as retrofitting vents with ⅛" hardware mesh to inhibit ember entry or installing non-combustible gutter guards to reduce leaf litter accumulation.

However, in high-risk areas, constructing new communities provides a unique opportunity to create a "resilience node" by building housing that incorporates robust wildfire mitigation features, including development clusters surrounded by defensible space,[76] sufficient distance between structures, and adherence to fire-safe building codes, standards, and best practices such as California Building Code Chapter 7A and others discussed in Section II. Furthermore,

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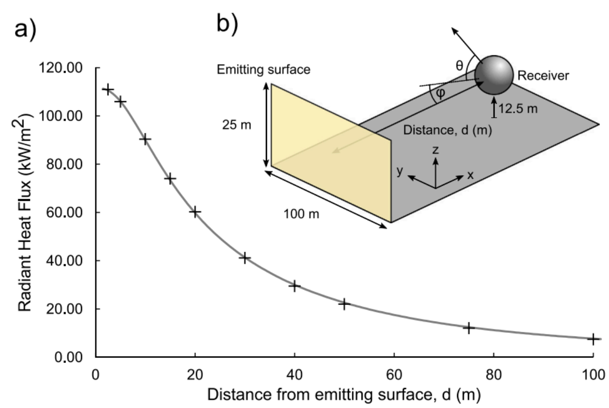
[67] Maranghides A, Mell W, Hawks S, Wilson M, Brewer W, Link E, Brown C, Murrill C, Ashley E (2020) Preliminary Data Collected from the Camp Fire Reconnaissance. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Technical Note (TN) 2128.
[68] Maranghides A, Mell W, Hawks S, Wilson M, Brewer W, Link E, Brown C, Murrill C, Ashley E (2020) Camp Fire Preliminary Reconnaissance. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Technical Note (TN) 2105.
[69] Lahaina fire Incident Analysis report.2024. fsri.org. https://doi.org/10.60752/102376.26858962
[70] Syphard, Alexandra D., Teresa J. Brennan, and Jon E. Keeley. "The role of defensible space for residential structure protection during wildfires." International Journal of Wildland Fire 23.8 (2014): 1165-1175.
[71] Syphard, Alexandra D., Teresa J. Brennan, and Jon E. Keeley. "The importance of building construction materials relative to other factors affecting structure survival during wildfire." International journal of disaster risk reduction 21 (2017): 140-147.
[72] Mahmoud, Hussam. "Reimagining a pathway to reduce built-environment loss during wildfires." Cell Reports Sustainability 1.6 (2024).
[73] Mahmoud, Hussam, and Akshat Chulahwat. "Assessing wildland–urban interface fire risk." Royal Society open science 7.8 (2020): 201183.
[74] Masoudvaziri, N., Bardales, F. S., Keskin, O. K., Sarreshtehdari, A., Sun, K., & Elhami-Khorasani, N. (2021). Streamlined wildland-urban interface fire tracing (SWUIFT): modeling wildfire spread in communities. Environmental Modelling & Software, 143, 105097.
[75] In most jurisdictions, including Lake County.
[76] https://www.next10.org/sites/default/files/2021-06/Next10-Rebuilding-Resilient-Final.pdf

new communities can include layouts that reduce the potential for fire spread through interruption of continuous vegetative fuels.

As a new development, MGV will meet, and in many ways exceed, the California Building Code Chapter 7A, reducing the susceptibility of these structures to potential wildfire threat (See Tables 2.1, 2.2, and 2.3 in Section II above). Both residential and commercial structures will implement and maintain robust defensible space and the community will be designed to minimize the potential for fire spread and conflagration. In particular, all residential structures will have a minimum of 100 ft of defensible space with active vegetation management.

Figure 5.14: Thermodynamics simulation of radiant heating showing exponential decay with distance[77]



Radiant heating decays exponentially with distance. Observational and simulation studies suggest that 30 meters (100 feet) separation distance between structures and the surrounding environment is sufficient to reduce the radiant heat transfer sufficiently to prevent structure ignition from flames as high as 20 meters (60 feet).[78,79,80] As shown in Figure 5.14, radiant heat decays exponentially with distance, so that additional increases in distance beyond 30 meters are projected to provide little benefit to structure ignition probability.

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[77] Hilton, James E., et al. "Radiant heat flux modelling for wildfires." Mathematics and Computers in Simulation 175 (2020): 62-80.
[78] Hilton J, Leonard J, Blanchi R, Newnham G, Opie K, Rucinski C, et al. Dynamic modelling of radiant heat from wildfires. Proceedings of the 22nd International Congress on Modelling and Simulation (MODSIM2017), Tasmania, Australia. 2017. pp. 3–8.
[79] Cohen, Jack D., and Bret W. Butler. "Modeling potential structure ignitions from flame radiation exposure with implications for wildland/urban interface fire management." In: Proceedings of the 13th Fire and Forest Meteorology Conference, International Association of Wildland Fire. p. 81-86. 1998.
[80] Cohen, Jack. "Preventing residential fire disasters during wildfires." WARM International Workshop. 2003.

5.3.1.1. Defensible Space and Home Hardening

During a wildfire event, the leading cause of home ignition is embers which can travel over a mile ahead of the fire.[81] These embers can ignite combustible materials on and immediately adjacent to structures which, in turn, ignite the structures. Therefore, it is imperative to prevent leaf and needle debris from accumulating on the roof and in gutters and remove any combustible materials within five feet of structures that may act as a ready ignition source for embers.

In addition, homes ignite due to direct flame contact and radiant heat projected by ignited nearby materials. Therefore, home hardening and the establishment of a non-combustible zone, which extends zero to five feet from structures ("Zone Zero") and includes attached combustible features such as decks and fences, are crucial components for structure defense in the WUI according to empirical and experimental evidence and expert analysis of past fires.[82] Between five and 30 feet from structures, vegetation should have fire smart characteristics, be appropriately irrigated, and be adequately spaced to eliminate a direct pathway for the fire to contact structures or from producing enough energy to ignite the home through radiant heat. Experimental studies have shown that vegetation more than 30 meters away from the structure is unlikely to lead to the ignition of that structure through radiant or convective heating.[83]

Due to spatial scale and the assumptions inherent in the model, industry standard quantitative fire modeling is limited in its capacity to express the influence of ignition resistant building materials and a non-combustible zero to five feet zone in reducing structure ignition probability. However, assessment of potential wildfire characteristics around the existing and proposed structures on the MGV site indicate that with defensible space design features alone (30 ft of irrigated landscape around structures), the structures will be exposed to lower-intensity fire and safer working conditions for firefighters in that zone. When also considering home hardening design features (particularly fire resistant exterior materials, wildfire safety design standards, rooftop suppression systems, ember resistant vents), design features alone are expected to substantially decrease susceptibility of structures to wildfire.

When including mitigation measures in addition to design features, this assessment determines that structures will be exposed to significantly lower-intensity fire, support safer working conditions for firefighters, and receive substantially less ember deposition after the DF+MM risk

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[81] Valachovic, Yana, Stephen L. Quarles, and Steven V. Swain. *Reducing the vulnerability of buildings to wildfire: Vegetation and landscaping guidance*. 2021. (pg.2) https://escholarship.org/uc/item/5z80w412

[82] https://ibhs.org/wildfire/near-building-noncombustible-zone/

[83] Cohen, Jack D., and Bret W. Butler. "Modeling potential structure ignitions from flame radiation exposure with implications for wildland/urban interface fire management." *In: Proceedings of the 13th Fire and Forest Meteorology Conference, International Association of Wildland Fire. p. 81-86*. 1998.

reduction activities are implemented. Under this case, within 100 feet of existing and proposed residential buildings, potential fire behavior modeling projects a decrease in average flame length by about 4.9 feet (68.2%) when both design features and mitigation measures are implemented. Furthermore, the area accessible to firefighters within 100 feet of existing and proposed structures is expected to more than double, from 41% of the available area to 85%, improving the likelihood that firefighters can successfully defend those areas. In addition, widespread reductions in canopy fire activity (50% relative reduction) are projected to reduce the number of medium- and long-range embers produced by burning vegetation, resulting in lower rates of ember deposition across the site and adjacent to buildings. This reduction is primarily driven by the mitigation measure of maintaining a minimum of 100 ft of defensible space for all residential buildings, where vegetation will be regularly managed to reduce fire risk. Therefore, this assessment determines that Case II will result in large decreases in susceptibility of the built environment on-site to wildfire. As noted above, for offsite communities, this reduction in on-site susceptibility could result in decreased ember cast and fire intensity reaching off-site communities for any wildfire affecting the site itself.

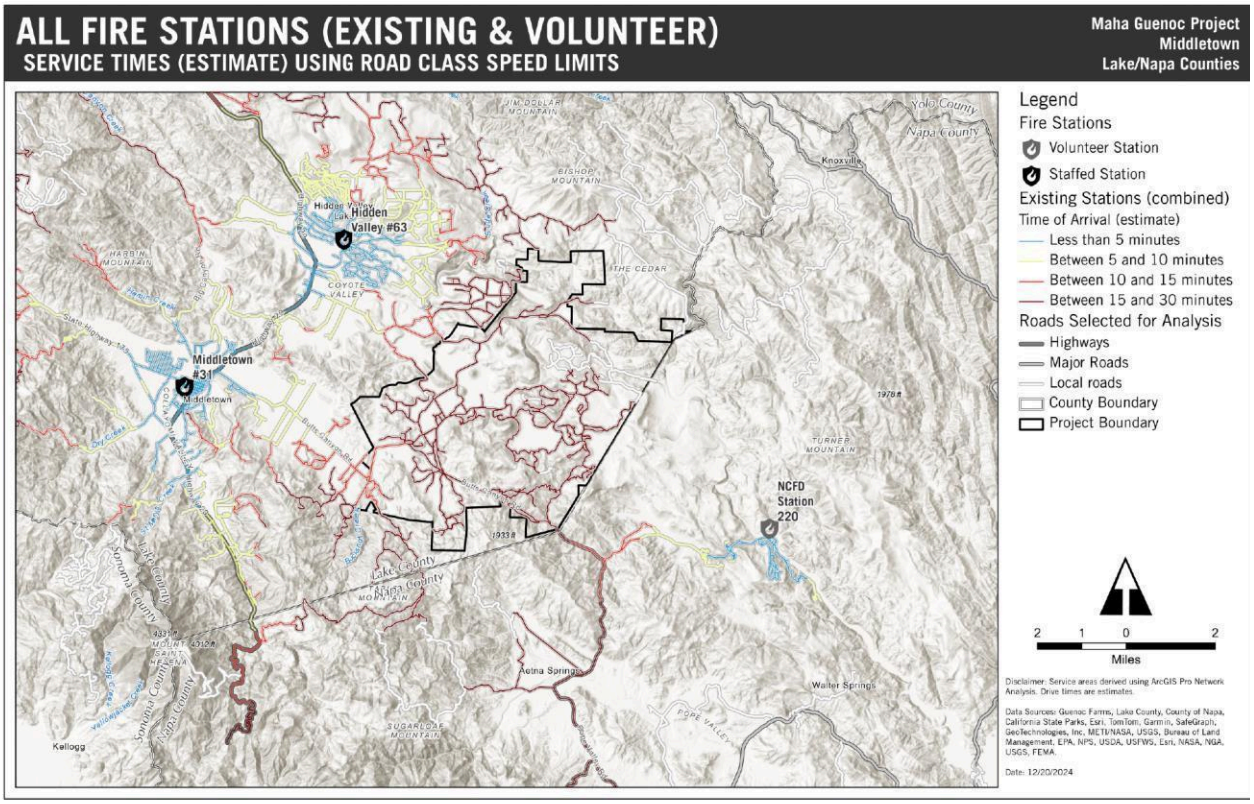
5.3.2. Analysis of Fire Response Time

Changes in fire behavior adjacent to buildings alone are projected to increase the resilience of new and existing buildings on the MGV site and, in the case of spotting, those adjacent to the project site. However, a single ember or a small flame can ignite a structure if it is not designed in accordance with best practices for fire safe design in the wildland-urban interface or if a firefighter is not present to extinguish the ignition. The planned ignition-resistant building materials, structural hardening measures, and robust Zone Zero noncombustible zones are projected to make the proposed buildings much less likely to ignite upon ember or flame contact. However, a recent, widely cited report by the National Institute for Standards and Technology (NIST), reported that the most important factor in preventing total structure loss was active defense,[84] and suggested that firefighter presence was even more important than construction materials and structures density in preventing structure ignition. Investments in cameras, firefighting resources, and on-site response capabilities will improve the capacity to quickly respond to fires on and adjacent to the MGV site.

Fire response time estimates were computed by measuring the time from the originating station to various points along the road network, both within and adjacent to the site. In the existing baseline, the site of the MGV project is first reached by firefighters between 15 and 30 minutes after departure.

[84] Maranghides, Alexander, et al. WUI Structure/parcel/community fire hazard mitigation methodology. US Department of Commerce, National Institute of Standards and Technology, 2022.

Figure 5.15. Estimated Fire Station Service Times, Existing Stations[85]

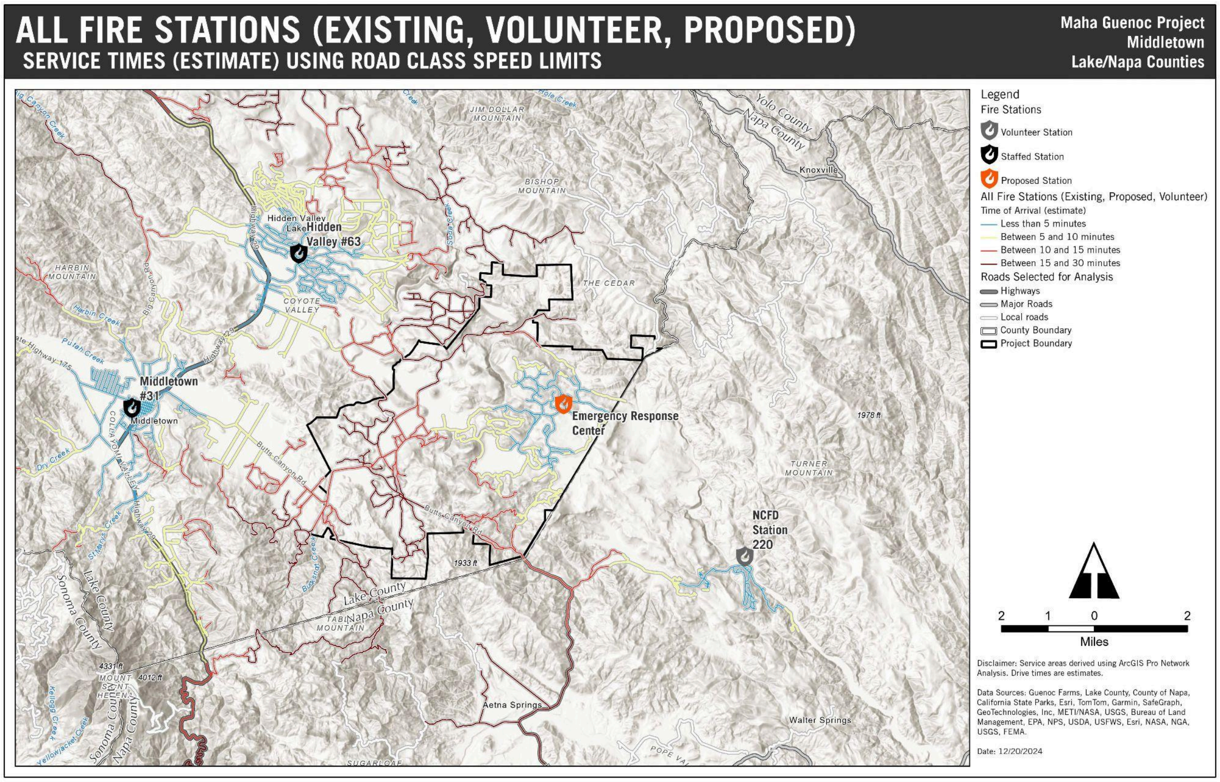


As shown in Table 5.16, the analysis indicates that, with the addition of a new Emergency Response Center and improved road network and surfacing, “design features” for phase 1 of the project, response times drop to less than 5 minutes for the center of the project site, and are within 5 to 10 minutes for a majority of the site. The fringes of the site are first reached within 10 to 15 minutes. The response times for areas west of Butts Canyon Road remain unchanged.

Adjacent to the site, first response is improved from 15 to 30 minutes to within 15 minutes. The most noticeable improvement in response times outside the developed portion of the site is located east of Butts Canyon Road.

[85] NCFD Station 220 is an unpaid volunteer fire department; response is not guaranteed.

Figure 5.16. Estimated Fire Station Service Times, Existing Stations plus the new Emergency Response Center[86]



Because fires grow exponentially in size, rapid response is paramount to containing fires before they become destructive. Wildland firefighters are exceptionally efficient at suppressing new starts while they are still small, with 98% of fires being suppressed before they exceed 100 acres.[87] Early detection systems have been proven to detect wildfire far earlier than human reports.[88] The MGV site will have an early detection system and rapid reporting capabilities. The early detection system will link with the on-site emergency response center.

The proposed design features and increased fire capabilities, including a new emergency response center, close collaboration with the adjacent fire jurisdictions (including Napa County, CalFIRE, and South Lake County Fire Protection District), and the addition of paved roads that support fast travel speeds by fire apparatus, are projected to benefit the site and the nearby communities of Middletown and Hidden Valley Lake. The response time to the center of the proposed phase 1 residential development is projected to decrease from 15-30 minutes to less than 5 minutes. While the response time analysis does not show significant decreases in response times to surrounding communities as a result of the new ERC design feature, we did not model more complicated relationships between fire stations, and thus did not capture the

[86] Note NCFD Station 220 is an unpaid volunteer fire department; response is not guaranteed.
[87] https://www.fs.usda.gov/detailfull/r5/home/?cid=FSEPRD1064021
[88] See, for instance, Govil, Kinshuk, et al. "Preliminary results from a wildfire detection system using deep learning on remote camera images." Remote Sensing 12.1 (2020): 166.

potential benefits of having more full time firefighters available for any large-scale fire in the larger region beyond that capacity of any one station to fulfill. Therefore, this assessment determines that there is a large decrease in community susceptibility on-site, and a moderate decrease in community susceptibility off-site due to the ERC design feature.

Additionally, the entire site is projected to be supported by fire response within 15 minutes, so buildout of future phases of the project would similarly benefit from response time reductions. Response times are also projected to improve in areas outside the site boundary, particularly along Butts Canyon Road. Having an appropriate number of responders and having responders trained in wildland fire operations and tactics[89] further bolsters fire containment probability on and adjacent to the site. Suitable equipment, in the form of fire engines, water delivery systems, and additive extinguishing agents (such as Class A foam) will improve firefighter effectiveness and safety. Two proposed helipads will provide a re-fueling site for aerial fire apparatus dispatched to fires in the southern portion of Lake County. The site is designed to provide responders with dedicated safety zones, where firefighters can take refuge in the event of extreme fire behavior or wind shifts,[90] and new roads, including an additional evacuation route along Grange Road, that may promote faster evacuation and improved firefighter ingress. Finally, designated temporary meeting refuge areas may be used by residents and guests in the event of a fast moving fire to reduce the need for large-scale evacuation, if conditions warrant.

Water is a critical resource during firefighting operations. The site will have a dedicated firefighting water supply system and hydrants spaced along access routes to structures and other infrastructure. Abundant water from several lakes on the project site is available for drafting and for helicopter bucket use. Additionally, structures will be equipped with an exterior fire suppression system with a dedicated water tank. A site-wide dedicated generator system will ensure ongoing power to water distribution systems in the event of an emergency.

Considering the large improvements in response times after analyzing the impact of the ERC design feature alone, this study determined that additional mitigation measures aimed at further improving response times on the site would not likely result in significant improvements beyond the already full time staffed fire station ERC.

5.3.3. Community Susceptibility Analysis Results

This study's analysis of design features impacting on-site community susceptibility finds again that Case I alone results in a large reduction of community susceptibility to wildfire on the site. As for the analyses of ignition likelihood and fire behavior intensity above, considering the highly stochastic nature of severe wildfire events, this analysis retains a determination that a project of this magnitude should implement the full suite of mitigation measures laid out in Table 1.1 in Section 1 above. After consideration of mitigation measures in addition to the design features of

[89] MGV response center staff will be employees of the South Lake County Fire Protection District, which are trained to National Wildfire Coordinating Group standards or higher and participate in the California Incident Command Certification Program.
[90] https://www.nwcg.gov/6mfs/operational-engagement/safety-zones-1-lces

the project, this analysis finds an additional moderate decrease in community susceptibility to wildfire risk due to mitigation measures.

Overall, these reductions in fire susceptibility on-site will also decrease ignition likelihood and fire behavior for communities off-site due to the reduction in potential new ignition sources (e.g. embers cast from burning structures on-site), and reduced fire behavior on site (e.g. if a structure-to-structure conflagration is prevented on-site).

Considering all of the design features and mitigation measures impacting community susceptibility will also apply to the buildout of future phases of the project, and some, like response times, are already tailored to the entire area of the buildout of future phases of the project, this study makes the same qualitative determination for buildout of future phases of the project, there will be a large reduction in community susceptibility to wildfire as a result of the design features and mitigation measures analyzed here.

5.4. Comprehensive Wildfire Risk Analysis Results

Tables 5.7 and 5.8 below summarize this study's determination of combined wildfire risk impacts from design features and mitigation measures to onsite and offsite communities, respectively, resulting from the analysis of: quantitative assessment of ignition likelihoods; qualitative assessment of ignition likelihood risk reduction design features and mitigation measures; quantitative assessment of fire intensity behavior and pathways under Baseline, Case I and Case II; qualitative assessment of community susceptibility built environment risks and risk impacts from design features and mitigation measures targeting susceptibility; and quantitative analysis of fire station response time improvements as a result of the planned ERC design feature.

Table 5.10 presents changes to wildfire risk types (likelihood, intensity, or susceptibility) compared to the baseline (no project) condition for on-site communities. Discussion of quantitative and qualitative analysis results throughout the assessment have, where relevant and feasible, differentiated risk assessment for on-site versus off-site communities. Many features impact both communities, like large-scale vegetation management or fuel breaks (intentional or indirect, like golf courses), because any reduction to fire intensity on-site will benefit reductions of fire spread to off-site communities. Other elements may only benefit on-site communities. In the Tables 5.10 and 5.11 below, we synthesize and simplify all of our analysis into clear tables for ease of reference. For detailed discussion of these impacts to risk, however, please refer back to the appropriate analysis section above.

Table 5.10. MGV Design Features and Mitigation Measures as they impact wildfire risk components **on-site**

Features to reduce wildfire risk	DF or MM	Ignition Likelihood[91] (onsite)	Wildfire Intensity[92] (onsite)	Community Susceptibility[93] (onsite)
Wildfire safety structure design standards and suppression systems for all buildings.	DF	Small Decrease		Moderate Decrease
Irrigated landscape defensible space around buildings (30 ft or greater)	DF		Moderate Decrease	
No open fires	DF	Small Decrease		
Golf course – irrigated landscape	DF		Moderate Decrease	
Vineyards – irrigated landscape	DF		Moderate Decrease	
Polo Field	DF		Moderate Decrease	
Fire suppression surface water sources and dedicated nighttime water source for aerial firefighting	DF			Moderate Decrease
Existing interconnected water pumping system and fire hydrants.	DF			Moderate Decrease
Power – existing generators for water system.	DF			Moderate Decrease
Underground power lines	DF	Large Decrease		
Additional emergency access route along Grange Road to SR 29.	DF			Moderate Decrease
On-site Emergency Response Center (ERC) staffed by South Lake County Fire Protection District	DF			Large Decrease
Two emergency helipads	DF			Small Decrease
Roadside hardscape shoulder (10 ft on either side of road)	DF	Large Decrease		
Revised road network and surfacing – paved two-way roads, added connector roads, no dead-end roads greater than 1 mile in length.	DF			Moderate Decrease
Safety zones for firefighters	DF			Moderate Decrease
Temporary refuge areas	DF			Moderate Decrease
Early detection system and emergency notification siren system.	DF	Moderate Decrease		
Fire-resistant landscaping, including planting design and species selection	DF		Moderate Decrease	

[91] Reductions to ignition likelihood referenced here would be relative to any natural or population-induced increases in ignitions discussed in Section 5.1.3.
[92] Reductions in wildfire intensity are compared to the baseline no-project case
[93] Reductions in community susceptibility are for on-site communities, relative to other communities with no wildfire protections

Features to reduce wildfire risk	DF or MM	Ignition Likelihood[94] (onsite)	Wildfire Intensity[95] (onsite)	Community Susceptibility[96] (onsite)
Home Hardening: Building exterior wildfire prevention strategies following CBC and WUI standards	DF			Large Decrease
Defensible space for all buildings (minimum 100 ft for residential, and 300 ft for non-residential)	MM		Moderate Decrease	
Vegetation management for fire risk reduction	MM		Large Decrease	
Restrictions on Debris Burning	MM	Moderate		
Property-wide fire breaks and resort edge defensible space.	MM		Large Decrease	
Roadside reduced fuel zone (40 ft on either side of road beyond 10ft hardscape shoulder)	MM	Moderate Decrease	Moderate Decrease	
Parking restricted on primary access roads.	MM			Moderate Decrease
Added firefighter staff during construction.	MM			Small Decrease
Fire safety oversight and procedures during construction.	MM	Small Decrease		
On-site construction and maintenance equipment equipped with spark arrestors	MM	Moderate Decrease		
HOA funding for annual vegetation and defensible space management.	MM		Large Decrease	
HOA contract with a wildfire expert for Project duration to support homeowner education and response planning.	MM	Moderate Decrease		Moderate Decrease
Opt-out alert and communication system.	MM			Moderate Decrease

Merging the results of this study's holistic analysis of *ignition likelihood*, *wildfire intensity*, and *community susceptibility to wildfire*, it is found that under Case I, design features alone, phase 1 of this project will lead to a small decrease in wildfire risk compared to baseline conditions. However, as noted above, due to the highly stochastic nature of severe wildfire events, and resulting high uncertainty in risk assessments such as this, this analysis retains a determination that a project of this magnitude should implement the full suite of mitigation measures laid out in Table 5.10 and in Table 1.1. in Section 1. With the inclusion of mitigation measures under Case II, this analysis has determined that this project will result in a large decrease in holistic wildfire risk within the project site, and a small decrease of wildfire risk to surrounding communities, driven primarily by mitigation measures decreasing wildfire flame lengths and rate of spread through the site, at least for wildfires that pass through the site on their way to surrounding communities. There may also be improvements to surrounding community wildfire response capacity due to the addition of a full-time staffed fire station on the project site (the ERC), decreasing community susceptibility.

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[94] Reductions to ignition likelihood referenced here would be relative to any natural or population-induced increases in ignitions discussed in Section 5.1.3.
[95] Reductions in wildfire intensity are compared to the baseline no-project case
[96] Reductions in community susceptibility are for on-site communities, relative to other communities with no wildfire protections

Table 5.11. MGV Design Features and Mitigation Measures as they impact wildfire risk components **off-site**[97]

Features to reduce wildfire risk	**DF or MM**	**Ignition Likelihood[98] (offsite)**	**Wildfire Intensity (offsite)**	**Community Susceptibility (offsite)**
Wildfire safety structure design standards and suppression systems for all buildings.	DF		Small Decrease	
Irrigated landscape defensible space around buildings (30 ft or greater)	DF		Small Decrease	
No open fires	DF			
Golf course – irrigated landscape	DF		Small Decrease	
Vineyards – irrigated landscape	DF		Small Decrease	
Polo Field	DF		Small Decrease	
Fire suppression surface water sources and dedicated nighttime water source for aerial firefighting	DF			
Existing interconnected water pumping system and fire hydrants.	DF			
Power – existing generators for water system.	DF			
Underground power lines	DF			
Additional emergency access route along Grange Road to SR 29.	DF			
On-site Emergency Response Center (ERC) staffed by South Lake County Fire Protection District	DF			Moderate Decrease
Two emergency helipads	DF			Small Decrease
Roadside hardscape shoulder (10 ft on either side of road)	DF			
Revised road network and surfacing – paved two-way roads, added connector roads, no dead-end roads greater than 1 mile in length.	DF			
Safety zones for firefighters	DF			
Temporary refuge areas	DF			
Early detection system and emergency notification siren system.	DF			
Fire-resistant landscaping, including planting design and species selection	DF		Small Decrease	
Home Hardening: Building exterior wildfire prevention strategies following CBC and WUI standards	DF		Small Decrease	
Defensible space for all buildings (minimum 100 ft for residential, and 300 ft for non-residential)	MM		Small Decrease	

[97] All reductions listed for Table 5.11 for off-site communities are compared against existing conditions off-site, but Case I or Case II for the project (i.e. how would the design features and mitigation measures proposed on-site impact off-site wildfire risk?).
[98] For Table 5.11 on off-site impacts, blank fields correspond to no anticipated change from existing baseline conditions

Features to reduce wildfire risk	**DF or MM**	**Ignition Likelihood[99] (offsite)**	**Wildfire Intensity (offsite)**	**Community Susceptibility (offsite)**
Vegetation management for fire risk reduction	MM		Large Decrease	
Restrictions on Debris Burning	MM			
Property-wide fire breaks and resort edge defensible space.	MM		Moderate Decrease	
Roadside reduced fuel zone (40 ft on either side of road beyond 10ft hardscape shoulder)	MM		Moderate Decrease	
Parking restricted on primary access roads.	MM			
Added firefighter staff during construction.	MM			
Fire safety oversight and procedures during construction.	MM			
On-site construction and maintenance equipment equipped with spark arrestors	MM			
HOA funding for annual vegetation and defensible space management.	MM		Moderate Decrease	
HOA contract with a wildfire expert for Project duration to support homeowner education and response planning.	MM			
Opt-out alert and communication system.	MM			

[99] For Table 5.11 on off-site impacts, blank fields correspond to no anticipated change from existing baseline conditions

6. Conclusion

Overall, this holistic risk assessment finds that, taken together, the design features and mitigation measures on the MGV site are projected to substantially decrease wildfire risk to the site, and slightly reduce risk to the surrounding communities of Middletown and Hidden Valley Lake.

The **design features** alone are projected to slightly decrease community wildfire risk. However, to increase MGV's and surrounding communities' resilience to even the most unpredictable catastrophic wildfires, the proposed **mitigation measures** are important to undertake. The mitigation measures are projected to further decrease fire behavior throughout the site, improve containment likelihood on the site, decrease rapid fire growth from residual ignitions, and improve structure ignition resistance, due to robust defensible space and other programs adjacent to structures, compared to the design features alone.

The WPP describes a robust suite of risk-reduction strategies aimed at reducing the ignition potential of structures located on the site. In addition to site-scale grazing and active landscape management, these activities include targeted fuel reduction around structures, the creation of a robust non-combustible zone adjacent to buildings, robust home hardening and construction techniques that meet and exceed the applicable building codes, rapid fire response by trained firefighters responding from a new emergency response center, efficient and timely alerting through an early detection and alerting system, and ongoing educational programs for residents and guests. These risk reduction activities are projected to reduce the likelihood of structure ignition for existing and proposed structures on the site by decreasing their ignitability (through home hardening and defensible space), decreasing their exposure (through reductions in fire intensity and ember deposition adjacent to the structures), and decreasing the time it takes firefighters to arrive at and defend them. Moreover, the site may offer some wildfire resilience benefits to the surrounding communities of Hidden Valley Lake and Middletown by slowing fire rate of spread and increasing the time it takes for fire to spread towards these communities, by providing enhanced fire detection and response capabilities, and by improving the likelihood of suppressing fires that occur on the MGV site on east wind days.

6.1. CEQA Impact Analysis

The Office of the Attorney General (OAG) published *Best Practices for Analyzing and Mitigating Wildfire Impacts of Development Projects under the California Environmental Quality Act* on October 10, 2022 (see Section II).[100] In addition to noting existing requirements under CEQA as they relate to assessing impacts of a project on wildfire risk (i.e. the four wildfire questions in the CEQA "environmental checklist form" in Appendix G of the CEQA Guidelines, Section XX),[101]

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[100]Office of the California Attorney General, *supra 1, page 7*
[101] CEQA Guidelines, Appendix G, XX

the OAG also presents some recommendations for determining thresholds of significance for impact analysis:

> "Lead agencies are encouraged to develop thresholds of significance that either identify an increase in wildfire risk as a significant impact or determine, based on substantial evidence, that some increase in the risk of wildfires is not considered a significant impact. Relevant factors should include the project's impact on ignition risk, the likelihood of fire spread, and the extent of exposure for existing and new residents based on various fire scenarios."[102]

Integrating the ignition likelihood analysis, the fire behavior and growth modeling, the response-time modeling, and the expert assessment of the impact of design features and mitigation measures on ignition prevention on the MGV site, we make the following conclusions:

1. The project with design features alone:
    a. Does not result in a statistically significant increased *likelihood* of predicted annual fires due to Phase 1 or full buildout of the project. The statistically insignificant predicted likelihood of 1.7 additional annual fires from Phase 1 and 5 fires from full buildout are determined to be moderately reduced due to design features alone (Case I);
    b. Slightly decreases potential wildfire *intensity*; and
    c. Greatly reduces community *susceptibility* to wildfire.
2. While this study therefore finds a slight reduction in holistic wildfire risk due to design features alone, considering the highly stochastic nature of the most catastrophic wildfires, this study concludes that holistic wildfire risk may still remain "**significant"** absent mitigation measures, and errs towards greater caution, recommending the implementation of the full suite of mitigation measures proposed in the WPP.
3. The project design features in addition to the proposed mitigation measures identified in the wildfire prevention plan greatly reduces projected increases in wildfire ignition *likelihood* from the project, greatly decreases modeled wildfire *intensity,* and greatly improves fire response times and structural resistance to fire (reducing *susceptibility*), effectively reducing the residual wildfire risk to **"less than significant"**.
4. Considering our conclusions above, we determine that design features and mitigation measures identified in the WPP for Phase 1 of the MGV Project do not "exacerbate wildfire risk" to the site or surrounding communities.
5. As the design features and mitigation measures applied to phase 1 will also be implemented for buildout of future phases of the project, and reduce fire intensity and improve response times for the entire site and surrounding communities, this study also determines that buildout of future phases of the project will be unlikely to "exacerbate wildfire risk" to the site or surrounding communities.

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[102] Office of the California Attorney General, *supra 1, page 9*

6.1.1. CEQA Wildfire Checklist Questions

3.16-1: Would the Project substantially impair an adopted Emergency Response Plan or Emergency Evacuation Plan, or result in an inconsistency with a Safety Element that has been updated to integrate wildfire and evacuation concerns, or recommendations developed by the California Board of Forestry regarding the safety of subdivisions?

This question is addressed by the July 2024 PREIR, and PREIR Appendix H: Community Wildfire Evacuation Analysis. The results of this wildfire risk assessment do not alter prior conclusions made in this regard in the 2024 PREIR and Appendix H.

3.16-2: Would the Project exacerbate wildfire risks and thereby expose Project occupants to *pollutant concentrations* from wildfire or the uncontrolled spread of wildfire?

The proposed design features and mitigation measures are projected to decrease wildfire risk on the site, by decreasing additional ignition likelihood due to the project, increasing resilience in the built environment, decreasing fire intensity and rate of spread throughout the MGV site, and providing public education, outreach, and improved firefighter response times. Therefore, with the implementation of the design features and mitigation measures, no exacerbation of wildfire risk is projected and no additional exposure of occupants to pollutants from wildfire or the uncontrolled spread of wildfire is expected.

3.16-3: Would the Project require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?

The proposed project will require installation of infrastructure including roads, which have been associated with an increase in ignitions elsewhere. However, the proposed design features and mitigation measures are projected to decrease wildfire risk on the site, by decreasing additional ignition likelihood due to the project, increasing resilience in the built environment, decreasing fire intensity and rate of spread throughout the MGV site, and providing public education, outreach, and improved firefighter response times. Therefore, no significant exacerbation of wildfire risk is projected. The 2020 EIR and 2025 PREIR address any environmental impacts from design features and mitigation measures identified in the WPP.

3.16-4: Would the Project expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?

As identified in the 2020 Final EIR, Mitigation Measure 3.16-2 will require that after a wildfire, soil stabilization measures are implemented and included in a post wildfire emergency response plan (PWERP) approved by the South Lake County Fire Protection District (SLCFPD). Furthermore, the PWERP will specifically include an action to develop a long-term recovery and restoration plan to remediate the burned areas, and thus reduce potential hazards in the future to the public and property. Implementation of Mitigation Measure 3.16-2 will reduce the impact to *a less-than-significant level. The results of this wildfire risk assessment have not altered the conclusions regarding the efficacy of MM 3.16-2 in terms of post-fire recovery and restoration.*

3.16-5: Would the Project expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving wildland fire?

*The proposed design features and mitigation measures are projected to decrease wildfire risk on the site, by decreasing additional ignition likelihood due to the project, increasing resilience in the built environment, decreasing fire intensity and rate of spread throughout the MGV site, and providing public education, outreach, and improved firefighter response times. The core project design features in combination with the proposed mitigation measures identified in the WPP greatly reduce projected increases in wildfire ignition likelihood due to the project, greatly decreases modeled wildfire intensity, and greatly decreases community susceptibility due to improved fire response times and increased resilience of the built environment on site, effectively reducing risk of loss, injury or death involving wildland fire to "**less than significant**".*

7. Qualifications of Preparers

In Alphabetical Order:

Thomas Azwell, PhD, is the Director of the UC Berkeley Disaster Lab, based in the College of Engineering. The Disaster Lab focuses on translational science—the development and implementation of disaster mitigation and response technology. Dr. Azwell bridges cutting-edge research and practical solutions to address environmental disasters, such as the 2010 Deepwater Horizon oil spill and recent California wildfires. Dr. Azwell co-founded Fire Foundry, a program that prepares underrepresented individuals for careers in the fire service, fostering equity and diversity in this critical workforce.

An expert in environmental engineering and community resilience, he is committed to advancing disaster preparedness through interdisciplinary collaboration, entrepreneurship education, and the ideation, innovation, and dissemination of transformative technologies.

Kathleen Cutter is an NFPA certified Senior Wildfire Mitigation Specialist with the Marin Wildfire Prevention Authority and U.C. Berkeley's Disaster Lab. At Marin Wildfire Prevention Authority, Kathleen co-leads the largest Defensible Space Inspection program in the State of California. Her team has completed over 65,000 inspections of residential properties, utilizing state of the art inspection software providing robust residential reports leading to significant risk reduction and enhanced safety for countless homes, setting a benchmark for fire prevention and mitigation efforts statewide. After graduating from UC San Diego, she began her career with the US Forest Service, working as an archaeologist and extending her seasonal work by joining a hand crew fighting fires in the Southwest and the Mountain West. She also served as a Firewise Liaison and program administrator for the first free county-wide curbside chipper program at Fire Safe Marin. There, her efforts aimed at reducing wildfire risk through community engagement, empowerment, and connecting residents with a convenient means of removing unwanted vegetation. Kathleen is also an active Marin Master Gardener focusing on fire smart landscaping.

Joshua Dimon, PhD, is the Lead Scientist of the UC Berkeley Disaster Lab, based in the College of Engineering. Dr. Dimon has over 20 years of experience evaluating environmental and social impacts from some of the largest energy, infrastructure and development projects in California and around the world. He has worked with communities on the frontlines of environmental disasters, first responders tackling those disasters, local governments hoping to build resilience, and innovative companies dedicated to improving disaster resilience. Dr. Dimon holds a Bachelors of Science in Conservation and Resource Studies from UC Berkeley, and a PhD in Environmental Science, Policy & Management also from UC Berkeley. Dr. Dimon completed a Postdoctoral Fellowship with Stanford's Bill Lane Center for the American West focusing on California's evolving grid and distribution of air pollution exposures, and then worked as a research scholar with Stanford's Precourt Institute of Energy where he focused on climate policy and resilience in California and Mexico. Since 2021, Dr. Dimon has been building the Disaster Lab with Dr. Azwell, and leads the lab's research into wildfire resilience.

Scott Farley is a wildfire behavior modeler and data scientist based in Boulder, Colorado. He is the founder and principal consultant of Willow Labs, a bespoke wildfire risk analysis firm that creates data-driven solutions to measure and improve wildfire resilience in communities throughout the West, and the co-founder and Head of Research and Development at XyloPlan, a software platform aimed at incentivizing community risk reduction through a shared view of risk with the insurance industry. Scott holds a Bachelors of Science from the University of California at Berkeley in Geography, where his research interests included developing novel approaches to wildfire risk assessment, and a Masters of Science in Physical Geography from the University of Wisconsin, Madison, where he studied the intersection between human activity, climate change, and data science. Scott is an NFPA certified wildfire mitigation specialist (CWMS) and has worked as a wildland firefighter with the US Forest Service both as an engine crewmember and a member of an Interagency Hotshot Crew.

Esther Mandeno has over 25 years of experience in GIS data management, map production, wildland fire behavior modeling, and natural resource management. During her time with California State Parks in the Lake Tahoe Basin, she became a Burn Boss, using prescribed fire to manage forests. Later, she shifted her focus to the Sierra District's GIS where she developed and implemented a wide variety of data and map products for land managers. After starting her own business, she focused on fire behavior predictions to support a wide range of land management planning documents; from Community Wildfire Protection Plans to Vegetation Management Plans.

She has extensive on-the-ground experience using Global Positioning Systems (GPS) to capture field data. In addition to her general GIS and GPS expertise, she has experience with data conversions between CAD (computer aided design) systems and ESRI data formats, aerial interpretation for vegetation and feature mapping, remote sensing data (i.e., LANDSAT, IK0N0S) for determining vegetation and forest fuel changes over time, and experience with LiDAR for stream restoration and resurfacing work. Esther can work on many levels to assist or write wildland fire management plans and bring those to the public with innovative online tools such as ESRI's Story Maps.

Carol Rice leads the operations of Wildland Res Mgt, a Nevada Corporation, a consulting firm that emphasizes wildland fire management in the urban-wildland interface. Several projects entailed preparation of fire management plans for large landowners in areas of sensitive species and concerned communities as well as development of community wildfire protection plans, spanning a local- to county-scale. Other projects have involved the use of state-of-the-art fire behavior prediction systems or developed training programs. Many of these projects include risk assessments.

Ms. Rice has more than 45 years of experience, building on an education in Forestry and Wildland Fire Science from the University of California, Berkeley. She has delivered and authored more than a hundred presentations and articles, and a textbook used by Cal Poly, Fire in the Urban-Wildland Interface: Practical Solutions for Local Government, Planners, Fire Authorities, Developers, and Homeowners. Presentations and publications address plan use planning, risk assessments, fire behavior modeling, ecological sensitivities in fuel reduction treatments, and best practices in fire hazard reduction planning and implementation. She has led and served on boards of the International Association of Wildland Fire (co-founder), California-Nevada-Fire Council, National Fire Protection Association Wildland Fire Section (co-founder), and Northern California Fire Prevention Officers WUI Committee.

Appendix W.1: Wildfire Behavior Analysis and Wildfire Behavior Risk Reduction Assessment

MAHA RESORT AT GUENOC VALLEY

Wildfire Behavior Analysis and Wildfire Behavior Risk Reduction Assessment

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Executive Summary

The Maha Resort at Guenoc Valley is a resort and residential development project in southern Lake County, California. Lake County has experienced large-scale wildfires, including some recent fires that affected nearby communities. The Maha Guenoc Valley (MGV) site is in an area designated by the California Department of Forestry and Fire Protection (CalFIRE)[103] as a high fire risk zone, with weather patterns, topography, and fuel types capable of supporting large and intense wildfires. However, the site's Wildfire Prevention Plan (WPP) outlines a holistic wildfire resilience strategy that includes passive design features and active vegetation management to reduce fire intensity, interrupt fire spread, and promote safe and effective emergency response. This impact assessment study uses quantitative wildfire modeling tools to evaluate the effectiveness of these risk reduction activities.

By comparing potential fire behavior in the unmitigated baseline state to the behavior projected to occur under the presence of the risk reduction activities specified in the WPP, this analysis provides a robust assessment of the potential changes to fire intensity, rate of spread, fire arrival time, and other characteristics attributable to the planned mitigation activities. The study integrates two leading models for fire behavior analysis: (1) potential fire behavior (including flame length, rate of spread, and spotting potential) across the 16,517 acre project site and (2) potential spread dynamics and trajectories ("Fire Pathways") across the site.

The risk reduction strategy for the MGV project includes two types of activities: design features (DF) and mitigation measures (MM). The design features include the strategic placement of passive landscape elements, such as roads, vineyards, structures, and irrigated landscaping, while mitigation measures include active risk reduction activities, such as prescribed grazing, roadside fuel reduction, and the construction and maintenance of strategic fuel breaks. These activities are grouped together to provide two alternative modeling cases that are compared to the existing baseline:

- **Case I: Design Features -** Project Design Features with passive impact on fire behavior and spread
- **Case II: Design Features and Mitigation Measures -** Project Design Features in combination with Mitigation Measures, such as active vegetation management.

Using geospatial analysis, the extant fuels (those existing on the site in the absence of additional development) were modified to reflect the Design Features and Mitigation Measures' role in changing the fuel type, volume, structure, and arrangement in the areas of the site corresponding to the proposed landscape elements. The fire behavior projected to occur under the baseline scenario and the two hypothetical modeling cases (DF and DF+MM) were evaluated using industry-standard wildfire risk assessment tools under two weather scenarios.

103 https://osfm.fire.ca.gov/what-we-do/community-wildfire-preparedness-and-mitigation/fire-hazard-severity-zones

These scenarios represent the reasonable worst-case fire weather conditions in southern Lake County.

Key Analysis Highlights

Fire behavior analysis of the baseline case indicates the potential for fast-moving and intense wildfire behavior throughout the MGV project site. In the baseline scenario, the average flame length on the MGV site is approximately 8 feet, and, further, approximately 60% of the MGV area is projected to support fire intensity that is resistant to control by ground-based firefighting personnel using direct attack tactics[104]. Under the modeled extreme fire weather conditions, wildfires are likely to spread very rapidly across the site, with the average site-wide spread rate exceeding 0.5 miles per hour, and exceeding 10 miles per hour in some locations[105]. The arrangement of surface and canopy fuels across the site suggests that nearly 50% of the MGV project site is likely to experience isolated or group torching[106], increasing intensity and further limiting the capacity for firefighters to engage the fire safely. project

Case I (Design Features) alone is projected to have a modest impact on the fire behavior and spread trajectories. The Design Features introduce non-burnable surfaces[107] (e.g., golf and sports fields, roads) and irrigated landscaping into the MGV site, producing localized impacts on flame length adjacent to the built environment. In Case I, the site-wide average flame length is projected to decrease by approximately 2.8%, the average rate of spread is projected to decrease by 3%, and the fraction of the site capable of supporting canopy fire activity is projected to be reduced by 2.8%. The most significant decrease in fire behavior attributable to the DF case is a result of the irrigation around residential and commercial buildings, which are projected to result in a 20-22% decrease in flame length within 100 feet of buildings. Similar reductions in other key fire behavior indicators are also projected adjacent to buildings.

DF elements are marginally beneficial in interrupting fire spread: together, these features are projected to increase fire arrival time to the existing and proposed buildings on the MGV site by approximately 20-30 minutes, providing additional time for evacuation and firefighter ingress. While the increase in fire arrival time is not insignificant, it is unlikely to be sufficient to facilitate a complete evacuation or the sufficient ingress of local and regional firefighting resources. In

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[104] Direct attack involves ground-based firefighters directly working along the fire's edge to extinguish flames, cool hotspots, and halt forward spread, typically by using water and/or hand tools.

[105] During the 2020 LNU fire and 2015 Valley Fire, local fire authorities reported relatively slow fire growth on the MGV site; however, this analysis reflects fire weather conditions that are more extreme than those observed during those fire events. For example, the Incident Action Plan (IAP) for the 2015 Valley Fire indicates that rain was forecasted for much of the time fire was present on the MGV project site and that daytime minimum relative humidity exceeded 35% and nighttime recoveries approached 90%. These conditions are substantially more mild than the potential fire behavior modeled in this report.

[106] Fire moving from the surface fuel layer into the tree canopy.

[107] Although these features could burn in some limited scenarios, they are not likely to be a significant contributor to the spread of a fire front. These features are modeled with the 09X ("NB") series of fuel models, which are designed to capture agricultural, developed, and barren portions of the landscape that will not carry fire. For more information, see https://www.nwcg.gov/publications/pms437/fuels/surface-fuel-model-descriptions.

many cases, the DF features are too small or too isolated to be broadly effective in interrupting the corridors of most rapid fire spread.

In contrast, the combination of Design Features and Mitigation Measures, Case II, is highly effective at reducing fire behavior and limiting fuel connectivity across the entire site. Site-wide, the DF+MM case is projected to reduce the average fire intensity by approximately 50%, the average rate of spread by 28%, and the proportion of the site area capable of supporting canopy fire activity by 25%. The widespread application of active management, including grazing, lop and scatter, and mastication are projected to have widespread benefits across the site and larger, and more localized benefits are projected to result from intensive defensible space around buildings. Further, fires spreading across the site in the presence of the Case II risk reduction activities are likely to spread much more slowly and encounter more fragmented fuels, providing firefighters an average of approximately two hours, and in many cases upwards of 4-to-5 hours, to reach the existing and proposed structures on the MGV site. The benefits of slower fire spread are also likely to extend to the nearby communities of Middletown and Hidden Valley Lake.

The key indicators for both cases are shown in Table 1.

	Key Indicator	**Projected Change: Baseline vs. Case I (DF)**	**Projected Change: Baseline vs. Case II (DF + MM)**
East Scenario	Site-Wide Average Flame Length	-3%*	-50%*
	Site-Wide Average Rate of Spread	-3%*	-29%*
	Fraction of Site Supporting Direct Attack	2%*	32%*
	Torching Fraction of Site	-1%*	-26%*
	Change in Fire Arrival Time at Existing and Proposed Buildings	+5%*	+19%*
	Number of Existing and Proposed Buildings Along Fire Pathway	-13%*	-54%*
West Scenario	Site-Wide Average Flame Length	-3%*	-50%*
	Site-Wide Average Rate of Spread	-3%*	-28%*
	Fraction of Site Supporting Direct Attack	2%*	31%*
	Torching Fraction of Site	-1%*	-26%*

	Arrival Time at Existing and Proposed Buildings	3%*	35%*
	Number of Existing and Proposed Buildings Along Fire Pathway	-15%*	-70%*

Table 1: Percent change in key indicators evaluated site-wide for each weather scenario. Metrics marked with a (*) show increased resilience after the addition of the DF or DF+MM risk reduction activities, compared to the baseline.

Assessment of the fire growth characteristics and the rate of spread on the MGV project site suggest that the DF+MM risk reduction activities described in the WPP are likely to positively impact the surrounding communities and the existing and proposed buildings on the site. Fires that ignite on the site are projected to be much smaller (-40% decrease) after the implementation of the DF+MM activities, improving the odds that local and regional firefighters will be able to contain the fire before it becomes too large. Additionally, fire pathways analysis suggests that the DF+MM activities will interrupt and slow large fires as they travel across the site, providing additional time to respond to fires before they reach adjacent communities or shifting priorities to other avenues of exposure in those communities.

Table of Contents

1. Introduction and Approach

1.1 Objectives

This study provides a detailed quantitative assessment of the role of proposed design features (DF) and mitigation measures (MM) in reducing wildfire behavior at the Maha Resort at Guenoc Valley project site, including a comprehensive analysis of key fire behavior metrics, including flame length, rate of spread, canopy fire potential, spotting distance, and fire travel pathways.

The development site is located in an area with a high potential for extreme wildfire activity; numerous recent wildfires have burned in and around the planned development. However, the scope of the risk reduction activities specified in the development's wildfire prevention plan (WPP) is wide-ranging and expected to effectively reduce fire behavior and growth potential.

This modeling study aims to determine the extent to which the risk reduction activities prescribed in the WPP reduce wildfire behavior on and adjacent to the site. To achieve this goal, a quantitative impact assessment framework is used to characterize the difference in wildfire threat before and after risk reduction activities. Fire behavior on the existing landscape (reflective of 2020 vegetation conditions[108]) is used as a baseline. Two alternative modeling cases are then compared to this baseline, and changes in fire behavior are attributed to the risk reduction measures included in each case:

(1) design features (DF) alone and

(2) design features combined with active ongoing mitigation measures (DF+MM).

To ensure a robust assessment of potential threats to the project, this analysis evaluates fire behavior under two potential fire weather scenarios representative of historical fire weather in Southern Lake County, CA.

Specifically, this study addresses the following questions:

1. Do the design features and mitigation measures reduce potential wildfire behavior in and around the proposed development areas? If so, by how much?
2. Do the design features and mitigation measures work together to reduce fuel continuity and interrupt potential fire spread across the site?
3. Are the design features and mitigation measures likely to improve the odds of fire suppression on the project site, thus benefiting the adjacent communities?

[108] The most recent high-resolution dataset available in the region.

This impact analysis provides key insights into how the proposed design features and mitigation measures influence fire intensity and spread dynamics and offers a data-driven foundation for ensuring community safety in a wildfire-prone landscape.

1.2 Fire Behavior Analysis Tools

This analysis integrates several industry-standard models for wildfire risk assessment to provide a detailed and multi-faceted evaluation of the effectiveness of risk reduction activity in decreasing wildfire risk in and around the development area.

Flammap: Flammap is a fire modeling software produced by the United States Forest Service's Missoula Fire Lab[109] that simulates potential fire behavior on heterogeneous landscapes under user-provided environmental conditions. FlamMap provides spatially varying outputs of key fire behavior metrics such as flame length, rate of spread, and crown fire activity. Flammap does not model temporal patterns in fire growth; instead, it provides detailed estimates of the characteristics of the fire at each pixel on the landscape, such as intensity and speed.

Fire Pathways: Fire Pathways[110] is a computational model of fire spread, developed by XyloPlan[111] and Toyon Labs, that identifies where topography, fuel, and wind align to produce the fastest routes fire could take to spread across a landscape. Fire spread trajectories are calculated using Finney's 2002 Minimum Travel Time algorithm[112] to estimate travel time between cells on a regular grid. Fire Pathways are useful for understanding how fire is likely to advance across a landscape, locating hazardous combinations of fuel and topography where the fire is expected to make runs, and identifying the portions of the community at greatest risk from rapidly spreading fire.

Fire behavior modeling is predicated on ignition. That is, they provide information on the characteristics and trajectories of the fires, given that one occurs. They do not indicate the probability of a fire occurring or an ignition happening either on or off of the MGV site.

1.3 Datasets

Contemporary fire behavior models require several data inputs:

- **Surface Fuel Data:** Spatially explicit data representing the type, load, and arrangement of combustible fuels in the surface stratum, including both the live (grasses and shrubs) and dead (accumulated vegetative debris) components of the fuelbed. This study uses data from the California Forest Observatory's Surface Fuels dataset at 10m resolution to provide a fine-scale assessment of surface fuel type, arrangement, and loading on and

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[109] https://www.firelab.org/project/flammap

[110] Fire Pathways is a registered trademark of Xylo Risk, Inc. Fire Pathways technology was licensed from Xylo Risk and Toyon Labs for use in this project.

[111] https://www.xyloplan.com/

[112] Finney, Mark A. "Fire growth using minimum travel time methods." *Canadian Journal of Forest Research* 32.8 (2002): 1420-1424.

around the site[113]. For the impact analysis, the surface fuels were modified to reflect the changes in fuel derived from the proposed wildfire mitigation measures and design features[114].

- **Canopy Fuel Data:** Spatially explicit data representing the canopy height, density, and thickness. This analysis uses 10m LIDAR-derived data from the California Forest Observatory. For the impact analysis, canopy layers are modified to reflect potential management activities to remove ladder fuels and, in some cases, change canopy cover.

- **Topography:** Spatially-explicit data indicating the elevation, slope, and aspect of the land surface. This analysis uses a 10m digital elevation model (DEM) from the United States Geological Survey[115]. Slope and aspect were calculated using the QGIS and the GDAL geospatial analysis toolkit[116].

- **Fuel Moisture:** Fuel moisture inputs represent the amount of moisture present in the surface fuels, reflecting the amount of energy necessary for the fuel to burn. This analysis uses fuel moisture settings that reflect the warm, dry, late summer months in Lake County and are conditioned to reflect location-specific variations in canopy shading, aspect, and other differences in solar radiation (discussed in greater detail in Section 2).

- **Wind Speed and Direction:** Catastrophic fires are typically driven by wind, and portions of the landscape where wind and slope align typically generate the highest fire behavior[117]. The fire models employed in this report use wind speed and direction inputs to represent common fire weather scenarios in southern Lake County. These prevailing wind patterns were adjusted using a computational fluid dynamics tool (Wind Ninja[118]) to adapt them to terrain features, such as valleys, ridges, and mountains, and create a spatially varying wind field. This approach is discussed in greater detail in Section 2.

1.4 Impact Assessment Approach

1.4.1 Modeling Cases

This study provides a quantitative impact analysis of the effectiveness of the site design features (DF) and mitigation measures (MM) in mediating fire behavior and spread potential under several weather scenarios. The potential fire behavior metrics evaluated include flame length,

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[113] https://salo.ai/assets/pdf/Forest-Observatory-Data-Description.pdf
[114] The industry standard approach to potential fire behavior modeling is to use regionally-available fire-specific datasets like those from the California Forest Observatory.
[115] https://www.usgs.gov/3d-elevation-program
[116] https://gdal.org/en/stable/
[117] Andrews, Patricia L. "The Rothermel surface fire spread model and associated developments: A comprehensive explanation." (2018).
[118] Wagenbrenner, Natalie S., et al. "Development and evaluation of a Reynolds-Averaged Navier–Stokes solver in WindNinja for operational wildland fire applications." *Atmosphere* 10.11 (2019): 672.

rate of spread, canopy fire potential, spotting distance, and fire travel time. These measures are evaluated on the site as a whole and in proximity to key features, such as buildings and roads.

Projected fire behavior is evaluated under three cases:

> **Baseline:** Represents the unmodified site conditions. In this scenario, the landscape represents its pre-development state, with all residential, commercial, and recreational structures located in their existing locations without modifications to their placement or surrounding conditions. Buildings do not have defensible space, and there are no additional fire management practices in place. This unmodified scenario serves as a reference point for comparing the effectiveness of design features and mitigation measures in the other modeling cases.
>
> **Case I - Design Features (DF):** Represents a post-development scenario where fire risk is reduced through planned landscape elements. Key features include the strategic use of golf courses, sports fields, and vineyards as fire buffers, the placement of paved roadways throughout the project site, and the introduction of isolated irrigated plots and irrigation around the proposed buildings.
>
> **Case II - Design Features + Mitigation Measures (DF+MM):** Integrates active land management practices into the design features of Case II to further mitigate wildfire risk. This case includes potential vegetation management activity throughout the project site, such as grazing, mastication, and the removal of dead, dying, or invasive vegetation, as well as the addition of roadside hardscaping and vegetation clearance, the creation of perimeter fuel breaks, and the establishment of defensible space around proposed residential and commercial structures.

Each case is assessed for its percentage change relative to the baseline to quantify the effectiveness of the interventions. When evaluating the impact on fire behavior adjacent to roads and buildings, the locations of all existing and proposed buildings and roads are used for all three cases, enabling a direct comparison among the three cases.

Table 2 shows the components included in each modeling case.

Feature/Measure to Reduce Wildfire Risk	**Case I: Design Features**	**Case II: Design Features + Mitigation Measures**
Paved Roads	Yes	Yes
10 ft Hardscaping on each side of Roadways	Yes	Yes
40 ft of vegetation clearance beyond 10 ft of hardscaping on each side of roadways	No	Yes
Grazing around Residential and Commercial Parcels	No	Yes
Active Landscape Vegetation Management	No	Yes

Vineyards	Yes	Yes
Irrigated Areas around Commercial Facilities	Yes	Yes
Irrigated Areas around Residential Buildings	Yes	Yes
Golf and Sports Fields	Yes	Yes
Irrigated Areas near Roadways	Yes	Yes
Defensible Space Adjacent to Buildings (Zone 1 and Zone 2)	No	Yes
Perimeter Fuel Breaks	No	Yes
Water Features	Yes	Yes

Table 2: Wildfire modeling cases, indicating the actions undertaken as design features (Case I) and ongoing mitigation measures (Case II).

The WPP includes several additional mitigation measures and design features; however, those features cannot be modeled with contemporary industry-standard wildfire modeling technology.These features include: Wildfire safety design standards and suppression systems for all buildings, fire suppression surface water sources and dedicated nighttime water source for aerial firefighting, existing interconnected water pumping system and fire hydrants, generators for water system, underground power lines and electric system, microgrid system for commercial buildings, additional emergency access route along Grange Road to SR 29, on-site Emergency Response Center (ERC) located in the Project core, two emergency helipads, parking restricted on primary access roads, safety zones for firefighters, temporary refuge areas, added firefighter staff during construction, fire safety oversight and procedures during construction, ERC with staffed wildfire mitigation expertise in access and evacuation, HOA funding for annual vegetation and defensible space management, HOA contract with wildfire expert for the project duration to support homeowner education and response planning, early detection system and emergency notification siren system, and an opt-out communication system. Excluded design features and mitigation measures are largely related to suppression, evacuation, and communication. These activities do not change the structure of the fuels on the MGV site and, therefore, generally do not influence the fire behavior.

1.4.2 Key Indicators

Fire modeling software calculates several important variables that describe how fire characteristics vary across the landscape. This study provides those outputs in the attached Map Book (see Appendix 1) and includes a statistical comparison of variables relevant to the proposed development. All key indicators are evaluated across the site as a whole and within 100’ of roads and buildings.

1. **Flame Length:** The expected intensity of the fire.
2. **Suppression Potential:** The proportion of an area with modeled flame lengths less than four feet, where firefighters are most likely to be successful engaging the fire using direct attack.

3. **Rate of Spread:** The expected forward rate of progress at the head of the fire.

4. **Canopy Fire Potential:** The proportion of an area where fire is likely to transition from the surface to the canopy.

5. **Spotting Distance:** The maximum travel distance of a burning firebrand as it is transported downwind, accounting for wind speed and terrain.

1.5 Incorporating Modifications into the Landscape

The MGV WPP prescribes a comprehensive suite of potential wildfire risk reduction activities. In collaboration with the project team, the types and locations of each potential risk reduction activity were integrated into a Geographic Information System (GIS) environment and used to modify the baseline set of fuels to reflect the changes in vegetation load and arrangement due to the risk reduction activities.

Roadside Treatments

Roadside treatments are designed to create ignition-resistant zones and support effective fire suppression along transportation corridors throughout the project site. The WPP prescribes 25 feet of impermeable roadway and 10 feet of hardscaping on both sides of the roadway (where feasible) within a 50-foot reduced-fuel zone on either side of the road. Vegetation management within the reduced fuel zone includes selective thinning of flammable species, removal of dead and dying vegetation, and the maintenance of reduced fuel conditions with periodic mowing, grazing, and ongoing management. Effective design and maintenance of roadside treatments can reduce wildfire intensity near critical evacuation routes, minimize the likelihood of roadside ignitions[119], and provide safe access for emergency responders during wildfire events.

Active Landscape Management

Active landscape management prescribes strategic landscape management to reduce fuel loads and enhance forest health throughout the development area. The WPP includes several potential treatment activities, including grazing, lop-and-scatter, mastication of invasive, dead, or overgrown vegetation, and selective thinning to maintain open-canopy conditions. Managed grazing rotations use livestock to reduce fuel loads in grasslands and shrub-dominated areas and to control the growth of flammable vegetation, such as dry grasses and low shrubs. Additional landscape management techniques are designed to decrease fire intensity and reduce the potential for canopy fire and spotting.

Vineyards and Irrigated Agriculture

Vineyards and irrigated agricultural areas are strategically located throughout the project site as natural firebreaks interrupting fuel continuity across the development site. These areas create wide, defensible buffers that are unlikely to support fire spread. The WPP also includes irrigation

[119] A common source of human-caused ignitions.

around the proposed residential and commercial structures and at regular intervals along roadways.

Defensible Space

Defensible space around buildings and key infrastructure reduces the risk of ignition and provides safe conditions for firefighters to perform structure protection. The WPP prescribes a defensible space plan that includes a buffer of cleared or maintained vegetation extending at least 100 feet around each structure. Some residential buildings may be provided additional defensible space, up to 150 feet, depending on fuel type and slope. In addition, commercial buildings will have at least 300 feet of defensible space. This buffer involves removing flammable materials, thinning trees and shrubs, and maintaining ground cover at a low height. In accordance with local regulations and leading wildfire science, the WPP suggests more intensive vegetation modification and removal within 30’ of the structure.

The surface and canopy fuel conversions used for each design feature and mitigation measure are described in detail in the tables in Appendix 3 and Appendix 4.

2. Results and Discussion

2.1 Weather Analysis

The MGV site is located in the southern portion of Lake County, California. Lake County is characterized by a Mediterranean climate regime with warm, dry summers and cooler, wetter winters. The area experiences a pronounced seasonal variation in precipitation, with the vast majority of precipitation coming between December and March. Daytime summer temperatures typically range from 85–95°F, with relative humidity commonly below 35%. The fire risk is generally greatest in the late summer and early fall when temperatures are high, relative humidity is low, and fuels are cured at the end of the growing season[120]. The fall months (September and October) also support Konocti and Diablo wind events, when strong foehn[121] winds move warm, dry air masses from the north and east into the region, exacerbating fire risk.

This report uses a structured statistical approach to derive two fire weather scenarios from the nearby Konocti Remote Automated Weather Station (RAWS) station, representative of local high-severity fire weather conditions. The Konocti RAWS station (38° 54' 43"N, 122° 42' 23"W) is located approximately 13 miles from the MGV project site. Following established best practices for producing meaningful and useful wildfire mitigation plans, this approach includes (a) developing fire weather scenarios using locally relevant wind and weather conditions observed at a representative weather station, (b) creating scenarios that reflect the local worst-case potential weather conditions, and (c) including fuel moisture conditioning to reflect the role of atmospheric humidity in the fire behavior assessment[122].

2.1.1 Scenario Development

Although strong winds occur in Lake County throughout the year, the most concerning fire weather scenarios are dry, high-speed wind events that occur during extended periods of low relative humidity at the end of the growing season when fuel moisture is at its seasonal lowest.

Live fuels (grasses and shrubs with herbaceous and living woody biomass) in Lake County have a seasonal growth cycle where moisture content is highest in the spring and early summer and lowest in the fall. Figure 1 shows the monthly average live fuel moisture for several shrub species recorded in the vicinity of Lake County. The moisture values for shrub fuels tend to reach their seasonal minima in September and October before early winter rains spur additional growth[123].

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[120] Cured fuels are herbaceous vegetation, such as grasses, that have dried out and lost their moisture content, making them highly flammable and prone to combustion during a wildfire.
[121] Foehn winds are dry, warm, and strong downslope winds caused by air descending from mountain ranges, which can significantly increase wildfire risk by drying out vegetation and driving rapid fire spread.
[122] Scott, Joe H. "Introduction to wildfire behavior modeling." National Interagency Fuel, Fire, & Vegetation Technology Transfer (2012).
[123] Data from: https://fems.fs2c.usda.gov/ui

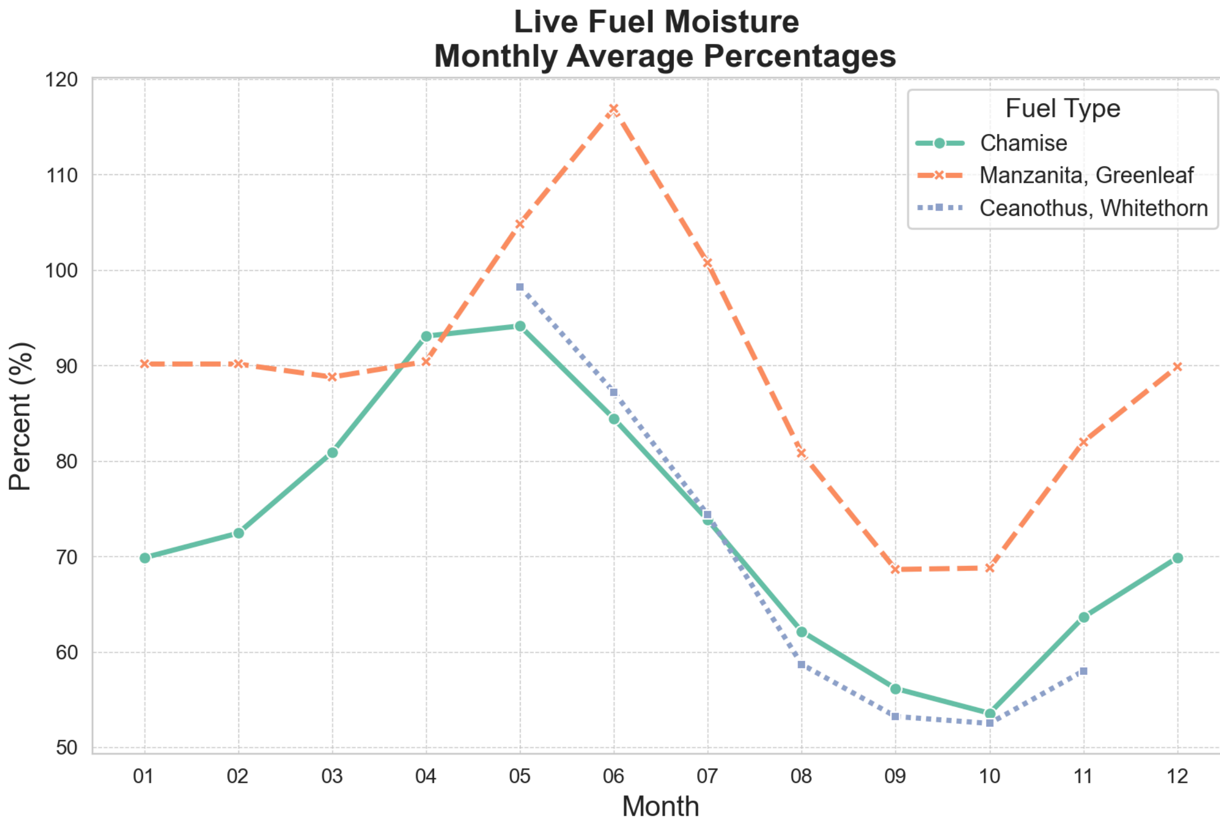

Figure 1: Historical average live fuel moisture values for each month recorded at sites in the vicinity of Lake County.

Within the fire season months of August, September, October, and November, the weather in southern Lake County tends to be warm, moderately dry, and relatively calm. Table 3 shows the average weather conditions recorded at the Konocti RAWS: daytime high temperatures tend to be around 79 degrees, with minimum relative humidity around 28%. Daily average high wind speeds are around six miles per hour.

Average Daily Minimum Relative Humidity	27.8%
Average Daily Mean Wind Speed	5.8 mph
Average Daily Maximum Temperature	78.7 F

Table 3: Average weather parameters during fire season months (August-November) recorded at the Konocti RAWS station.

Although the daily average minimum relative humidity during the fire season months is around 28%, approximately 35% of the days during the fire season show relative humidity below 20%, indicating very dry conditions capable of supporting rapid fire growth. Figure 2 shows the distribution of minimum daily relative humidity observations during the fire season months at the Konocti RAWS.

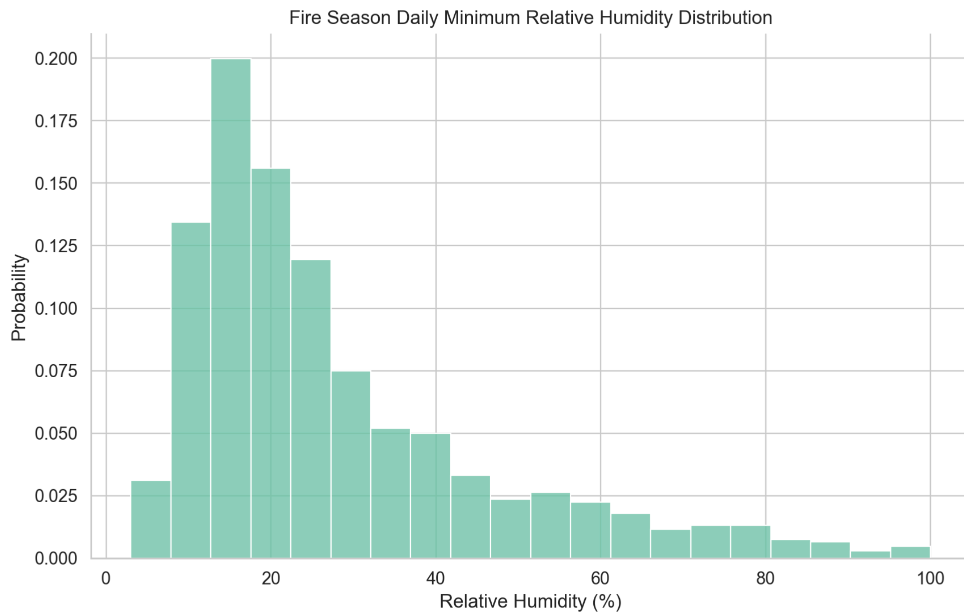

Figure 2: Daily minimum relative humidity at the Konocti RAWS station for the fire season months of August, September, October, and November.

Catastrophic fires and extreme fire behavior are most likely to occur during high-wind events that coincide with periods of sustained low relative humidity. Figure 3 shows the frequency distribution of hourly wind speed and direction observations at the Konocti RAWS during periods with extended low relative humidity (preceding 72-hour average of less than 20%). Note the clear bimodal distribution shown in the histogram: during dry periods, winds greater than ten mph either come from the west (220 to 300 degrees) or from the east (40-110 degrees). Winds from the west are slightly more frequent and can be substantially stronger. Strong, dry winds from the north (330-30 degrees) or south (120-220 degrees) are not frequently seen in the historical record.

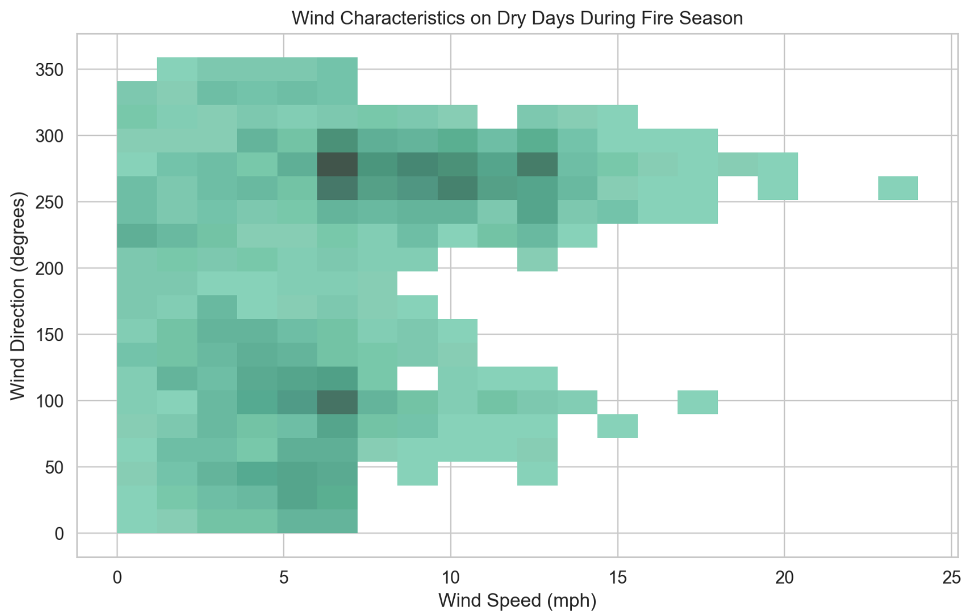

Figure 3: Hourly average sustained wind speed and direction distribution for days during fire season when the average relative humidity of the preceding 72 hours was below 20%, and the hourly relative humidity was also below 20%.

Figure 3 provides strong evidence that wildfire planning scenarios at the MGV site should include (a) a west wind scenario and (b) an east wind scenario. Although winds from other directions are possible, sustained high-speed wind events during extended dry periods from other directions are less likely and, according to the historical record, are likely to be less severe.

An event selection algorithm was employed to select historical weather events (consecutive sequences of 4-12 hours) for use in fire modeling scenarios. First, hourly observations during the October-November fire season at the Konocti RAWS were filtered to those with a relative humidity of less than 20% and a trailing 72-hour average relative humidity of less than 20% to reflect extended dry periods where both live and dead fuels are likely to be most receptive to fire. These records were then scored to identify those with the greatest potential fire behavior:

$$S = \frac{(100 - RH_{72}) + max(30 - WS_0, 1) + (100 - RH_0)}{3}$$

Where:

- RH_{72} is the 72-hour trailing average of relative humidity
- WS_0 is the hourly sustained wind speed
- RH_0 is the hourly average relative humidity

Records at or above the 95th percentile in this formula reflect those with the most conducive conditions for extreme fire growth. After scoring all records, sustained wind events were identified by locating the longest sequences of high-percentile records.

Scenario 1: East Wind

Figure 4 shows the east wind scenario, representing conditions observed on October 30th, 2019. This early-morning wind event drove substantial growth of the Kincade fire in nearby Sonoma County on the same day. As shown in the red brackets, this foehn wind event reflects sustained wind speeds out of the east of about 14 miles per hour with relative humidity around 10%.

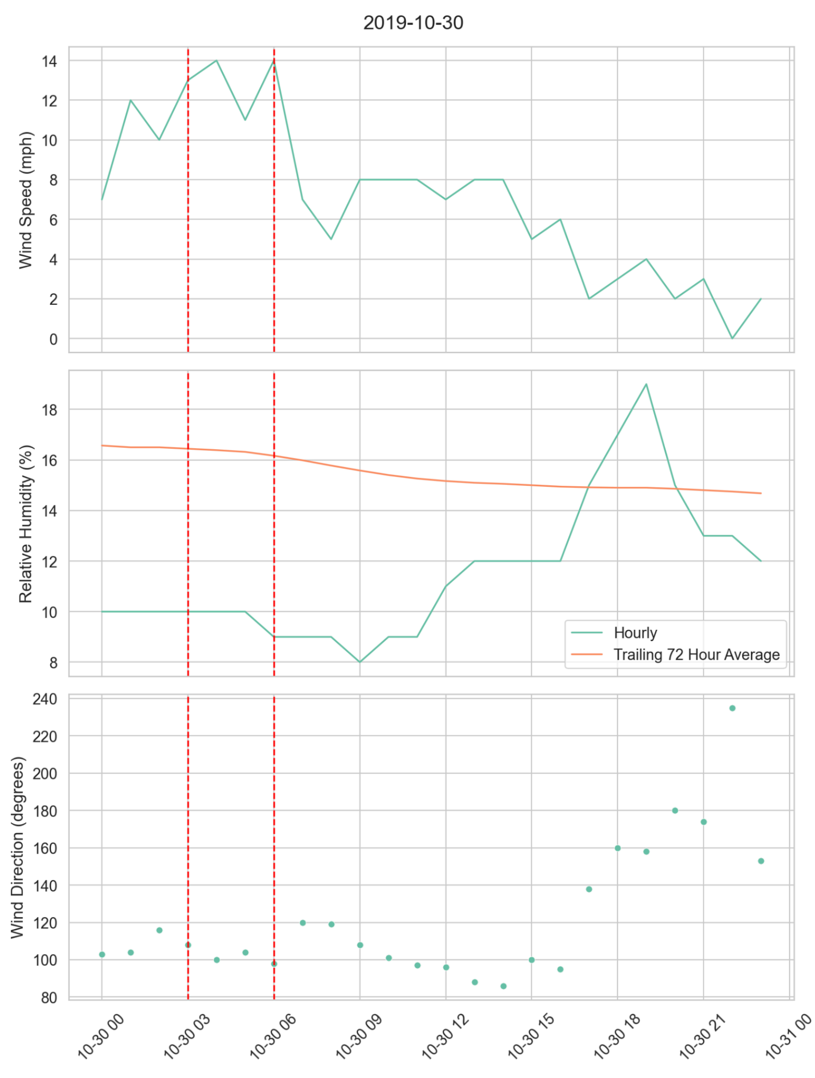

Figure 4: Conditions observed at the Konocti RAWS station on October 29th, 2019. The period annotated in red was selected as the representative fire weather event for an east wind.

Table 4 shows the conditions of the 2019 wind event that are used in the fire behavior modeling.

Characteristic	Value
Wind Speed	14 mph
Wind Direction	100 degrees (East)
Relative Humidity	9%
Representative Date	October 30, 2019
Representative Time	Early Morning

Table 4: Fire Weather Planning Scenario for the East Wind Scenario

Scenario 2: West Wind

The second selected wind scenario represents the conditions of the late afternoon of September 28, 2009. Although this event did not coincide with the growth of a significant fire in Lake County or its surroundings, as shown in Figure 5, this dry wind event was characterized by winds around 17mph from the west. Relative humidity increased through the afternoon but averaged around 8%, with a 72-hour trailing average relative humidity of less than 12%.

Figure 5: Conditions observed at the Konocti RAWS station on September 28th, 2009.

Table 5 shows the representative conditions of the selected 2009 west wind event that is used in the fire behavior modeling.

Characteristic	Value
Wind Speed	17mph
Wind Direction	270 (West)
Relative Humidity	8%
Representative Date	September 28, 2009
Representative Time	Late Afternoon

Table 5: Fire behavior scenario for west wind

2.1.2 Modeling Terrain Influences

Topographic variations have a substantial influence on the local observed wind vector (speed and direction) at any given location on the landscape. To reflect the influence of mountains and valleys in shaping the prevailing wind flow, the computational fluid dynamics tool WindNinja[124] was used to adapt the prevailing wind to the terrain around the MGV project site. Figure 6 shows the variations in wind speed projected across the project site. Although the prevailing wind speed is only 14 miles per hour, ridgetops across the project site can exceed 30 miles per hour, reflecting the heightened wind speeds in exposed locations like ridgetops and mountain summits. Similarly, valleys and areas in the lee of terrain features can experience less-than-prevailing wind speed, with modeling indicating that some areas will experience winds as low as 5-7 miles per hour. WindNinja also tracks the deformation of the wind direction as the wind is forced around or over terrain obstacles.

[124] https://www.firelab.org/project/windninja

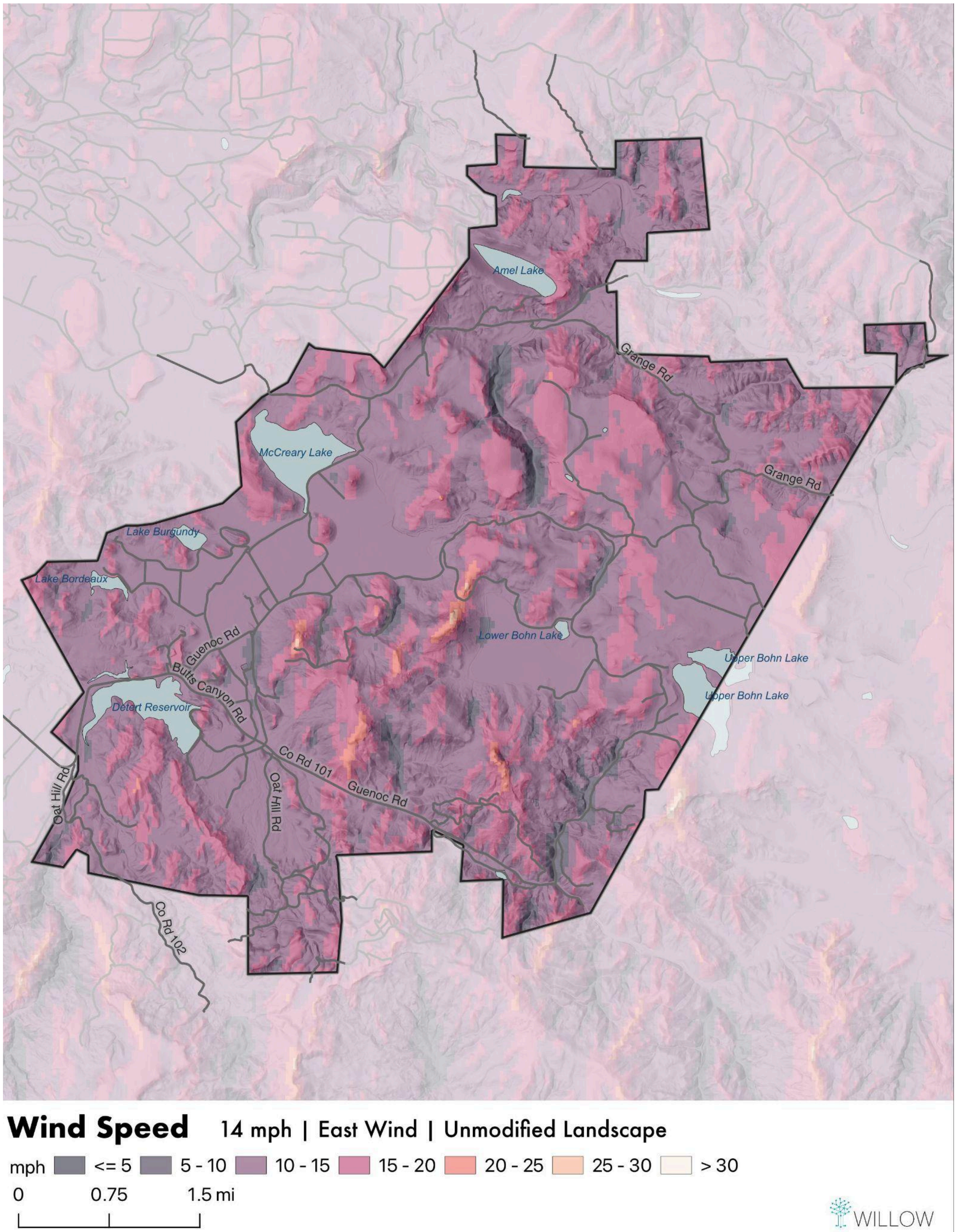

Figure 6: Terrain-adapted wind speed computed using WindNinja.

2.2 Potential Fire Behavior

2.2.1 Fire Behavior Model Settings

Potential fire behavior was calculated using Flammap, the industry-standard fire modeling software package in the United States. Flammap is used on federal wildland fire incidents and for numerous planning and pre-fire use cases. Flammap Version 6.2[125] was run on a Windows PC for this analysis.

Fuel Class	Initial Value
1-hour (<0.25")	3%
10-Hour (0.25-1")	4%
100-Hour (1-3")	5%
Live Herbaceous	40%
Live Woody	70%

Table 6: Initial fuel moisture percentages used to seed the dead fuel moisture conditioning module.

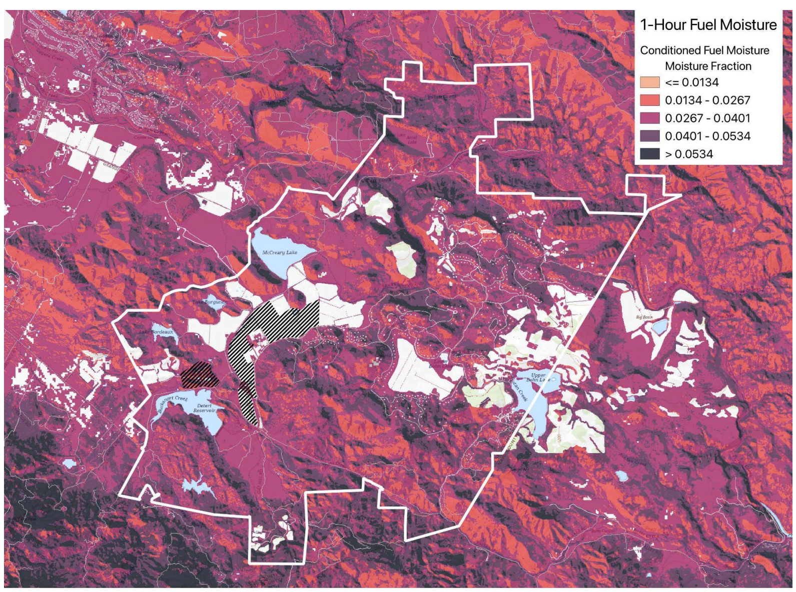

Figure 7: Conditioned fuel moisture content values in the east scenario, baseline case.

Both the East and West weather scenarios were seeded with standard low fuel moistures, as shown in Table 6. Seed moistures were conditioned for 72 hours (3 days) in advance of the simulation start time, enabling the software to calibrate the moisture values to the humidity of

[125] https://www.firelab.org/project/flammap

the atmosphere. The fuel moisture conditioning also accounts for canopy shading, slope, and aspect, providing higher moisture content on north-facing and shady sites than in sunny, south-facing locations (Figure 7).

Finney's crown fire module was used to model the canopy's receptivity to fire, and a foliar moisture content of 80% was used to reflect a prolonged drought and moisture-stressed canopy vegetation. These conditions are chosen to reflect the worst-case scenario fire conditions; fires occurring during average conditions, particularly those outside of the summer dry season, may exhibit lower fire behavior than that modeled here.

2.2.2 Flame Length

Flame length is a common operational measure of wildland fire intensity. As shown in Figure 8, flame length reflects the average length of the flame from base to tip. High flame lengths indicate more intense fires and a greater likelihood of fire spreading to the tree canopy. Flame length is influenced by the surface fuel type, loading, and arrangement as well as the local topography, moisture, and wind conditions.

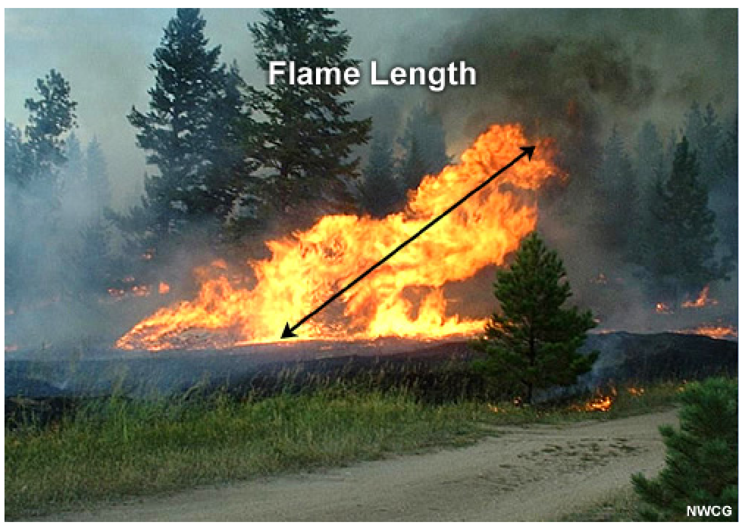

Figure 8: Illustration of flame length.

Firefighters commonly use flame length to assess the best tactics for engaging the fires shown in Table 7, shorter flames (under 4 feet) can often be engaged directly by ground personnel, while flames over 8 feet often require aerial support or indirect tactics[126] due to their high heat output and potential extreme behavior.

[126] Such as burnouts and back fires, in which firefighters strategically use fire to create control lines by removing fuel in front of the main body of fire.

Flame Length	Interpretations
Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. The handline should hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractor-plows, engines and retardant drops can be effective.
8 to 11 feet	Fire may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

Table 7: Flame length interpretations from the Incident Response Pocket Guide (IRPG[127]).

Key Changes

Key changes in flame length due to the DF and MM risk reduction activities are highlighted in Table 8. Within the site boundary as a whole, average flame length is projected to decrease by approximately 0.2 feet (2.8%) under Case I and 4.2 feet (50.0%) under Case II. Flame length is largely driven by the surface fuel model, a classified representation of the size, loading, and arrangement of fuels on and above the ground[128,129]. Because the design features are expected to result in fuel modifications to a smaller percentage - focusing instead on the addition of non-burnable and irrigated landscape features in strategic, but highly-localized, areas - the impact of the DF activities in reducing flame length is relatively small site-wide. In contrast, the active land management, large-scale fuel breaks, and additional defensible space (30ft-100ft from structures) modeled in Case II are projected to have a much larger impact on fire behavior across the project site.

Adjacent to existing and proposed buildings, the flame length is projected to decrease by 1.6 feet (22.3%) under Case I and 4.9 feet (68.2%) under Case II. Irrigation around the proposed residential and commercial buildings is a substantial driver of the lower flame lengths around buildings in the DF case; however, as with the site as a whole, the intensive defensible space specified under the MM case are projected to result in even lower flame lengths around buildings once applied.

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[127] https://www.dnr.wa.gov/publications/rp_cb_incident_response_pocket_guide.pdf

[128] Fuels are classified into 40 distinct “Fuel Models”. For more information, see Scott, Joe H., and Robert E. Burgan. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel’s Surface Fire Spread Model. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-153, June 2005.

[129] See Appendix 2 for complete descriptions of the standard fuel models.

Weather Scenario	Analysis Region	Baseline Case	Case I: DF	DF Absolute Change	DF Relative Change	Case II: DF + MM	DF+MM Absolute Change	DF+MM Relative Change
East Scenario	Within 100' of Buildings	7.2	5.6	-1.6	-22.3%	2.3	-4.9	-68.2%
West Scenario	Within 100' of Buildings	8.1	6.5	-1.6	-20.2%	2.7	-5.4	-66.9%
East Scenario	On Parcels	7.3	6.2	-1.0	-14.4%	2.3	-5.0	-68.8%
West Scenario	On Parcels	8.3	7.1	-1.2	-13.9%	2.7	-5.6	-67.9%
East Scenario	Within 100' of Roads	6.8	6.7	-0.1	-1.6%	4.3	-2.5	-36.4%
West Scenario	Within 100' of Roads	7.6	7.5	-0.1	-1.5%	4.9	-2.8	-36.4%
East Scenario	Within Site Boundary	7.6	7.4	-0.2	-2.8%	3.8	-3.8	-50.3%
West Scenario	Within Site Boundary	8.5	8.2	-0.2	-2.8%	4.2	-4.2	-50.0%

Table 8: Key changes in flame length under the baseline, design feature, and mitigation measure modeling cases. Flame length units are in feet.

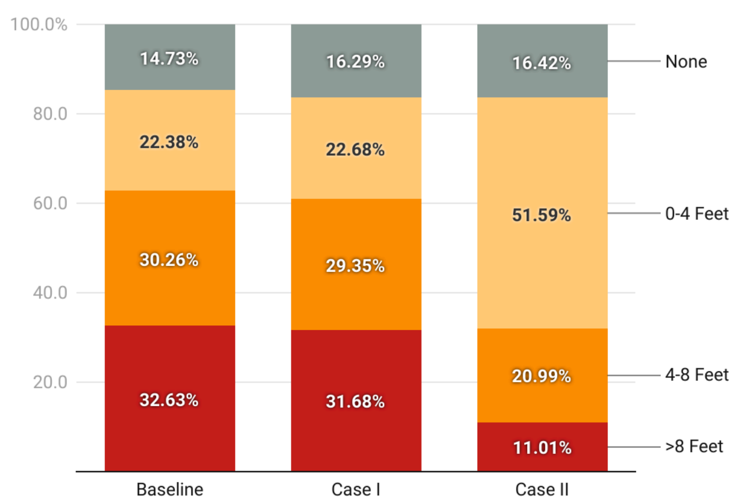


Figure 9: Proportion of the MGV project site likely to support fire intensities of different magnitudes under the three modeling cases.

As shown in Table 9, in addition to reducing the site-wide average flame length, the DF+MM risk reduction activities are also highly beneficial at reducing the most severe fire activity across the entire site. The DF+MM activities are projected to reduce the 70th percentile flame length by about 48% and the 90th percentile flame length by about 61%. These projections suggest that firefighters are more likely to encounter fire moderate fire behavior throughout the MGV project site and that the areas of greatest concern are likely to be exhibit substantially reduced fire behavior[130].

	East Scenario			West Scenario		
Percentile	**Baseline**	**Case I: DF**	**Case II: DF+MM**	**Baseline**	**Case I: DF**	**Case II: DF+MM**
Minimum	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
20	0.7	0.5	0.5	0.7	0.5	0.5
30	2.6	2.3	1.2	2.7	2.4	1.3
40	4.3	3.9	1.8	4.6	4.3	1.9
Median	5.6	5.4	2.3	6.2	6.0	2.5
60	6.3	6.2	2.8	6.9	6.8	3.1
70	7.7	7.5	3.9	8.7	8.4	4.5
80	11.0	10.8	5.8	12.6	12.3	6.4
90	20.0	19.6	7.6	22.2	21.8	8.7
Maximum	151.7	132.1	67.7	166.4	153.6	73.3

Table 9: Changes in the flame length distribution attributable to the DF and DF+MM cases compared to the baseline.

Based on the interpretations in Table 7, approximately 38% of the baseline landscape would allow ground-based firefighters to safely and effectively engage in direct fireline construction during a wildfire incident. The remaining 60% of the landscape would likely not support effective firefighting and would require indirect line construction, aircraft, or heavy equipment to engage the wildfire safely and effectively. As shown in Figure 9, the DF+MM modeling case suggests that mitigation measures are likely to be highly effective at increasing the proportion of the project site that can facilitate safe and effective firefighting.

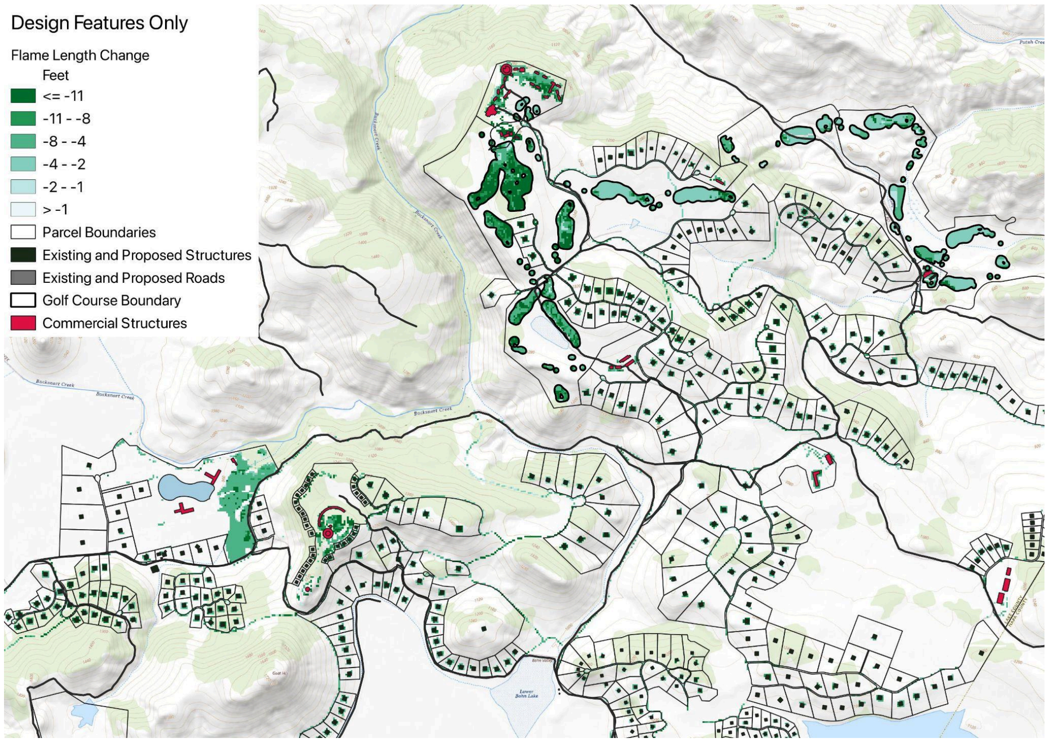
[130] Note, however, that suppression difficulty is not linearly related. As discussed in Table 7, suppression activities on flame lengths greater than eight feet are likely to be ineffective. Therefore, although the 90th percentile flame length was reduced from 22.2 feet to 8.7 feet (west scenario), both cases are projected to produce flame lengths greater than the threshold required for effective firefighting.

Directly adjacent to existing and proposed buildings, the area accessible to firefighters for direct attack is projected to more than double under the DF+MM case, from approximately 40% to over 80%. This indicates that firefighting personnel are likely to have dramatically better conditions for safely and effectively engaging the fire adjacent to structures, lowering the risk of ignition to these structures (Table 10).

Similarly, in addition to interrupting fuel continuity, roadside clearance along transportation corridors is projected to result in a greater capacity for firefighters to engage fires along new and existing roadways, which can be both access routes and ignition sources. In the baseline case, direct attack tactics are projected to be possible in around 40% of the area within 100 feet of roads. While the DF case is not projected to change this figure significantly, the MM+DF activities are projected to increase the area accessible to firefighters adjacent to roadways by about 60%, such that approximately 65% of the area adjacent to roadways would be accessible to firefighters.

Weather Scenario	Analysis Region	Baseline Case	Case I: DF	DF Absolute Change	DF Relative Change	Case II: DF+MM	DF+MM Absolute Change	DF+MM Relative Change
East Scenario	Within 100' of Buildings	41.0%	54.5%	13.5%	33%	85.0%	44.1%	107%
West Scenario	Within 100' of Buildings	38.5%	50.5%	11.9%	31%	82.0%	43.4%	113%
East Scenario	On Parcels	39.6%	48.2%	8.6%	22%	84.4%	44.8%	113%
West Scenario	On Parcels	36.6%	45.1%	8.6%	23%	81.4%	44.8%	123%
East Scenario	Within 100' of Roads	41.5%	42.7%	1.2%	3%	65.7%	24.2%	58%
West Scenario	Within 100' of Roads	39.4%	40.5%	1.1%	3%	63.9%	24.5%	62%
East Scenario	Within Site Boundary	38.8%	40.6%	1.8%	5%	70.4%	31.6%	81%
West Scenario	Within Site Boundary	37.1%	38.8%	1.7%	5%	68.0%	30.9%	83%

Table 10: Percentage of area likely to facilitate direct attack by ground-based firefighters under the three modeling cases.



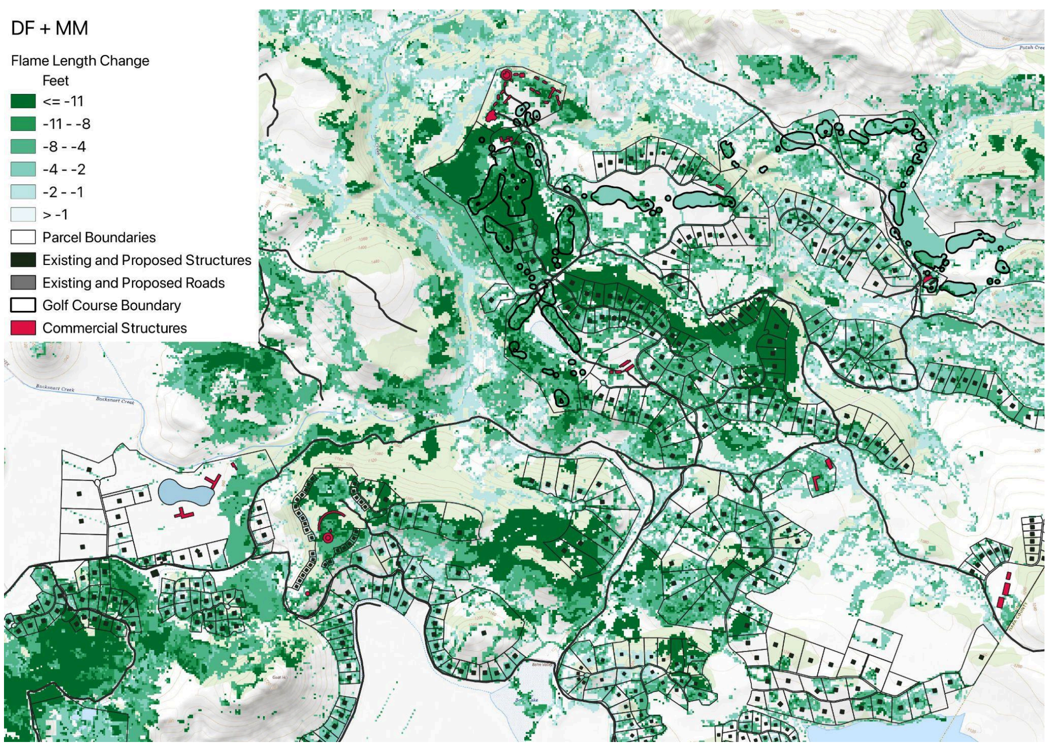


Figure 10: Projected flame length changes in feet. Top: Design Features only. Bottom: Design Features and Mitigation Measures together. See the attached map book for a higher-resolution image.

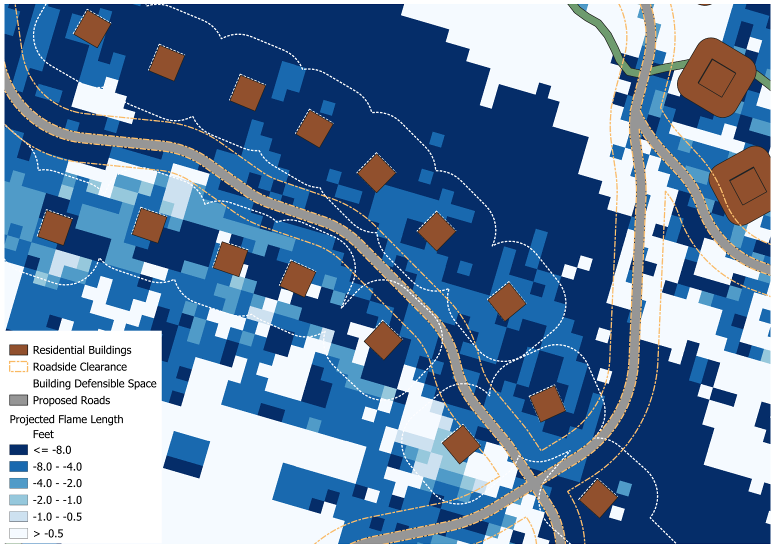


Figure 11: Projected flame length changes around a cluster of residential buildings in the MGV site.

Conclusion: *The proposed design features (Case I) are projected to slightly decrease fire intensity and, correspondingly, slightly increase the capacity for firefighters to engage the fire safely and effectively on the project site. While the DF features are projected to change how fire spreads across the landscape by reducing fuel continuity, they do not alter the fuel loading or arrangement on a substantial proportion of the site and are not projected to change potential site-wide fire behavior substantially. In contrast, the widespread vegetation management and defensible space prescribed in the DF+MM case are projected to vastly decrease the fire intensity across the entire project site and substantially increase the area accessible to firefighters, both across the project site as a whole and adjacent to existing and proposed roads and buildings.*

2.2.3 Rate of Spread

Rate of spread represents the speed at which a fire moves across an area[131]. In the existing baseline, portions of the MGV project site and its surroundings are expected to support rapid fire growth. The average baseline rate of spread across the project site exceeds 0.5 mph and some locations are projected to support spread rates of greater than 12 miles per hour. These fires may run long distances in a short period, making suppression challenging and dangerous. Fast-moving fires are also associated with catastrophic losses within the built environment. High-intensity fires that move slowly are generally not associated with large-scale loss; however, fast-moving fires in light fuels can result in widespread destruction, have a higher potential for

[131] Spread rate is typically measured in chains per hour. To convert to standard English units, multiply the chains per hour measure by 1.1 to derive spread rates in feet per minute.

structure-to-structure conflagration initiation, and can result in dangerous conditions for firefighters and civilians[132,133].

Fire behavior modeling software provides measurements for the head fire rate of spread. The head of the fire is the fastest-moving portion of a fire, usually spreading with the wind and often in alignment with the slope. Fire growth in the absence of heterogeneous fuels, topography, and wind follows an elliptical shape, where the head grows most rapidly, and the flanking (side) and backing (upwind) fires spread substantially more slowly. This study focuses on the head fire rate of spread since it is the most hazardous and the rate most likely to affect community safety.

Key Changes

The non-burnable features introduced in the DF activities are projected to interrupt fire spread by creating non-burnable barriers through which the fire cannot travel: with the exception of irrigated areas around buildings, these landscape modifications stop, rather slow, fire travel in strategic locations[134]. Because these features are highly localized around commercial and residential buildings and roads, and thus only alter the surface or canopy fuel loading or arrangement on a small minority of the overall site surface area, the projected reduction in average spread rate is modest. DF risk reduction activities are projected to only slightly decrease spread rate on the project site (2.9% projected decrease).

As with flame length, the DF+MM landscape management activities are projected to produce a much larger reduction in site-wide average rate of spread. Together, the DF+MM risk reduction activities are projected to result in an average rate of spread decrease of more than 28% site-wide. Adjacent to buildings, DF+MM mitigations are projected to result in a spread rate decrease of nearly 60%.

Weather Scenario	Analysis Region	Baseline Case	Case I: DF	DF Absolute Change	DF Relative Change	Case II: DF+MM	DF+MM Absolute Change	DF+MM Relative Change
East Scenario	Within 100' of Buildings	33.3	25.7	-7.6	-22.9%	13.4	-19.9	-59.8%
West Scenario	Within 100' of Buildings	42.0	33.4	-8.6	-20.4%	17.9	-24.0	-57.3%
East Scenario	On Parcels	31.7	26.8	-4.8	-15.3%	12.3	-19.4	-61.2%
West Scenario	On Parcels	39.9	34.1	-5.9	-14.7%	16.6	-23.4	-58.5%
East Scenario	Within 100' of Roads	42.2	41.4	-0.7	-1.8%	34.0	-8.2	-19.3%

[132] https://www.nwcg.gov/6mfs/weather-fire-behavior/common-denominators-of-fire-behavior-on-tragedy-fires
[133] Balch, Jennifer K., et al. "The fastest-growing and most destructive fires in the US (2001 to 2020)." *Science* 386.6720 (2024): 425-431.
[134] The role of these features in interrupting fire spread in key locations will be examined in Section 3.

West Scenario	Within 100' of Roads	52.5	51.6	-0.9	-1.7%	42.5	-10.0	-19.0%
East Scenario	Within Site Boundary	37.5	36.4	-1.1	-3.0%	26.8	-10.8	-28.7%
West Scenario	Within Site Boundary	46.4	45.1	-1.3	-2.9%	33.4	-13.1	-28.1%

Table 11: Head-fire spread rates for different analysis regions. Spread rate is measured in chains per hour.

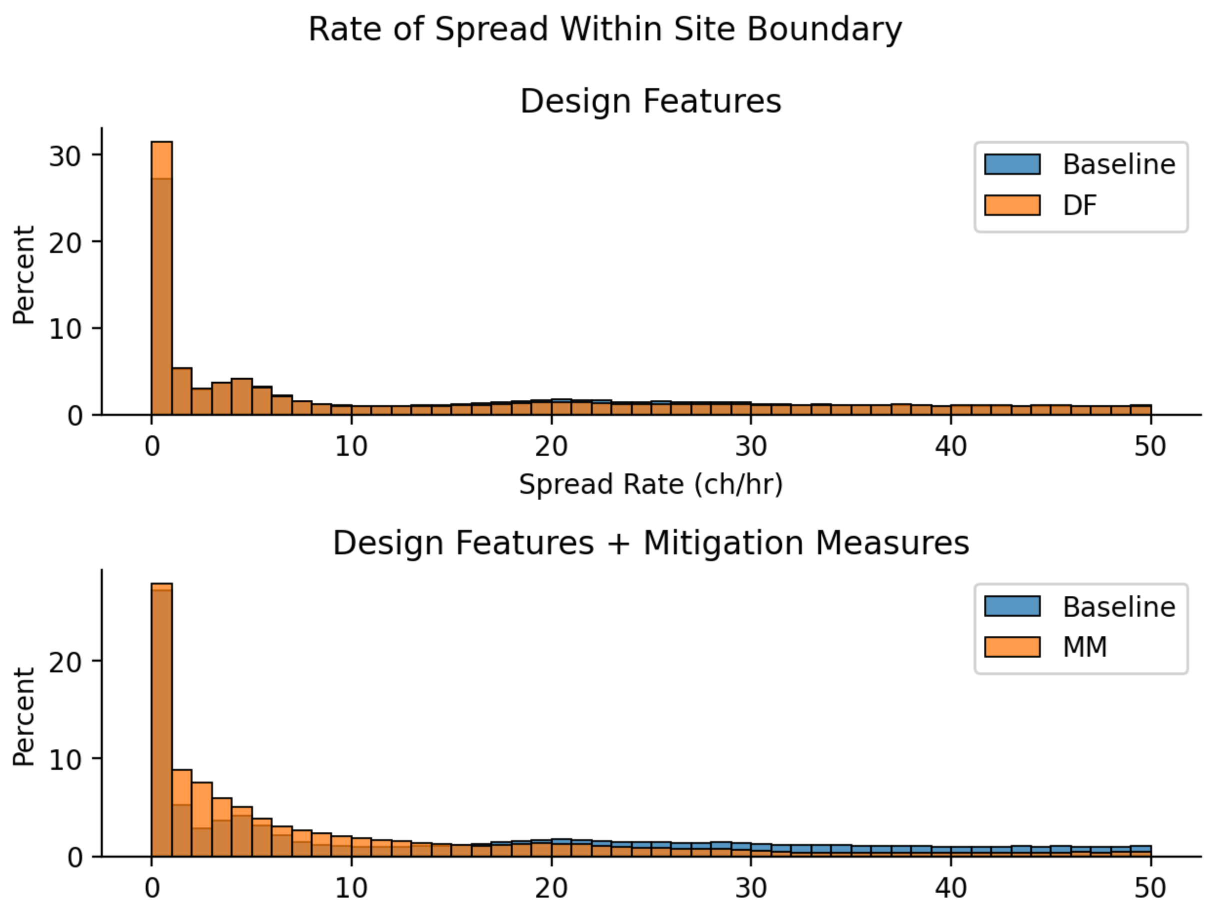


Figure 12: Distribution of projected spread rate within the project site for the DF case (top) and DF+MM case (bottom).

As shown in Table 11, the average baseline rate of spread of 40 chains/hour corresponds to a 107-acre fire after one hour[135], assuming a point-source ignition within the project boundary.[136]

[135] Calculated using the BEHAVE software package Point Source Fire Size Module: https://www.firelab.org/project/behaveplus

[136] This modeling does not imply that this ignition is human caused (e.g., downed electrical line) versus natural (e.g., lightning).

Fire size increases exponentially; therefore, after eight hours of growth under uniform conditions, that fire could reach nearly 7,000 acres without suppression. With the implementation of the DF+MM risk reduction activities, fire size projected to be reduced by approximately 38%. Under this case, the average fire size after an hour of uniform growth would be approximately 67 acres.

This is an illustrative example: actual terrain, fuels, and wind patterns drive heterogeneous rates of spread. However, it is a useful assessment because it indicates the potential for local and regional firefighters to successfully engage and contain fires originating on the site before they become too large. The data in Table 12 suggest that fires originating from ignitions on the MGV site are likely to be smaller after the DF+MM risk reduction activities are implemented, creating better operating conditions for firefighters and potentially reducing risk to adjacent communities.

	Baseline[137]	**Case I: DF + MM**[138]	**Case II: DF + MM**[139]
1-Hour	107	103	67
2-Hour	430	412	266
3-Hour	966	926	598
6-Hour	3,867	3,706	2,393
8-Hour	6,874	6,588	4,254

Table 12: Potential fire size under uniform growth conditions. Fire size figures are in acres.

In a very small number of locations (~0.1% of the area of the site, or less than 20 of the project's 16,517 acres) spread rate is projected to increase in the DF+MM state (Case II) compared to the existing baseline. The DF+MM landscape management and defensible space activities are projected to remove ladder fuels and decrease canopy cover in some areas. Canopy cover plays an important role in fire dynamics by creating friction with prevailing winds and sheltering surface fuels from solar radiation, reducing midflame wind speeds (the winds directly affecting the fire) and increasing fuel moisture through shading. Although the surface fuel changes are likely to greatly reduce fire rate of spread and intensity in most cases, the corresponding changes to the canopy layer may result in surface fuels experiencing higher midflame wind speeds and increased solar exposure, leading to higher spread rates in limited cases. Although this effect is reliably modeled in the industry-standard fire behavior modeling software, the

[137] Calculated using an assumed uniform average rate of spread of 46.5 chains per hour representing the site-wide average from the west wind scenario in the baseline case.
[138] Calculated using an assumed uniform average rate of spread of 45.1 chains per hour representing the site-wide average from the west wind scenario in the DF Case I.
[139] Calculated using an assumed uniform average rate of spread of 33.3 chains per hour representing the site-wide average from the west wind scenario in the DF + MM Case II.

scientific and observational basis for this effect is debated[140,141,142,143,144]. Most observational studies indicate that this effect is purely computational, and is not observed in real-world fuel treatment projects. In any case, this change affects a very small portion of the project site and results in only minor increases (<10 chains/hour) in spread rate, and, furthermore, in these areas, the potential for canopy fire and long-distance spotting is dramatically reduced, illustrating the holistic nature of fire risk reduction.

Conclusion: *Overall, the modifications in the DF+MM case are projected to significantly and substantially reduce the fire spread rate likely to occur on the site. The defensible space around the proposed buildings is projected to be particularly important in decreasing the spread rate adjacent to existing and proposed structures. Although a slow-spreading fire can still result in structure ignition, lower rates of spread correspond with a greater probability of firefighter response and improved capacity to engage in defensive actions prior to fire arrival at the structure. Furthermore, the DF+MM modifications are projected to dramatically reduce the fire size of a wildfire originating on the site, improving the effectiveness of local and regional fire response resources in engaging the fire before it becomes too large, potentially decreasing the risk to the surrounding communities.*

2.2.4 Crown Fire Activity

Crown fires occur when a wildfire transitions from burning surface fuels (on and near the ground) to burning in the tree canopy. Torching (isolated instances of canopy transition) and crown fires (sustained canopy fire activity) indicate extreme fire behavior: fire that exceeds the threshold for canopy fire transition supports very high heat output and rate of spread, making it difficult to contain and potentially dangerous for firefighters. Canopy fires generally support very high flame lengths, are also a prerequisite for long-range spotting, and can cause the ignition of nearby structures.

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[140] Scott, Joe. 2003. Canopy Fuel Treatment Standards for the Wildland-Urban Interface. USDA Forest Service Proceedings RMRS-P-29. 2003.
[141] McKinney, S.T., Abrahamson, I., Jain, T. et al. A systematic review of empirical evidence for landscape-level fuel treatment effectiveness. fire ecol 18, 21 (2022). https://doi.org/10.1186/s42408-022-00146-3
[142] Brodie, E.G., Knapp, E.E., Brooks, W.R. et al. Forest thinning and prescribed burning treatments reduce wildfire severity and buffer the impacts of severe fire weather. fire ecol 20, 17 (2024). https://doi.org/10.1186/s42408-023-00241-z
[143] Martinson, Erik J., and Philip N. Omi. "Performance of fuel treatments subjected to wildfires." Fire, Fuels Treatment, and Ecological Restoration.[vp]. 16-18 Apr (2002).
[144] Agee, J.K. 1996. The influence of forest structure on fire behavior. Pages 52-68 in Sherlock, J. (chair). Proceedings of the 17th annual forest and vegetation management conference. The Conference, Redding, CA.

Figure 13: Illustrative examples of crown fire activity. Left: Surface fire. Middle: Torching. Right: Active Crown Fire.

In this analysis, crown fire activity is quantified as the percentage of the landscape able to support torching or active crown fire. In most northern California Oak Woodland landscapes, active crown fire is highly unlikely due to the composition of the species and ecological characteristics of the forested landscapes. However, torching is still a concern for several reasons, including spotting, firefighter safety, and evacuation. Crown fire initiation depends on the surface fire intensity (flame length) and the structure of the ladder and canopy fuels. Ladder fuels, which provide connectivity between the surface fuels and the tree canopy, are particularly impactful in facilitating the fire transition into the canopy. In the fire behavior modeling software, the presence of ladder fuels is measured by the height-to-live-crown data layer.

Key Changes

As shown in Table 13, approximately 50% of the MGV project site is projected to support canopy fire activity in the existing baseline. Due to the species composition, crown fire is exceedingly unlikely in this landscape (only approximately 0.1% of the area is expected to reach the conditions necessary for active crown fire), much of the project site is expected to produce isolated or group torching, posing control and safety issues on the site, and creating the potential for ember-driven spot fires.

The DF activities largely do not alter the structure of the tree canopy or ladder fuels, and, as discussed previously, are not projected to substantially decrease fire intensity, except in the irrigated areas adjacent to structures. Therefore, the DF features are projected to result in only an approximately 1% decrease in the area of the landscape projected to support torching or crown fire activity. These changes are primarily located in the areas converted to a non-burnable fuel type, such as the golf course and water features.

In contrast, the widespread active landscape management in the DF+MM case, along with the defensible space, roadside clearance, and perimeter fuel breaks, are projected to modify both the surface fuel and the canopy characteristics. These activities are designed to remove ladder fuels and increase the height-to-live crown while removing some portions of the canopy to reduce connectivity within the canopy fuels. These modifications, along with the substantial reductions in fire behavior projected to occur as a result of the corresponding surface fuel changes, are projected to reduce the proportion of the site area likely to support torching or canopy fire activity from 50% to approximately 25%, a 50% relative reduction.

Weather Scenario	Analysis Region	Baseline Case	Case I: DF	DF Absolute Change	DF Relative Change	Case II: DF+MM	DF+MM Absolute Change	DF+MM Relative Change
East Scenario	Within 100' of Buildings	49.6%	37.5%	-12.1%	-24.4%	15.5%	-34.1%	-68.7%
West Scenario	Within 100' of Buildings	51.5%	39.5%	-12.0%	-23.3%	17.4%	-34.1%	-66.2%
East Scenario	On Parcels	51.3%	43.9%	-7.4%	-14.3%	15.9%	-35.4%	-69.0%
West Scenario	On Parcels	53.2%	46.2%	-7.1%	-13.3%	18.3%	-35.0%	-65.7%
East Scenario	Within 100' of Roads	42.6%	41.9%	-0.7%	-1.7%	22.3%	-20.3%	-47.7%
West Scenario	Within 100' of Roads	44.0%	43.3%	-0.7%	-1.6%	23.9%	-20.1%	-45.7%
East Scenario	Within Site Boundary	49.2%	47.8%	-1.4%	-2.8%	22.8%	-26.3%	-53.5%
West Scenario	Within Site Boundary	50.3%	48.9%	-1.4%	-2.8%	24.7%	-25.6%	-50.9%

Table 13: Proportion of the landscape subject to torching or crown fire activity under the different cases.

The defensible space activities adjacent to buildings, including both irrigation (DF) and defensible space (MM) are projected to dramatically decrease (66-86% relative reduction) the likelihood of torching or crown fire activity within 100 feet of buildings. This change is likely to improve the safety of firefighters engaged in structure protection in these locations and decrease the likelihood of radiant heating or flame contact from the torching trees causing the ignition of these structures. Roadside clearance activities (MM) are also projected to reduce the likelihood of canopy fire behavior adjacent to existing and proposed roadways, potentially facilitating a safer evacuation and more rapid firefighter ingress in the case of a wildfire.

Conclusion: *Overall, the DF+MM case is projected to substantially reduce the portions of the landscape capable of supporting fire activity in the canopy. The proposed design features and mitigation measures are together projected to reduce torching and crown fire activity from 50% of the project site to less than 25%, a substantial reduction in risk to buildings on the MGV site. These decreases in fire behavior are likely to increase the safety and effectiveness of* *firefighters engaging fires on the site, decrease the potential for long-distance spotting, and may reduce the likelihood of structure ignition.*

2.2.5 Potential Spotting Distance

Spotting occurs when burning or smoldering embers are lifted by wind or heat and carried by the prevailing winds before landing in unburned areas, potentially igniting spot fires. Spotting can facilitate rapid fire growth by depositing embers ahead of the main fire front, starting new spot fires and rendering natural and artificial barriers, such as roads, rivers, and constructed fire lines ineffective at controlling fire growth.

Figure 14: Illustration of embers blowing across a road, a feature that would likely prevent surface fire growth in the absence of spotting.

The MaxSpot algorithm (Maximum Spotting Distance) built into Flammap is a method for calculating the maximum potential distance that an ember can be carried by prevailing winds and deposited with sufficient thermal energy to ignite a new spot fire. Based on Albini's 1979 physical model of firebrand transport[145], the model accounts for the topographic position, fuel type, and the vector of the prevailing winds. Although Flammap and the MaxSpot algorithm provide the best available science for operational wildfire modeling, these tools have substantial limitations in shrub-dominated fuels: Flammap assumes that embers must be launched from burning trees (i.e., crown fire initiation is a prerequisite) and does not model ember generation and transport from shrub fuels.

The MGV project site is largely occupied by grass and shrub fuels in rolling hills that are not projected to produce long-distance ember travel (in the modeling software). In the baseline case, approximately 4% of the project site is projected to produce embers with the capacity to travel more than 500m. Drivers of long-distance ember travel include fire intensity and canopy characteristics (needed to produce torching or crown fire initiation), as well as the prevailing

[145] Albini, Frank A. *Spot fire distance from burning trees: a predictive model*. Vol. 56. Intermountain Forest and Range Experiment Station, Forest Service, US Department of Agriculture, 1979.

winds and topographic position of the fuels. Exposed ridgetop sites tend to produce longer-distance trajectories because the embers can become entrained in higher-velocity prevailing winds and carried longer distances before being deposited on downwind surfaces. In contrast, sheltered valley bottoms are projected to produce only short-range spotting, due to the lower wind speed and greater fuel sheltering in these locations.

Key Changes

Neither the DF nor the DF+MM risk reduction activities are likely to substantially change the fuel type (i.e., convert timber to shrub fuels) or change the canopy density, both of which are important drivers of spotting distance. Furthermore, spotting distance is largely dependent on the topographic position of the fuel, rather than the type of fuel. Therefore, the changes in spotting distance shown in Table 14 are largely due to preventing canopy fire activity (the necessary precursor to spotting in the MaxSpot model) in timber fuels. As discussed in the section on canopy fire activity (2.2.4), the DF+MM activities are highly effective at reducing surface fire intensity, limiting connectivity between surface and canopy fuels, and raising canopy base height in ways that restrict canopy fire activity. These changes have further implications for spotting distance. As shown in Table 14, reductions in canopy fire activity are projected to correspond to a roughly 47% decrease in the proportion of the MGV project site that is projected to cast embers more than 500m.

Weather Scenario	Analysis Region	Baseline Case	Case I: DF	DF Absolute Change	DF Relative Change	Case II: DF+MM	DF+MM Absolute Change	DF+MM Relative Change
East Scenario	Within 100' of Buildings	2.97%	2.52%	-0.45%	-15.12%	1.55%	-1.42%	-47.75%
West Scenario	Within 100' of Buildings	4.31%	3.69%	-0.63%	-14.52%	2.19%	-2.12%	-49.17%
East Scenario	On Parcels	3.87%	3.65%	-0.23%	-5.81%	2.38%	-1.50%	-38.65%
West Scenario	On Parcels	5.30%	4.83%	-0.47%	-8.91%	2.98%	-2.32%	-43.72%
East Scenario	Within 100' of Roads	2.62%	2.58%	-0.04%	-1.37%	1.87%	-0.75%	-28.58%
West Scenario	Within 100' of Roads	3.84%	3.79%	-0.06%	-1.47%	2.65%	-1.19%	-30.99%
East Scenario	Within Site Boundary	3.06%	3.00%	-0.07%	-2.21%	1.63%	-1.43%	-46.69%
West Scenario	Within Site Boundary	4.27%	4.18%	-0.09%	-2.21%	2.24%	-2.03%	-47.47%

Table 14: Proportion of the landscape projected to support ember transport greater than 500m.

Conclusion: *The DF+MM risk reduction activities are projected to substantially reduce the areas of the MGV project site where fire is likely to transition from the surface to the canopy. In* *addition to improving firefighter safety and evacuation, these changes are projected to reduce the likelihood of long-distance spotting on the project site by approximately 50%, benefitting both the site itself and the surrounding communities.*

2.3 Fire Growth Analysis: Fire Pathways

2.3.1 Introduction to Fire Pathways Modeling

Assessing potential fire behavior (flame length, rate of spread, crown activity, etc.) is a powerful technique to understand the likely characteristics of a fire burning under high-severity fire weather conditions. However, it lacks a temporal component and cannot be used to assess the continuity of the fuels across which a fire could develop.

Assessing community wildfire risk using fire pathways is an emerging technique that characterizes fuel continuity and fire rate of spread, delineates the landscape features likely to support fire runs, and identifies the portions of the community most vulnerable to fire exposure and potential urban conflagration during the initial phases of wind-driven fires. Fire pathways are the paths of least resistance for fire spread across a landscape: contiguous routes along which wind, topography, and fuel are likely to align to produce runs toward community values at risk, such as buildings or other key infrastructure[146].

The fire pathways approach is based on Finney's Minimum Travel Time Algorithm[147]. In this algorithm, fire spread is computed over a regular two-dimensional graph, where navigable edges are weighted by the rate of spread. Minimum travel time paths are the shortest paths (sequences of nodes and edges) through this graph from a user-provided ignition location to the furthest distance away from the ignition that the fire can reach within the given time interval. The physical basis for calculating the rate of spread and direction of maximum spread is the same set of semi-empirical models used in other widely-used fire behavior software packages (including Flammap, Farsite, BEHAVE, etc)[148].

Fire pathway modeling uses an archetypical line representing an established fire front upwind from the community being assessed. Studies modeling fire growth must determine where to place the fire ignition location, a deterministic choice representing a highly stochastic random process: numerous factors, including fuel type, slope, moisture, and local fire suppression capacity control whether a fire will become established. Small differences in ignition location can have substantial impacts on fire growth rate and overall fire size. Rather than explicitly model the location of a point-source ignition, the fire pathways approach assumes a fire has already become established, and the model indicates what the fire is likely to do next, reducing the importance of the initial choice of ignition location.

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[146]Fire pathways is a trademark of XyloPlan, Inc.
[147] Finney, Mark A. "Fire growth using minimum travel time methods." *Canadian Journal of Forest Research* 32.8 (2002): 1420-1424.
[148] I.e., the Rothermel equations. For more information, see Andrews, Patricia L. "The Rothermel surface fire spread model and associated developments: A comprehensive explanation." (2018).

Quantitative analytical testing and qualitative validation from experienced wildland fire professionals have shown that, in general, fire pathways are relatively invariant to the initial conditions used to configure the simulations. Like rivers and streams in a watershed, fire is likely to find the trajectories of least resistance (i.e., those delineated as fire pathways) under various wind speeds, wind directions, and initial ignition locations. Sensitivity analyses have been performed to understand the model's sensitivity to two primary input variables: wind direction and ignition location. These studies indicate that, while some variations in exact pathway location are likely, the overarching patterns of fire spread are quite similar under a wide range of different inputs.

2.3.2 Fire Pathways Modeling Settings

A 14-hour fire growth simulation was used to construct the fire pathways for each wind scenario. This time frame reflects a period of rapid fire growth under extreme wind and weather conditions from a manually-constructed archetypal ignition representing an established fire front approximately 1 mile outside of the MGV project site. Because fire pathways modeling assumes an already established fire front, it is most appropriate to use an archetypical fire front line located outside the site and to use the model to identify possible pathways and barriers as the fire front travels across the site itself. The 14-hour time horizon was chosen to illustrate the impact of uncontained fire growth before en-masse firefighter arrival (i.e., resources responding to a large fire from the Bay Area or southern California, which may take upwards of 5-12 hours). Throughout the fire growth simulations, no fire suppression was modeled or assumed. Fuel model, fuel moisture, weather, and other key settings were kept the same as in the potential fire behavior modeling. Fire pathways modeling does not directly include long-distance spotting, both because it is difficult to calculate pre- and post-mitigation differences in arrival time when a stochastic component is included, and because spotting can mask the primary patterns of fire growth, making it difficult to delineate the most hazardous areas. This model does employ a module that addresses spotting over a limited-width roadway. This approach is consistent with other applications of Fire Pathways modeling throughout California.

Because fire pathways modeling focuses on the most likely pathways under the most probable high-fire risk weather conditions, these pathways may not capture the fire pathways from all historical fires. Not all historical fires occurred during worst-case scenario weather conditions, and thus may follow other routes. The intent of these fire pathway models is to understand likely fire pathways under the worst-case scenario conditions that are representative of historical high-risk weather conditions.

2.3.2 Key Changes in Fire Growth Characteristics

The existing baseline fire pathways simulation shows several key fire growth corridors that could drive rapid fire growth onto the pre-development landscape. As shown in Figure 15[149], under the east wind scenario, fire is likely to grow rapidly into the project site along the following Fire Pathways from the east:

[149] Additional scenarios and fire pathways graphics are provided in the attached map book.

(1) Through Butts Canyon, paralleling Butts Canyon Road
(2) Along the prominent ridgeline separating Butts Canyon and Upper Bohn Lake
(3) Through the Bucksnort Creek drainage
(4) Along the northern boundary of the MGV project site, paralleling Grange Road.

Under the west wind scenario, fire pathways from the west include:

(1) Between Detert Reservoir and the existing network of vineyards on the west side of MGV project site
(2) North of McCreary Lake
(3) Along the Bucksnort Creek drainage

In both cases, fire may grow slowly through the network of existing vineyards and other non-burnable surfaces (i.e., adjacent to Upper Bohn Lake or adjacent to Detert Reservoir, Lake Bordeaux, and Lake Burgandy). However, the landscape in these areas is much more fragmented than along the other fire growth corridors. Left unsuppressed, there is sufficient vegetative fuel for the fire to burn onto the project site using these fuel corridors, but other avenues of exposure are likely to be more rapid (and therefore more hazardous), given the effective barrier created by the existing vineyards and water features.

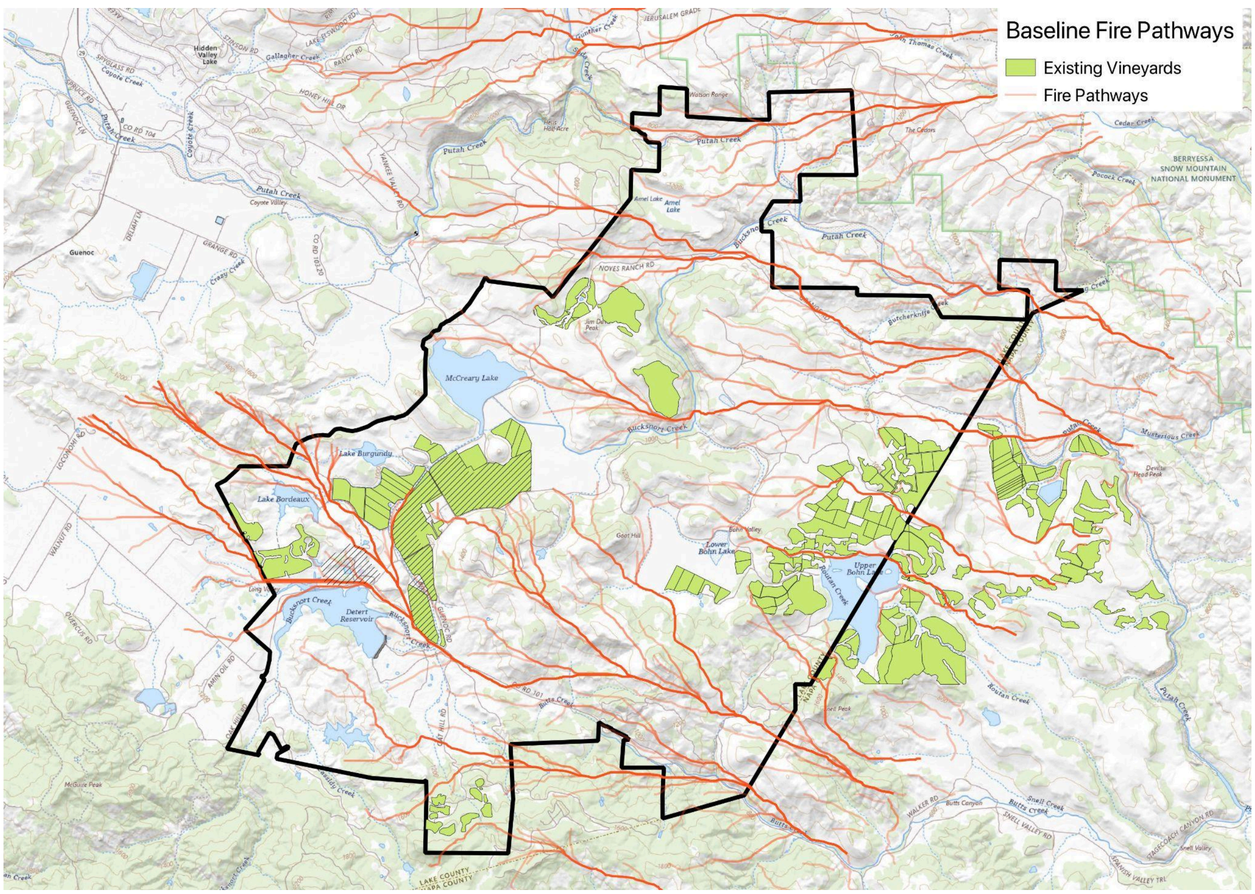


Figure 15: Fire pathways for the west wind scenario under the Baseline landscape conditions. Fire pathways show the trajectories of *most rapid* fire spread.

Although the DF landscape elements create non-burnable features throughout the landscape, these features (roads, isolated irrigated plots of vegetation, golf courses, and other landscape elements) are generally too small, are non-contiguous, or are placed in locations that do not effectively change the overall trajectory of fire growth. Although these features (and the golf course in particular) can and do interrupt the baseline fire pathways (see West Scenario fire pathways in the Appendix 1 Map Book), additional intensive vegetation management between non-burnable landscape elements in strategic locations would afford greater benefit in interrupting rapid fire spread.

When DF features are combined with the roadside clearance, active land management, and defensible space of the MM risk mitigation activities, the combined risk reduction activities are projected to substantially reduce fuel continuity and lower the capacity for rapid fire growth across the project site. These activities substantially reduce fire rate of spread throughout the landscape, and, further, create continuous or semi-continuous obstacles that fire must burn through. Unlike the golf course or isolated irrigated areas, which fire can easily and quickly burn around, these obstacles substantially slow fire growth and restrict the fire pathways.

Together, the DF+MM measures are highly effective at reducing fire growth into the central development area of the MGV site. Some pathways, such as the one through Butts Canyon and the ridgeline between Butts Canyon and Upper Bohn Lake, are projected to remain after the DF+MM measures are implemented. Additional risk reduction activities in these areas would be particularly beneficial to improving safety for the rest of the site. For example, extending the perimeter fuel breaks to include a segment extending from Butts Canyon Road and tying into the network of vineyards adjacent to Upper Bohn Lake could provide an effective interruption to the remaining pathways coming from the east.

In addition to comparing maps presented in the accompanying map book (Appendix 1), one way to assess the effectiveness of the DF and DF+MM risk reduction activities is to determine the number of structures located along a fire pathway. Structures located along fire pathways are those likely to be exposed to the most rapidly spreading fire, and where evacuation and firefighter ingress may be most constrained. Table 15 shows the number of structures within 100m of a fire pathway for the three modeling cases[150]. The DF features alone result in a 12-15% reduction in the number of existing and proposed structures located along a pathway. The DF+MM features result in a 50-70% decrease in the number of these structures within 100m of a fire pathway, reflecting the role of the DF+MM activities in effectively slowing fire growth in strategic locations.

[150] Note that this table does not indicate the number of structures exposed to fire in total, only those located along the corridors of most rapid growth.

Weather Scenario	Baseline	DF	DF Absolute Change	DF Relative Change	DF+MM	DF+MM Absolute Change	DF+MM Relative Change
East	373	326	-47	-12.60%	172	-201	-53.89%
West	353	301	-52	-14.73%	105	-248	-70.25%

Table 15: Number of buildings located along a Fire Pathway under the different landscape cases.

The location of the archetypical fire front used to produce the fire pathways is manually constructed and essentially arbitrary; therefore, the simulated arrival time of the fire at structures or other key infrastructure is not useful. However, the increase in arrival time between the baseline, DF, and DF+MM scenario states is meaningful because it indicates the additional time for evacuation and firefighter ingress afforded by the risk reduction activities, regardless of the exact ignition location[151]. As shown in Table 16, existing and proposed structures within the MGV project site are projected to receive fire approximately 20-30 minutes slower in the DF case compared to the baseline and 109-213 minutes slower in the DF+MM case, compared to the baseline.

Together with the metrics in Table 14, these key indicators suggest that existing and proposed structures on the project site are less likely to be located in the paths of most rapid fire growth and that firefighters may be more able to respond with sufficient time to engage in effective structure protection on the MGV project site.

Weather Scenario	DF Change	DF+MM Change
East Wind	29	109
West Wind	20	213

Table 16: Change in fire arrival time at buildings resulting from the DF and MM risk reduction activities. Higher numbers indicate more time for firefighters to arrive and for a safe and orderly evacuation. Numbers are in minutes.

[151] As long as the fire started off of the project site.

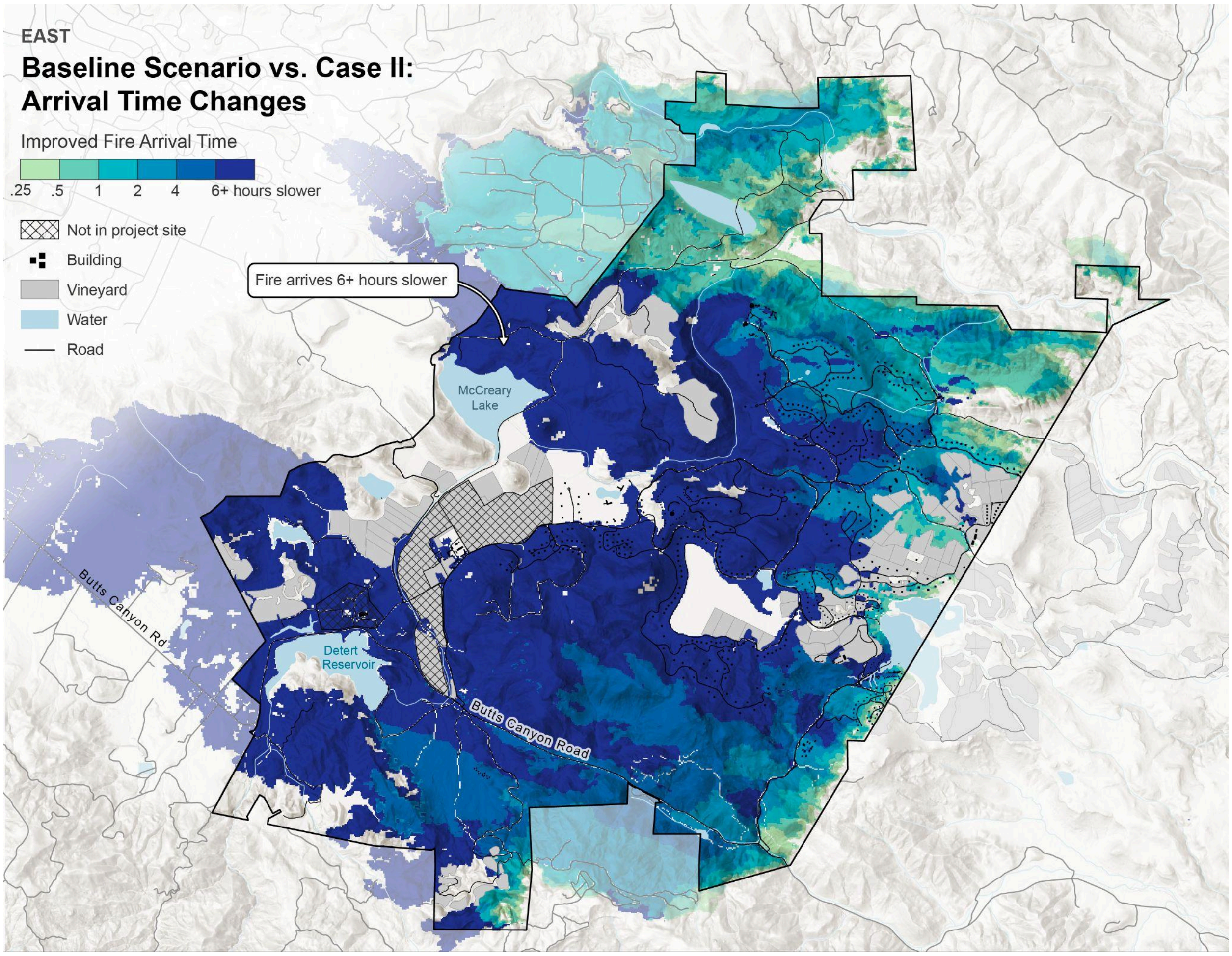


Figure 16: Changes in fire arrival time attributable to the implementation of the DF+MM risk reduction activities compared to baseline.

Although benefits are most highly concentrated on the project site, the DF+MM risk reduction activities are projected to produce ripple effects in arrival time that may positively affect the surrounding communities. As shown in Figure 16, under an east wind, the DF+MM risk reduction activities are projected to slow fire growth along several of the primary corridors of fire growth into Hidden Valley Lake, reducing arrival time at that community by at least one hour, but by perhaps as much as three hours or more, depending on weather conditions and initial ignition location. Similarly, the DF+MM may slow fire arrival time to Middletown by as much as three hours, as shown in Figure 16. Although fewer communities are located to the east of the project site, there are similar off-site benefits created by the DF+MM activities under a west wind scenario as well.

Conclusion: *The DF landscape elements slightly reduce fuel connectivity and are projected to result in a slight increase in fire arrival time to existing and proposed structures on the MGV project site. However, these elements are generally too spread out and too narrow to produce wide-ranging disruptions to fire spread. In contrast, the MM+DF risk reduction activities are* *projected to substantially reduce the capacity for fire growth across the project site, decrease the number of buildings located along fire pathways, and increase the fire arrival time at existing and proposed buildings. Increases in fire arrival time are also likely to correspond with a safer and more orderly evacuation and a greater firefighting response, both within the MGV site and in adjacent communities. For any fires passing through the site, fire pathways model outputs show significant potential increases in fire arrival time to surrounding communities as well.*

3. Conclusion

This study provides quantitative evidence that, taken together, the risk reduction activities prescribed in the MGV WPP are highly effective at mitigating wildfire behavior on and around the project site.

In particular:

- Under the worst-case-scenario fire weather conditions, the current baseline conditions are projected to produce rapid, intense, and potentially hazardous fire spread throughout the project site. A large portion of the project site is expected to support flame lengths resistant to control by ground-based firefighters and nearly half of the site is likely to produce at least isolated torching activity under the most fire-conducive weather and fuel moisture scenarios.
- The Design Features are projected to slightly decrease fire activity and may create minor obstacles for fire spread. However, because these features are very localized (e.g. irrigated landscaping around buildings), these changes are relatively small site-wide - on the order of 1-5% reductions for most key indicators. Implemented alone, these measures may create an additional 20-30 minutes for evacuation and firefighter response at existing and proposed buildings.
- The Design Features in combination with the Mitigation Measures are projected to result in much larger decreases in fire behavior. These activities, which substantially alter the surface and canopy fuel layers, are projected to reduce the average fire intensity across the site by over 50%, expand the areas available for firefighters to successfully engage the fire, and reduce the rate of spread and likelihood of transition into the canopy. Moreover, these activities are projected to substantially increase the time of fire arrival to existing and proposed buildings on the site and in adjacent communities.
- The combined defensible space (MM) and irrigated landscaping (DF) around proposed buildings is a robust combination of risk reduction activities that is projected to significantly decrease fire behavior adjacent to proposed structures. Across indicators evaluated in this study, the area within 100’ of buildings shows the greatest decrease in projected fire behavior under the DF and DF+MM scenarios. Once implemented, these structures are likely to be directly exposed to only mild fire behavior. Furthermore, changes in fire behavior are expected to create safer and more effective working conditions for firefighters defending these structures.
- Due to the technical limitations of industry-standard fire behavior modeling tools, only a subset of the design features and mitigation measures specified in the MGV WPP were

included in this study. Decreases in potential fire behavior indicators and increases in fire arrival time are most meaningful in the context of the robust and multi-dimensional wildfire mitigation strategies described in the WPP, including rapid fire response, efficient and orderly evacuation of residents and guests, and ongoing maintenance of vegetation management and roadside clearance. The results of this study should be interpreted only in the context of the larger WPP strategy.

Appendix W.1.A: Map Book

East Scenario

1. Unmodified Scenario - Flame Length
2. Unmodified Scenario - Rate of Spread
3. Unmodified Scenario - Crown Activity
4. Unmodified Scenario - Spotting Distance
5. Case I: Flame Length
6. Case I: Rate of Spread
7. Case I: Crown Activity
8. Case I: Spotting Distance
9. Case II: Flame Length
10. Case II: Rate of Spread
11. Case II: Crown Activity
12. Case II: Spotting Distance
13. Unmodified Scenario vs. Case I: Flame Length Delta
14. Unmodified Scenario vs. Case I: Rate of Spread Delta
15. Unmodified Scenario vs. Case I: Crown Activity Delta
16. Unmodified Scenario vs. Case I: Spotting Distance Delta
17. Unmodified Scenario vs. Case II: Flame Length Delta
18. Unmodified Scenario vs. Case II: Rate of Spread Delta
19. Unmodified Scenario vs. Case II: Crown Activity Delta
20. Unmodified Scenario vs. Case II: Spotting Distance Delta
21. Unmodified Scenario: Fire Pathways
22. Case I: Fire Pathways

23. Case II: Fire Pathways
24. Unmodified Scenario vs. Case I: Arrival Time Changes
25. Unmodified Scenario vs. Case II: Arrival Time Changes

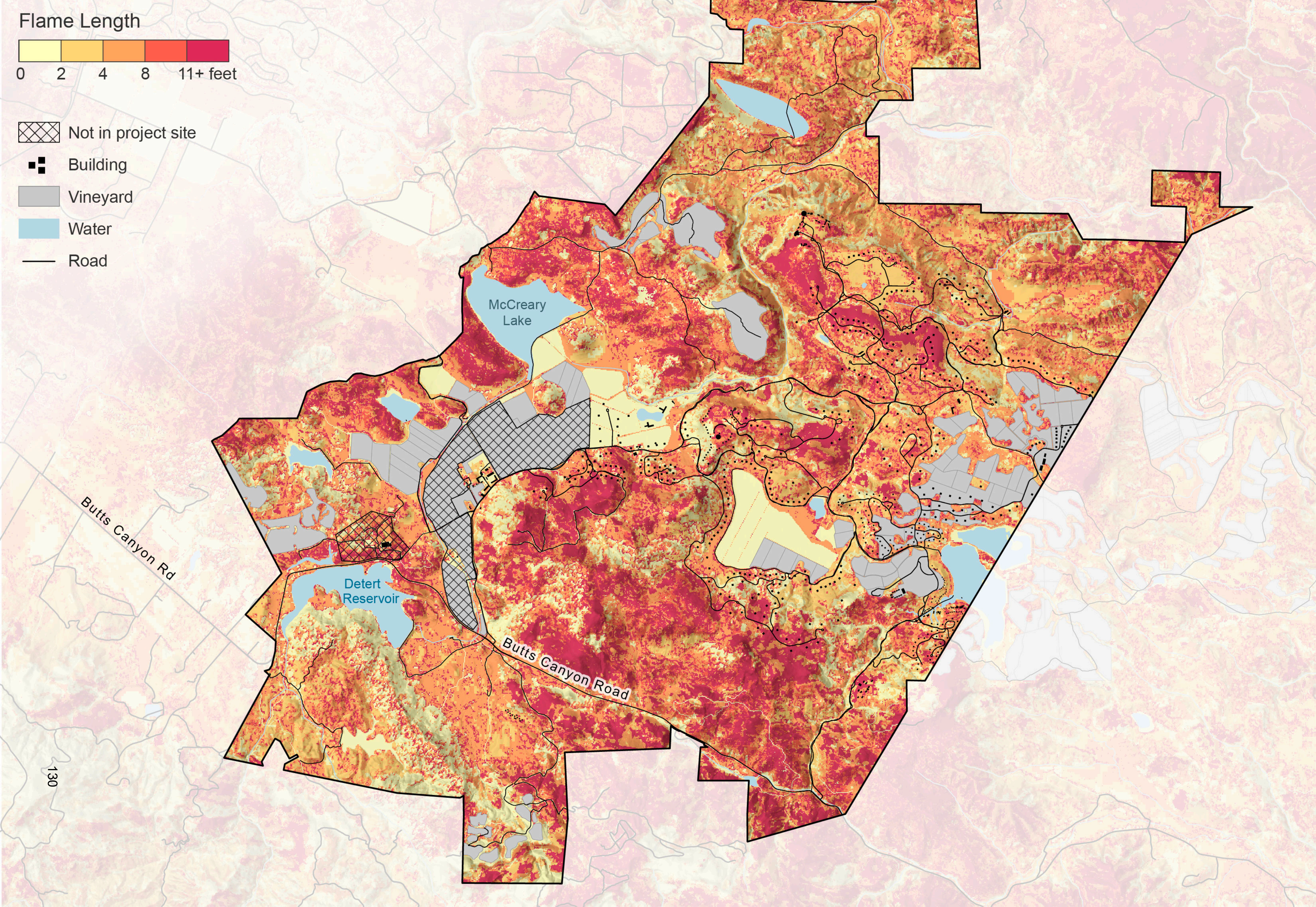
West Scenario

26. Unmodified Scenario - Flame Length
27. Unmodified Scenario - Rate of Spread
28. Unmodified Scenario - Crown Activity
29. Unmodified Scenario - Spotting Distance
30. Case I: Flame Length
31. Case I: Rate of Spread
32. Case I: Crown Activity
33. Case I: Spotting Distance
34. Case II: Flame Length
35. Case II: Rate of Spread
36. Case II: Crown Activity
37. Case II: Spotting Distance
38. Unmodified Scenario vs. Case I: Flame Length Delta
39. Unmodified Scenario vs. Case I: Rate of Spread Delta
40. Unmodified Scenario vs. Case I: Crown Activity Delta
41. Unmodified Scenario vs. Case I: Spotting Distance Delta
42. Unmodified Scenario vs. Case II: Flame Length Delta
43. Unmodified Scenario vs. Case II: Rate of Spread Delta
44. Unmodified Scenario vs. Case II: Crown Activity Delta
45. Unmodified Scenario vs. Case II: Spotting Distance Delta

46. Unmodified Scenario: Fire Pathways
47. Case I: Fire Pathways
48. Case II: Fire Pathways
49. Unmodified Scenario vs. Case I: Arrival Time Changes
50. Unmodified Scenario vs. Case II: Arrival Time Changes

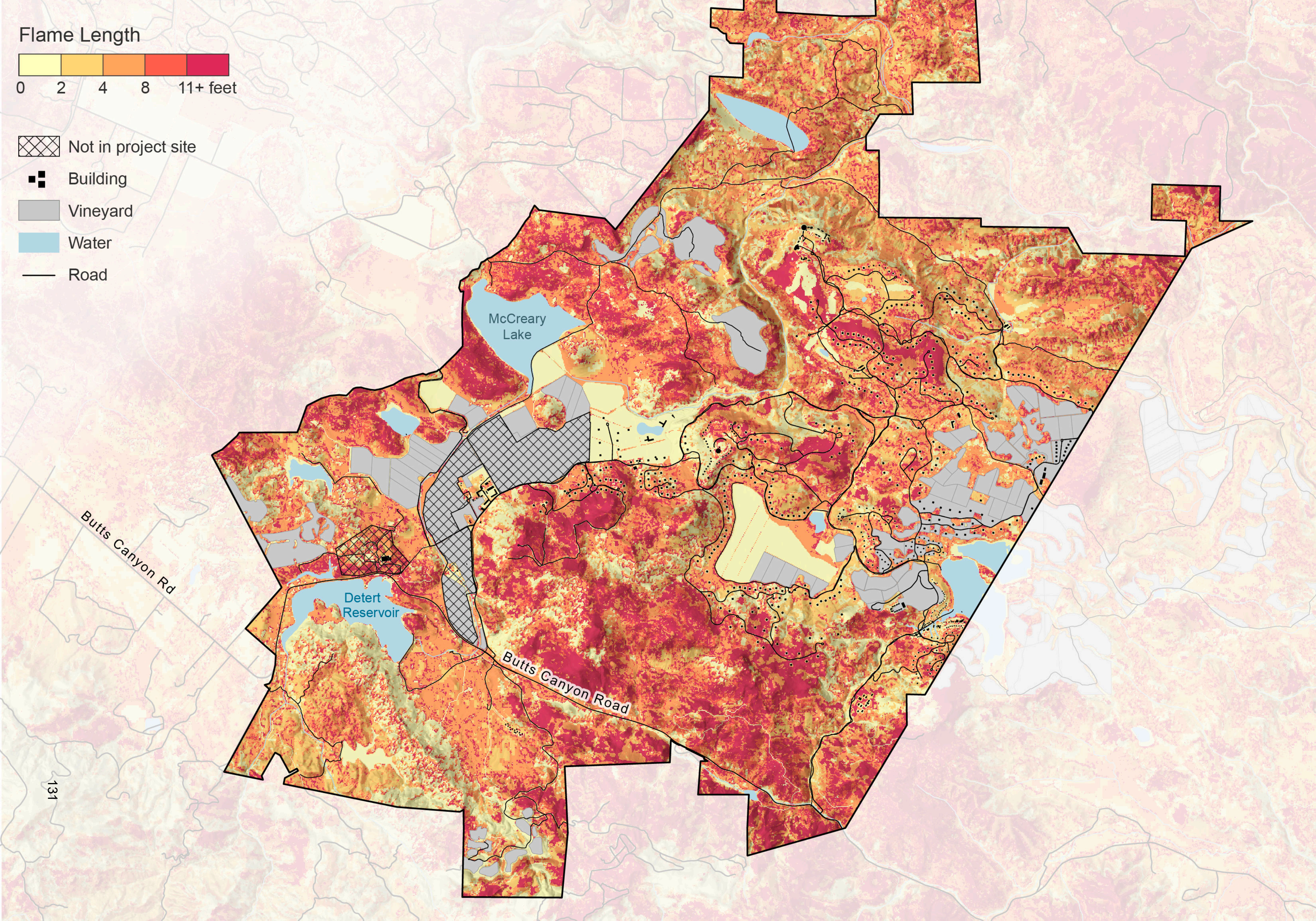
EAST

Baseline Scenario - Flame Length



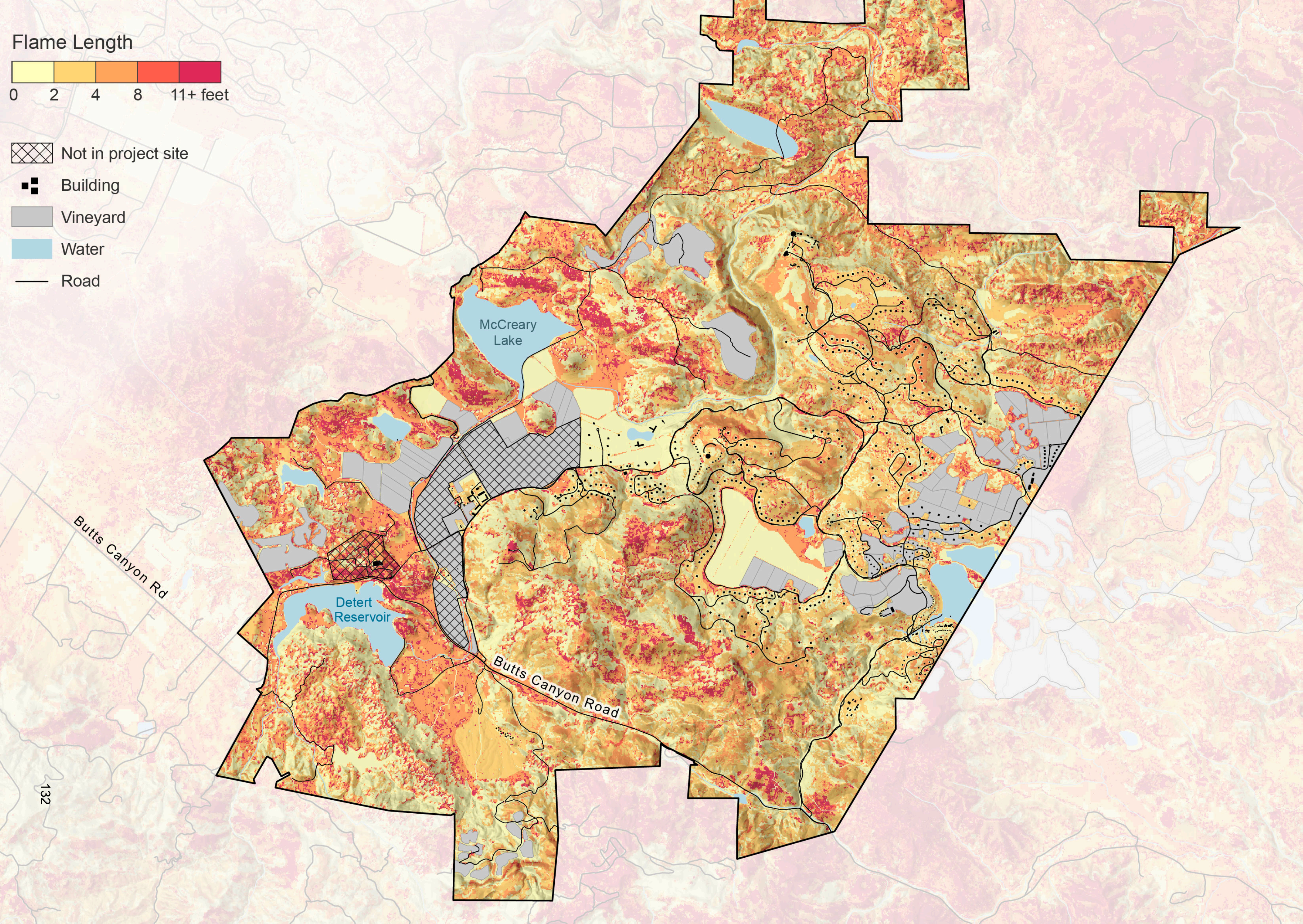
EAST

Case I: Flame Length



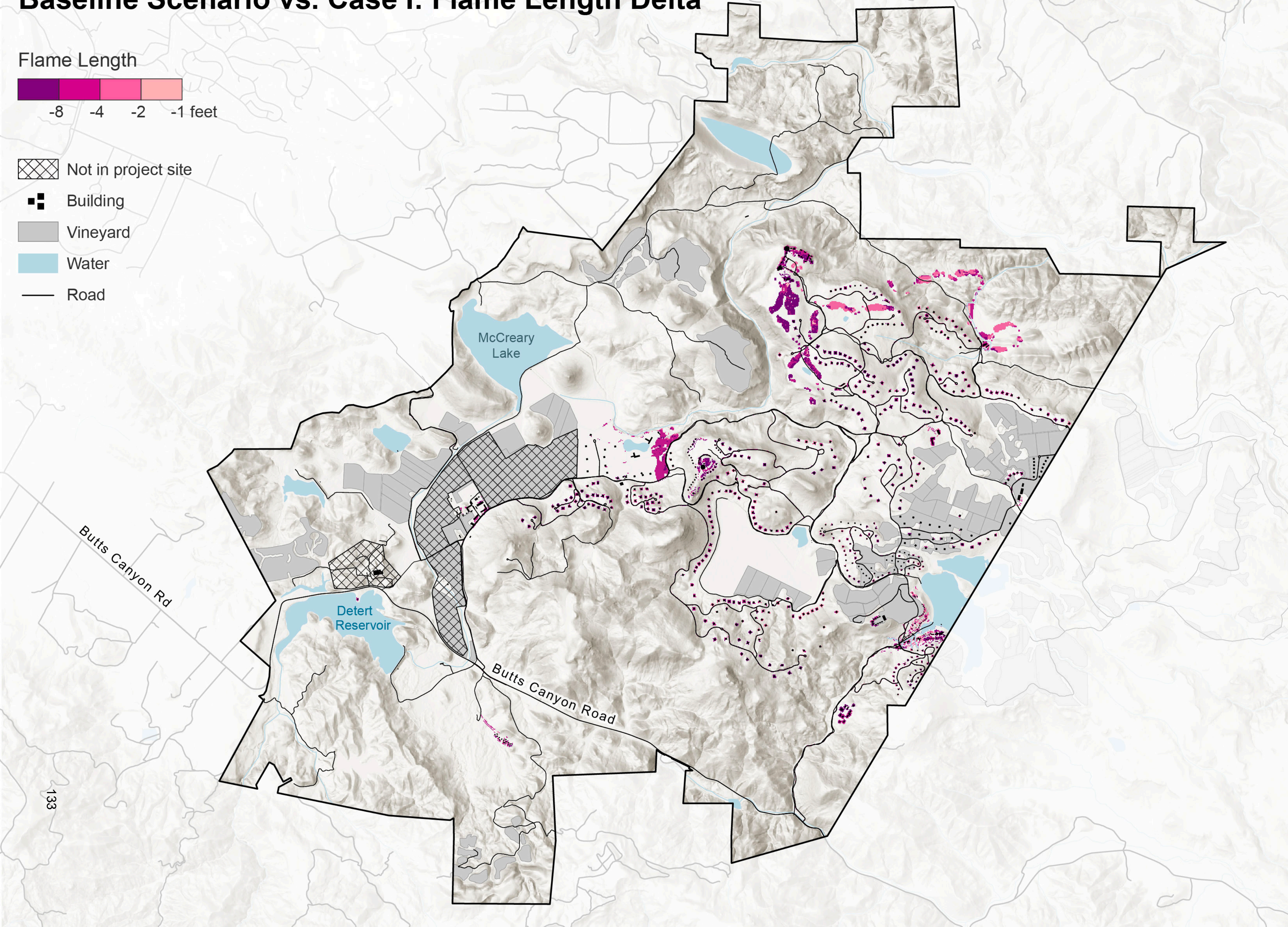
EAST

Case II: Flame Length



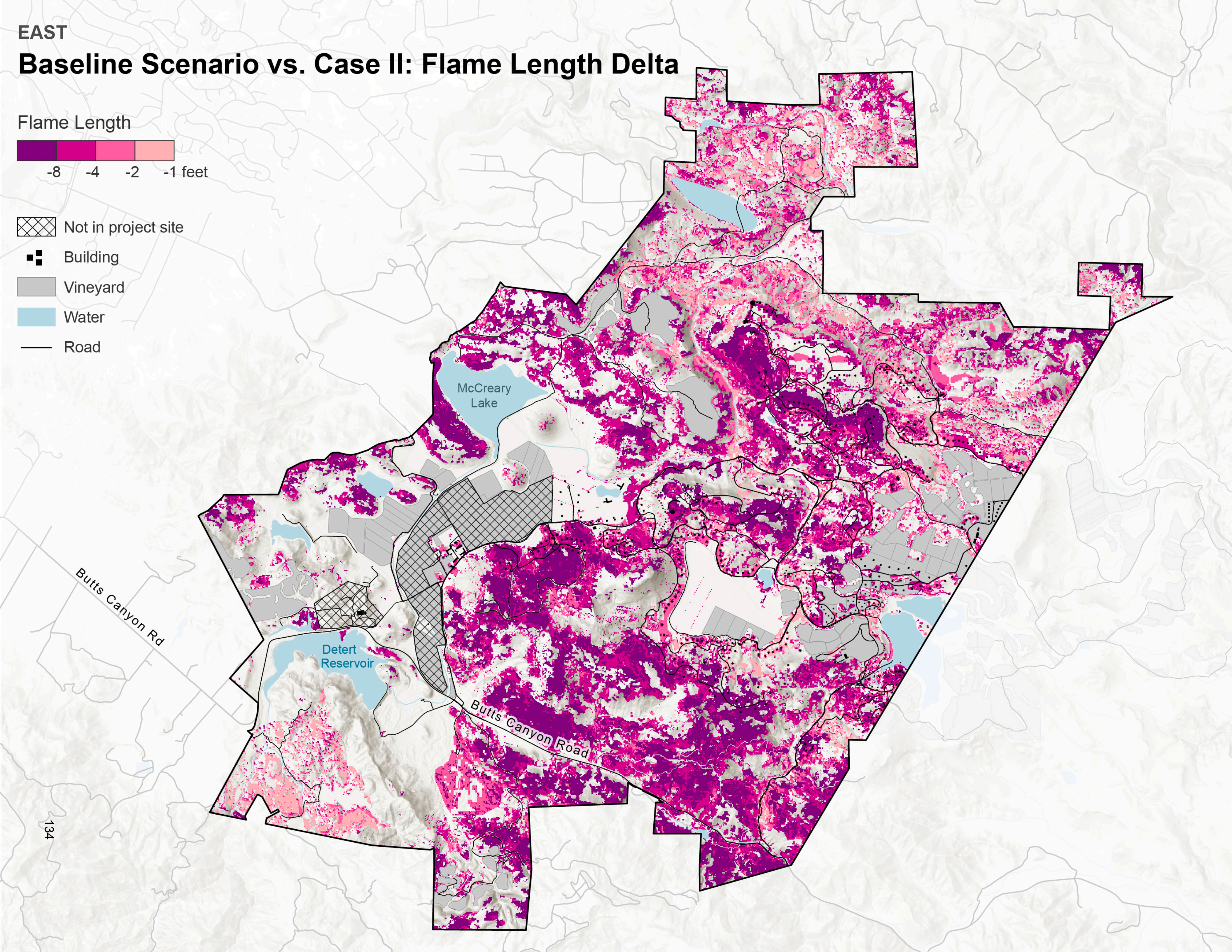
EAST

Baseline Scenario vs. Case I: Flame Length Delta



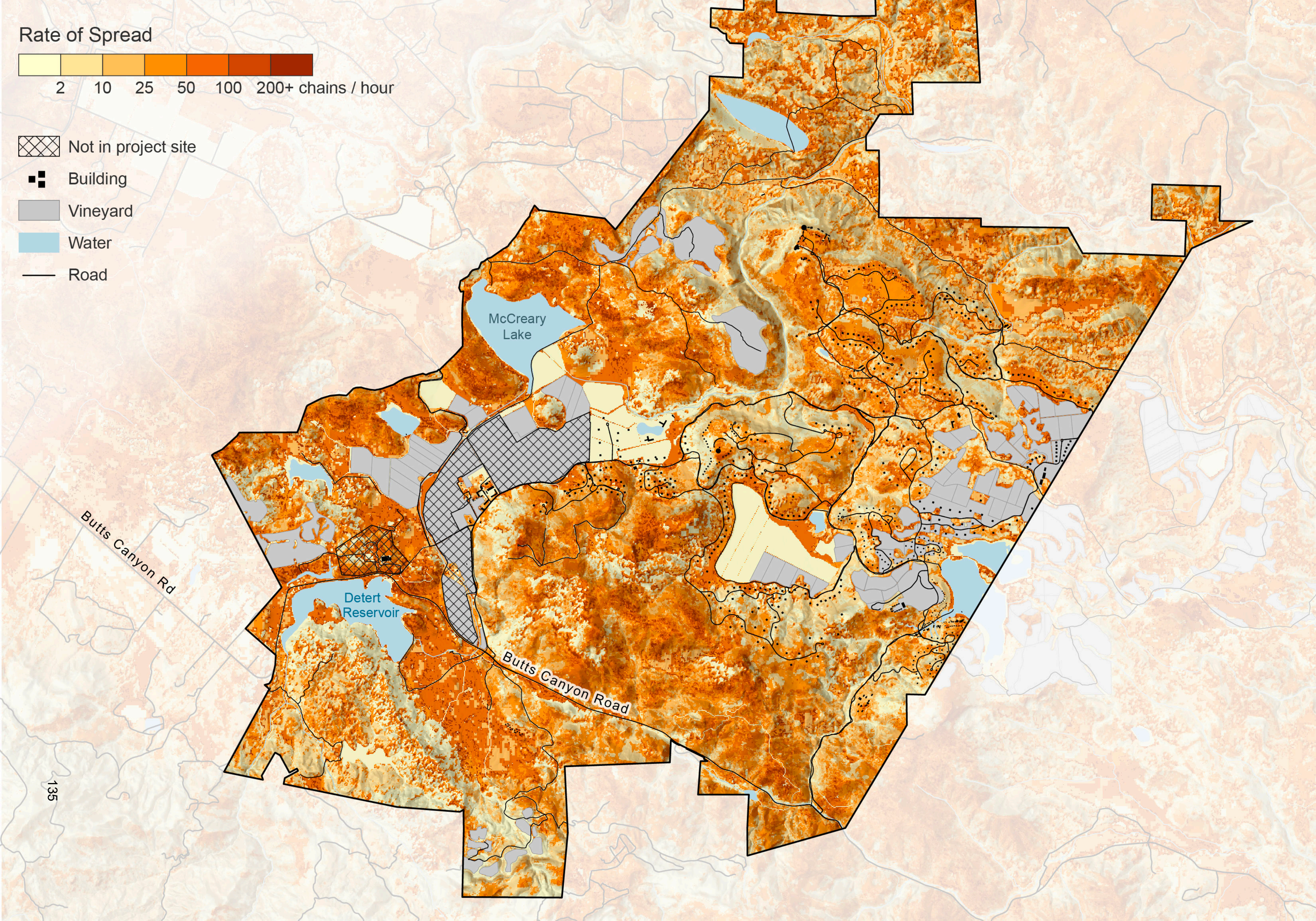
EAST

Baseline Scenario vs. Case II: Flame Length Delta



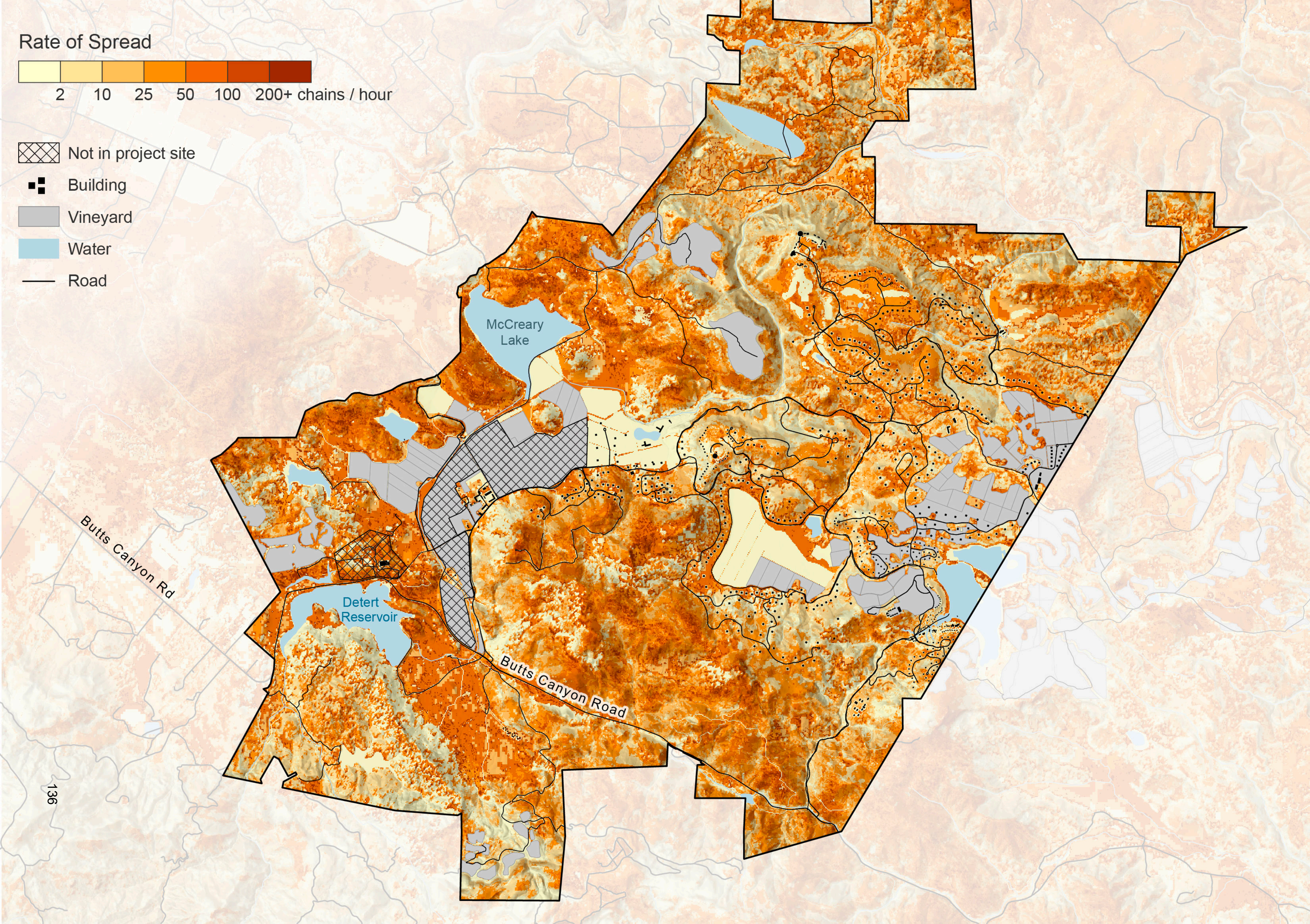
EAST

Baseline Scenario - Rate of Spread



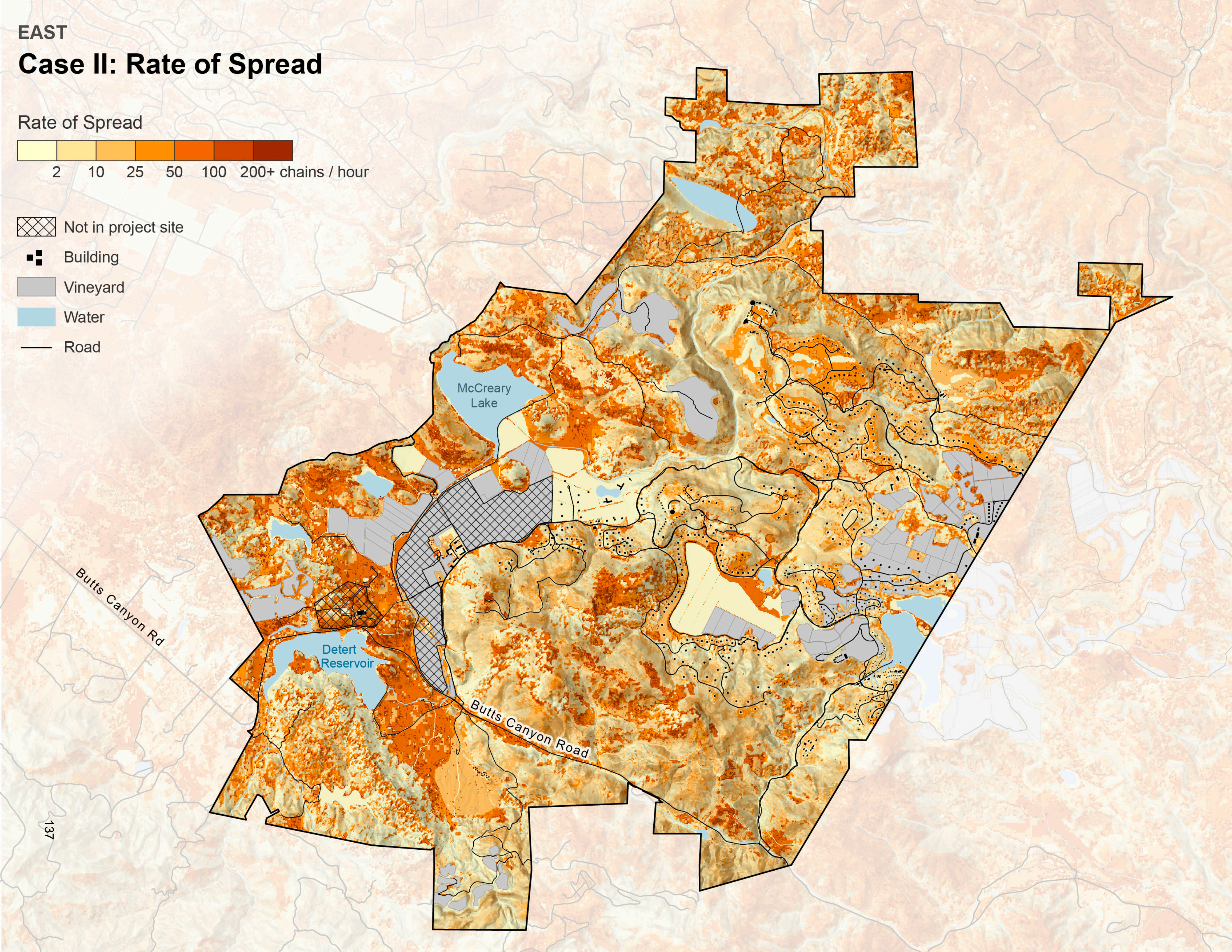
EAST

Case I: Rate of Spread



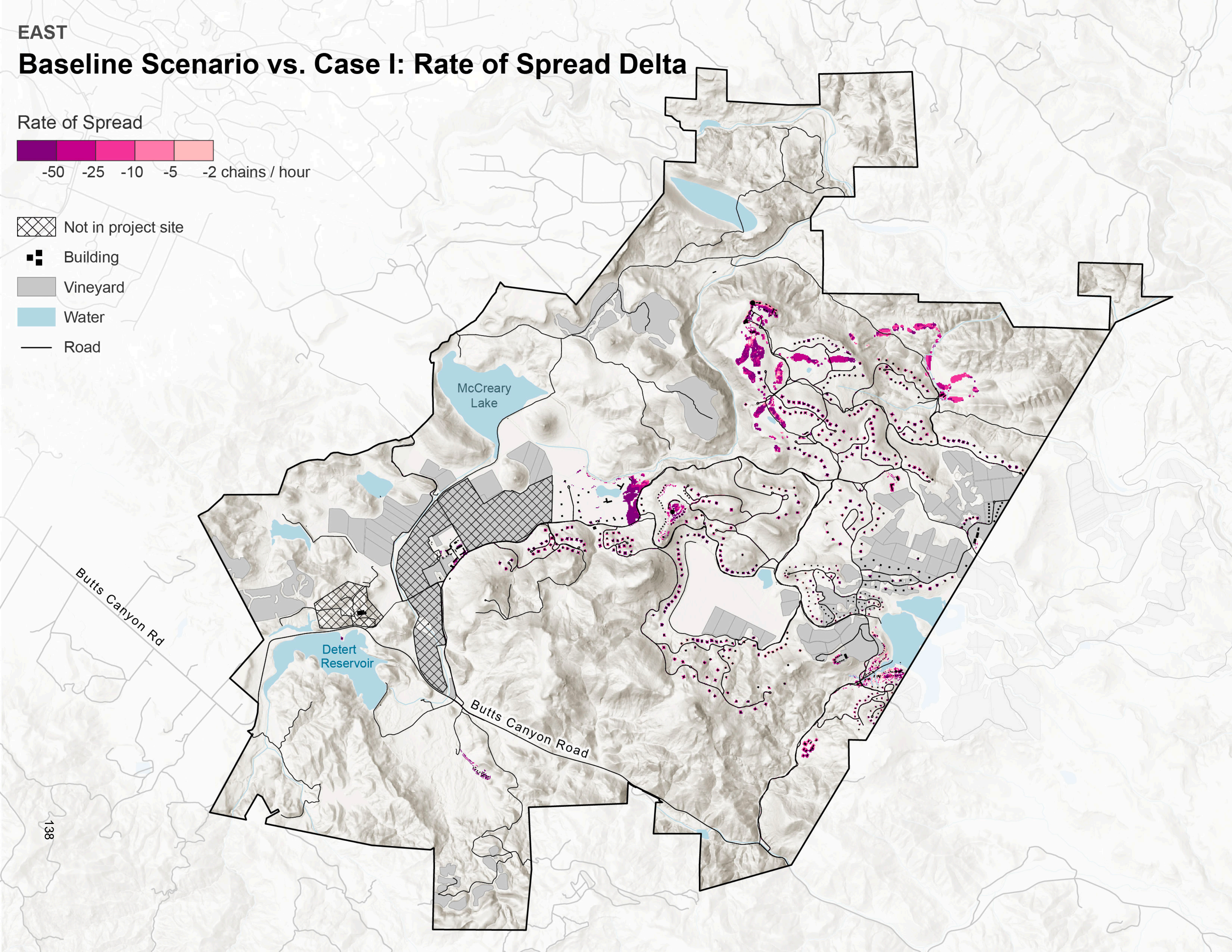
EAST

Case II: Rate of Spread



EAST

Baseline Scenario vs. Case I: Rate of Spread Delta



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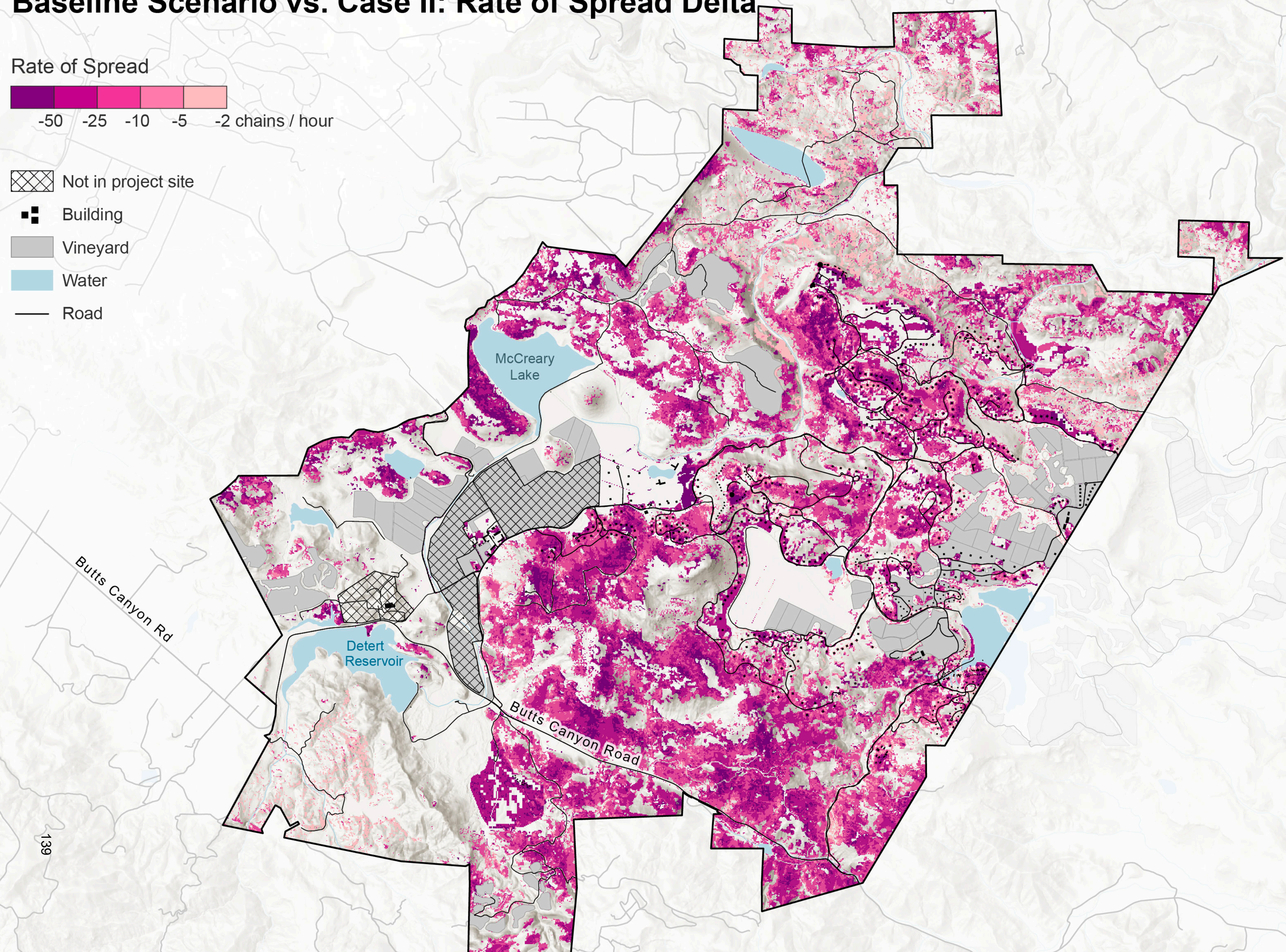
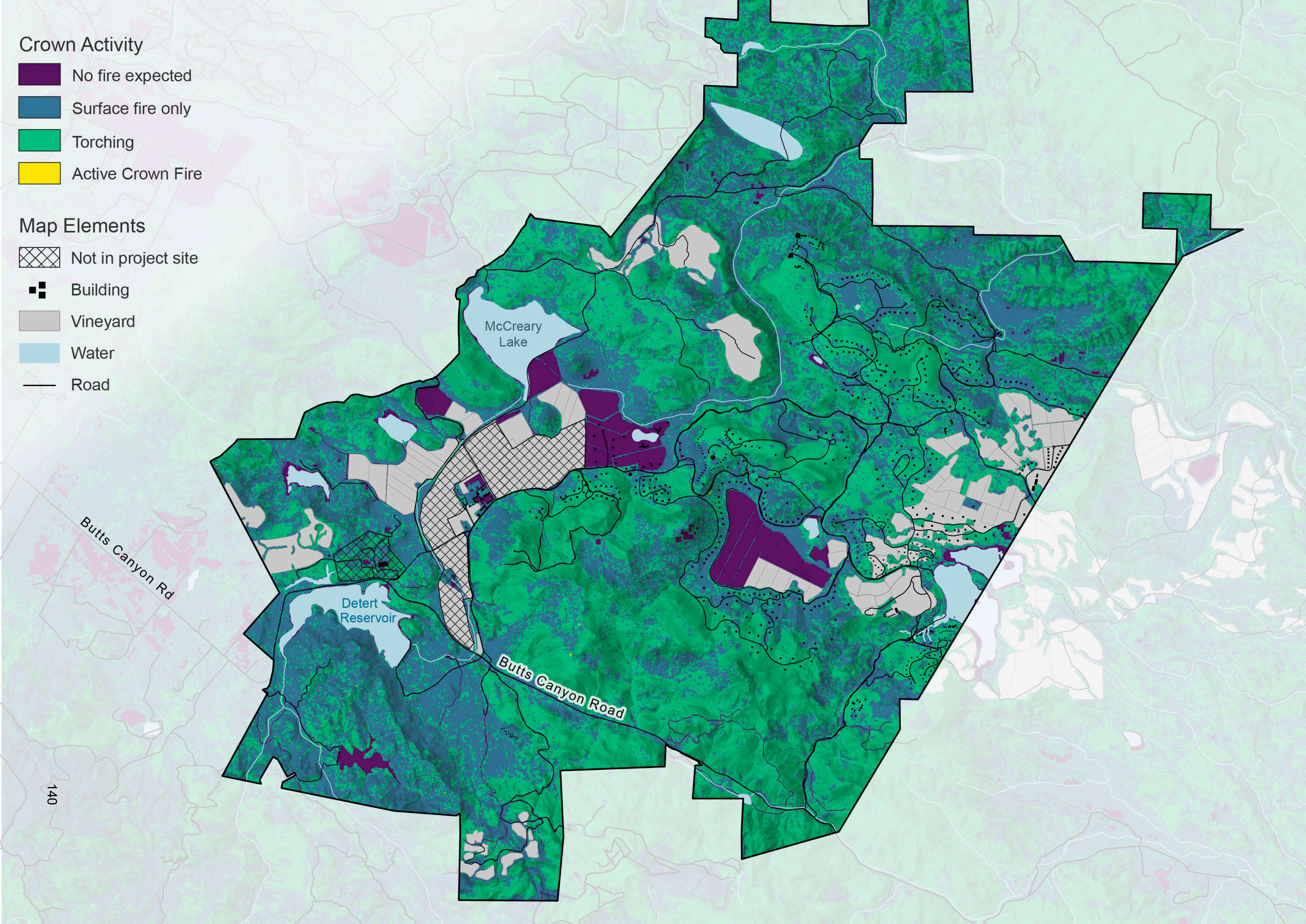
Baseline Scenario vs. Case II: Rate of Spread Delta



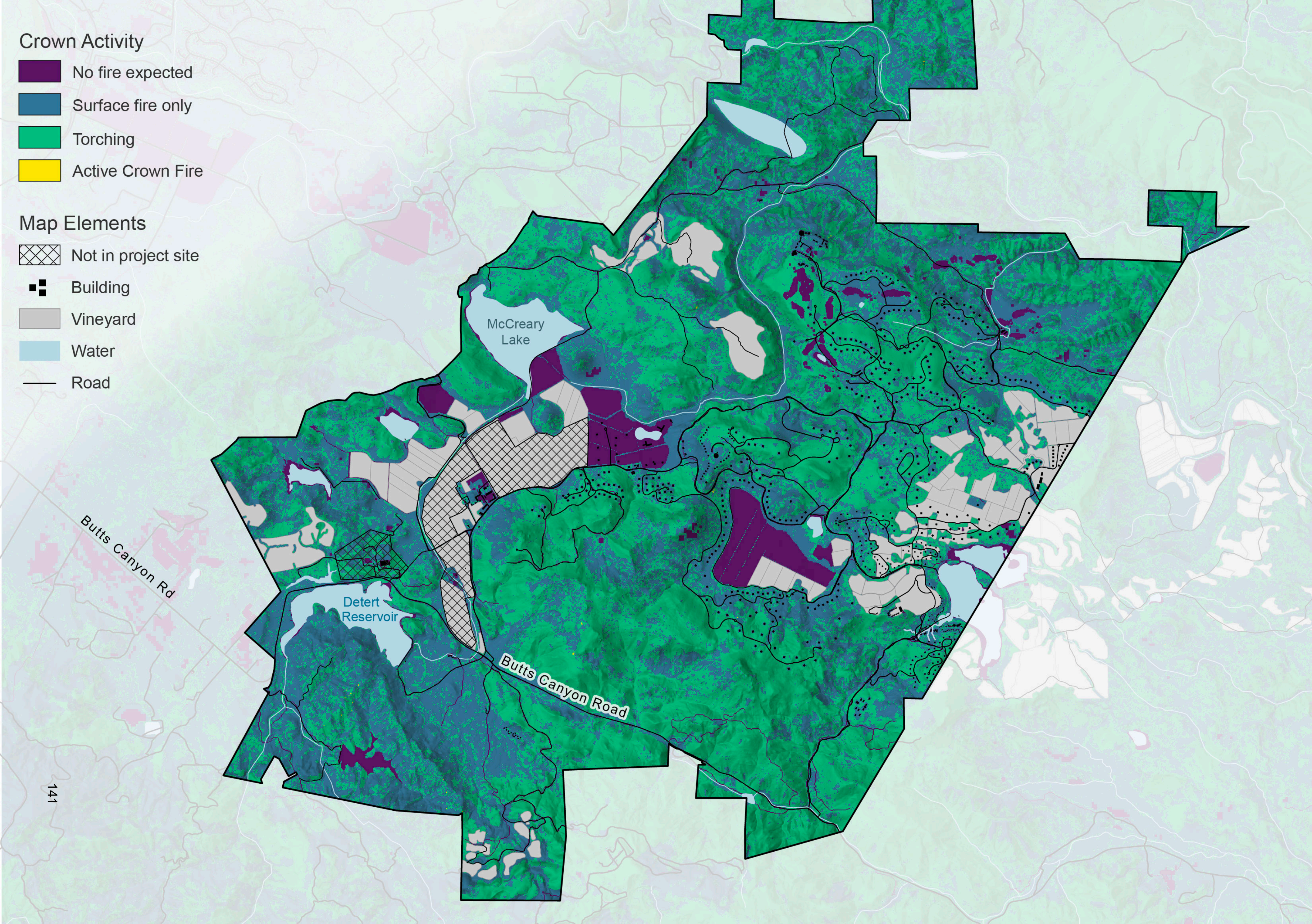
EAST

Baseline Scenario - Crown Activity



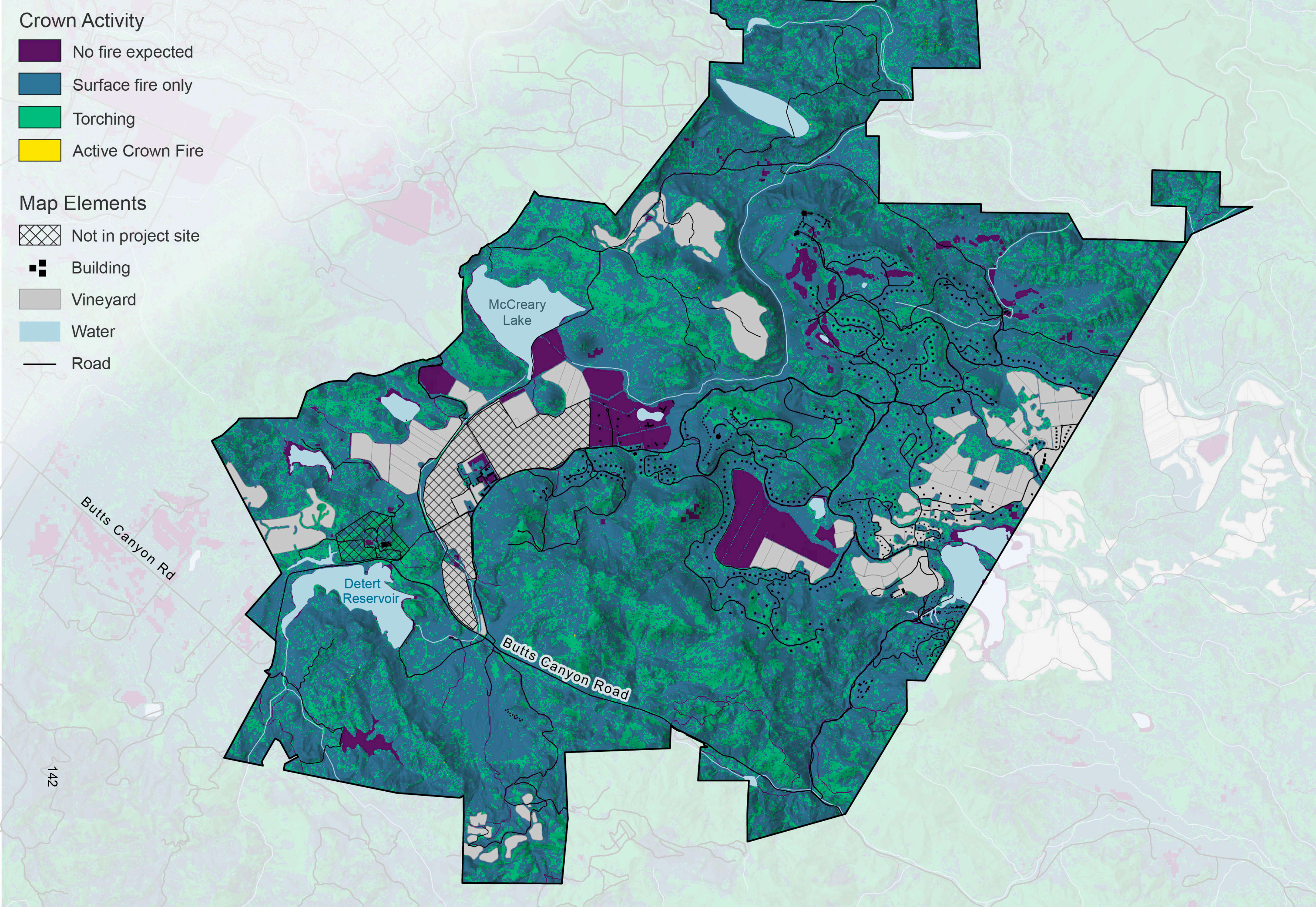
EAST

Case I: Crown Activity



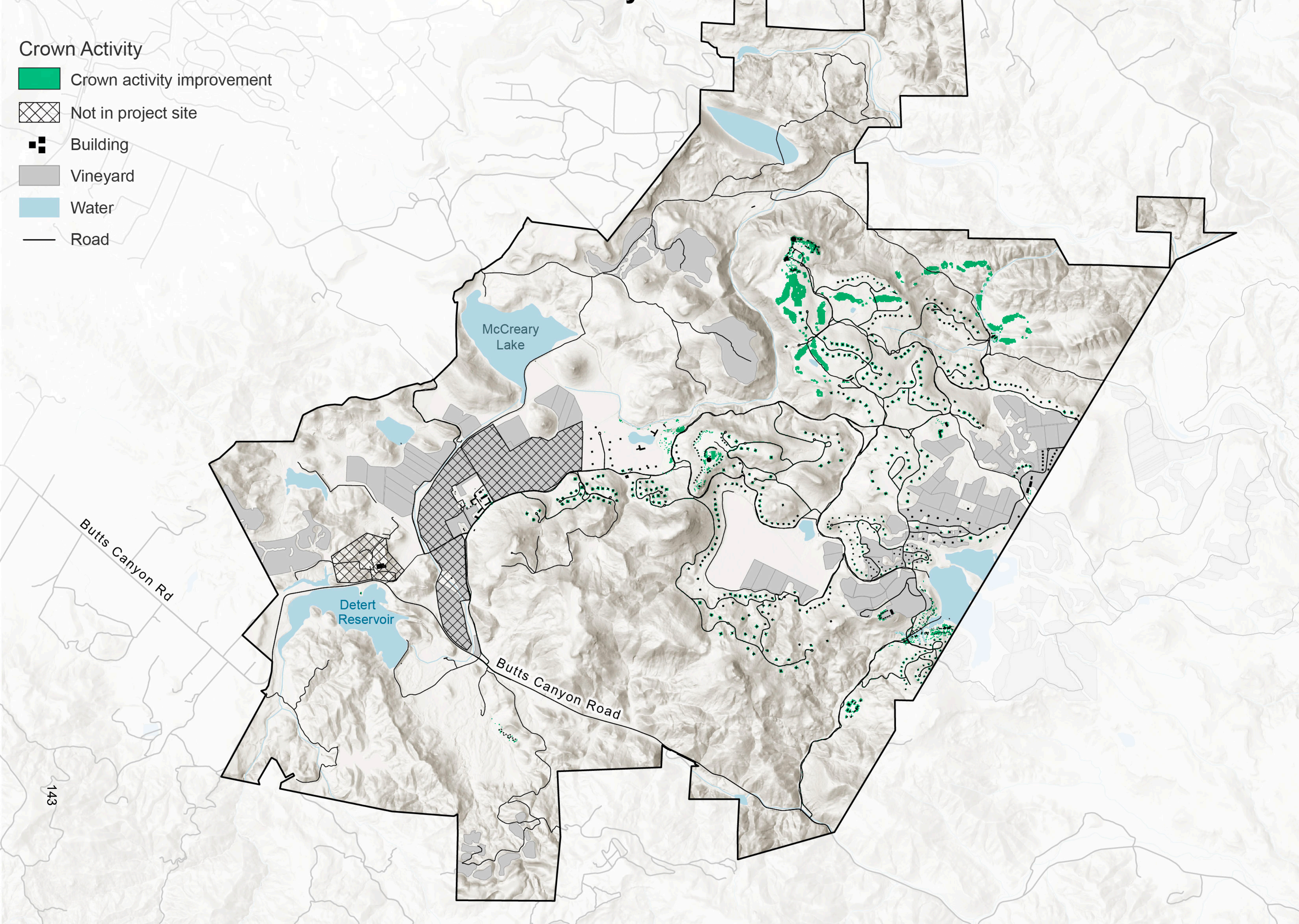
EAST

Case II: Crown Activity



EAST

Baseline Scenario vs. Case I: Crown Activity Delta



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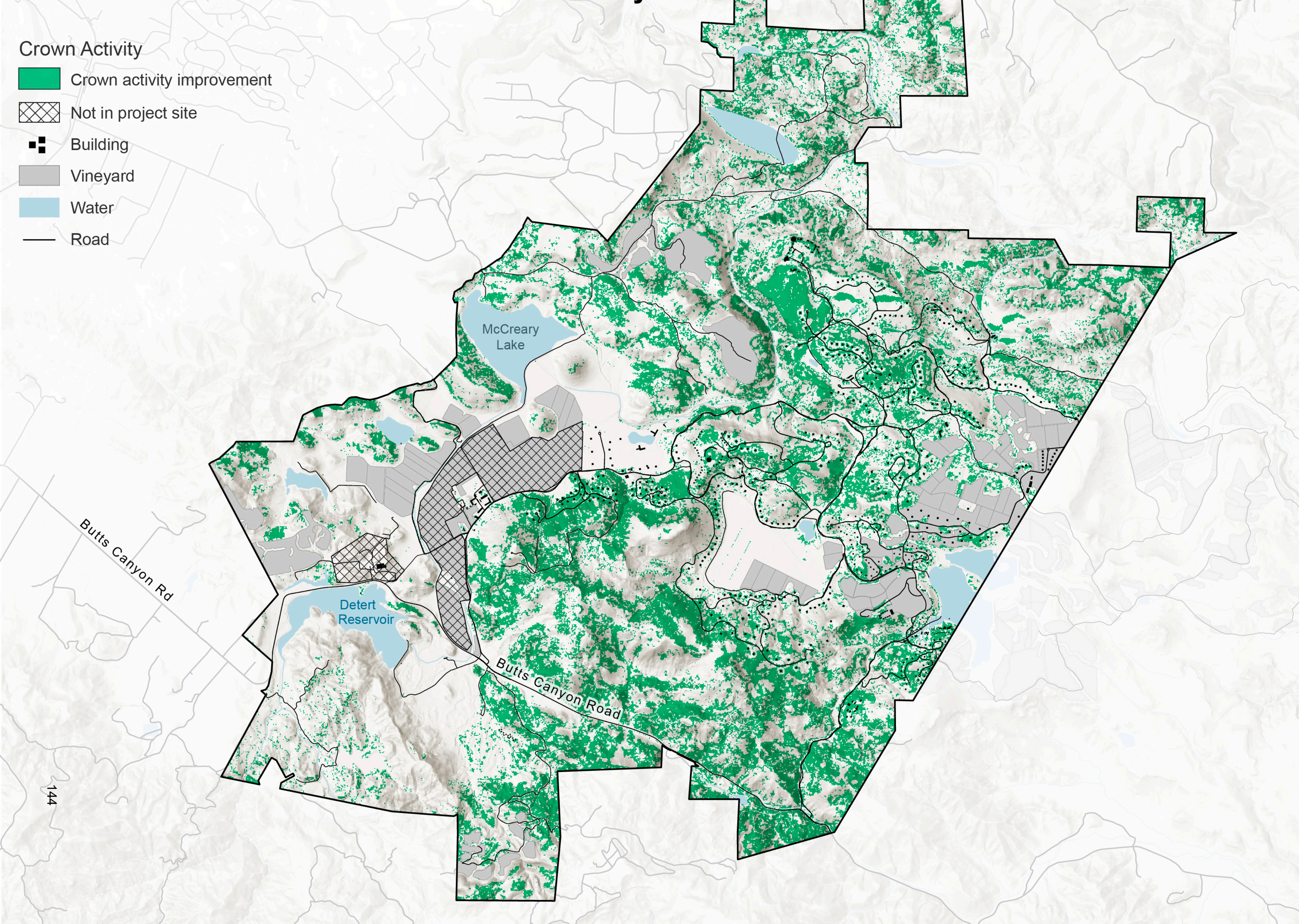
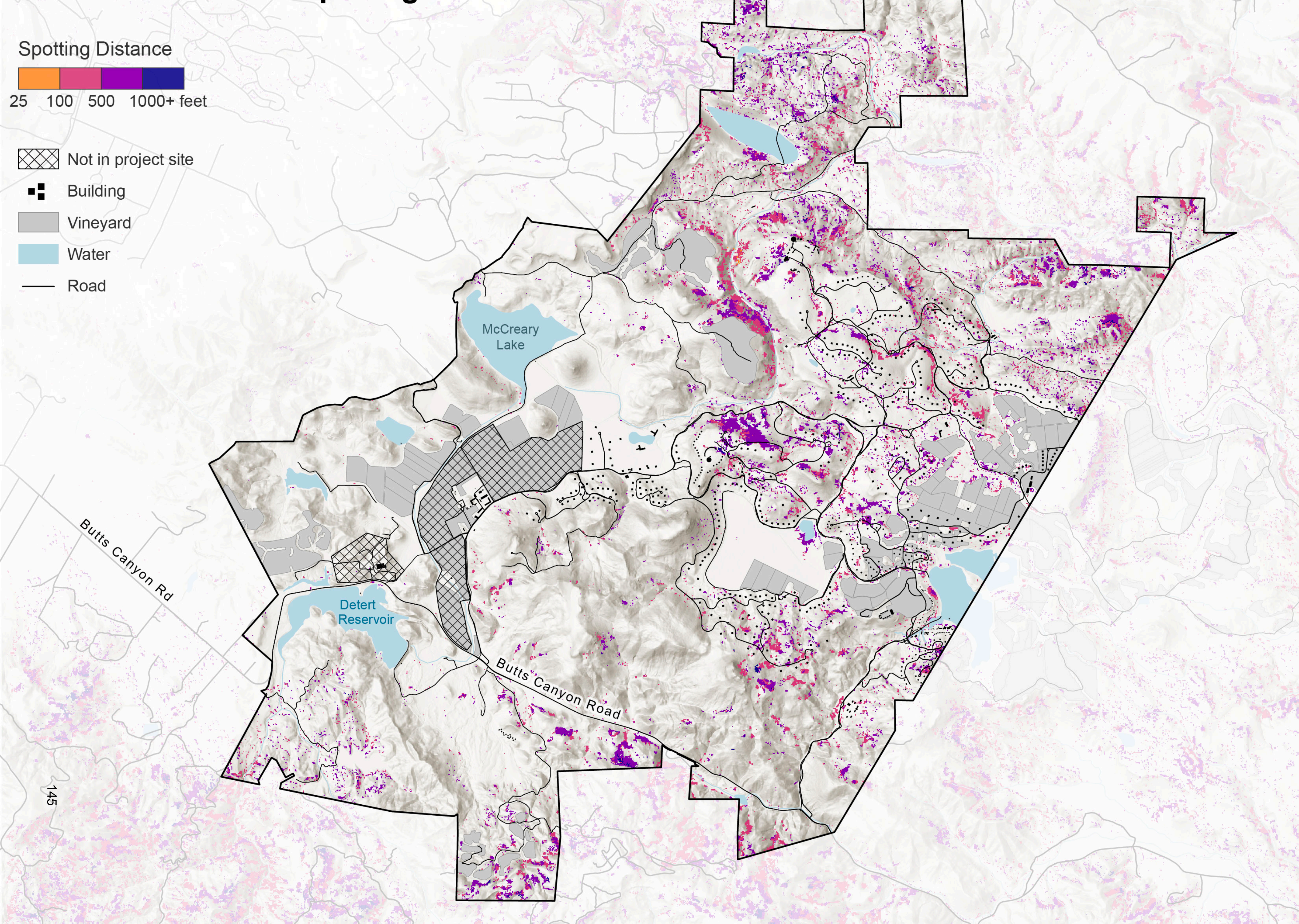
Baseline Scenario vs. Case II: Crown Activity Delta



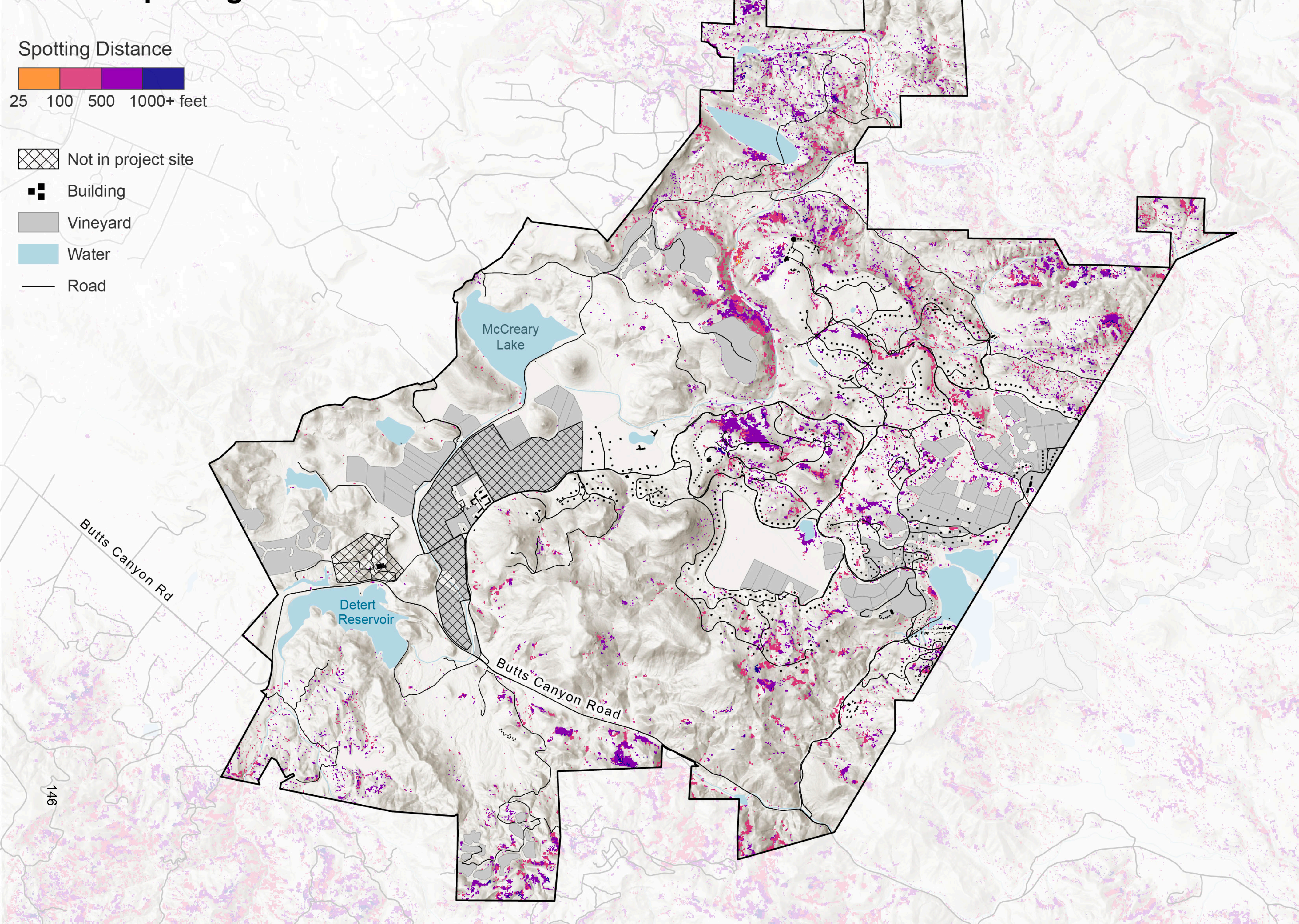
EAST

Baseline Scenario - Spotting Distance



EAST

Case I: Spotting Distance



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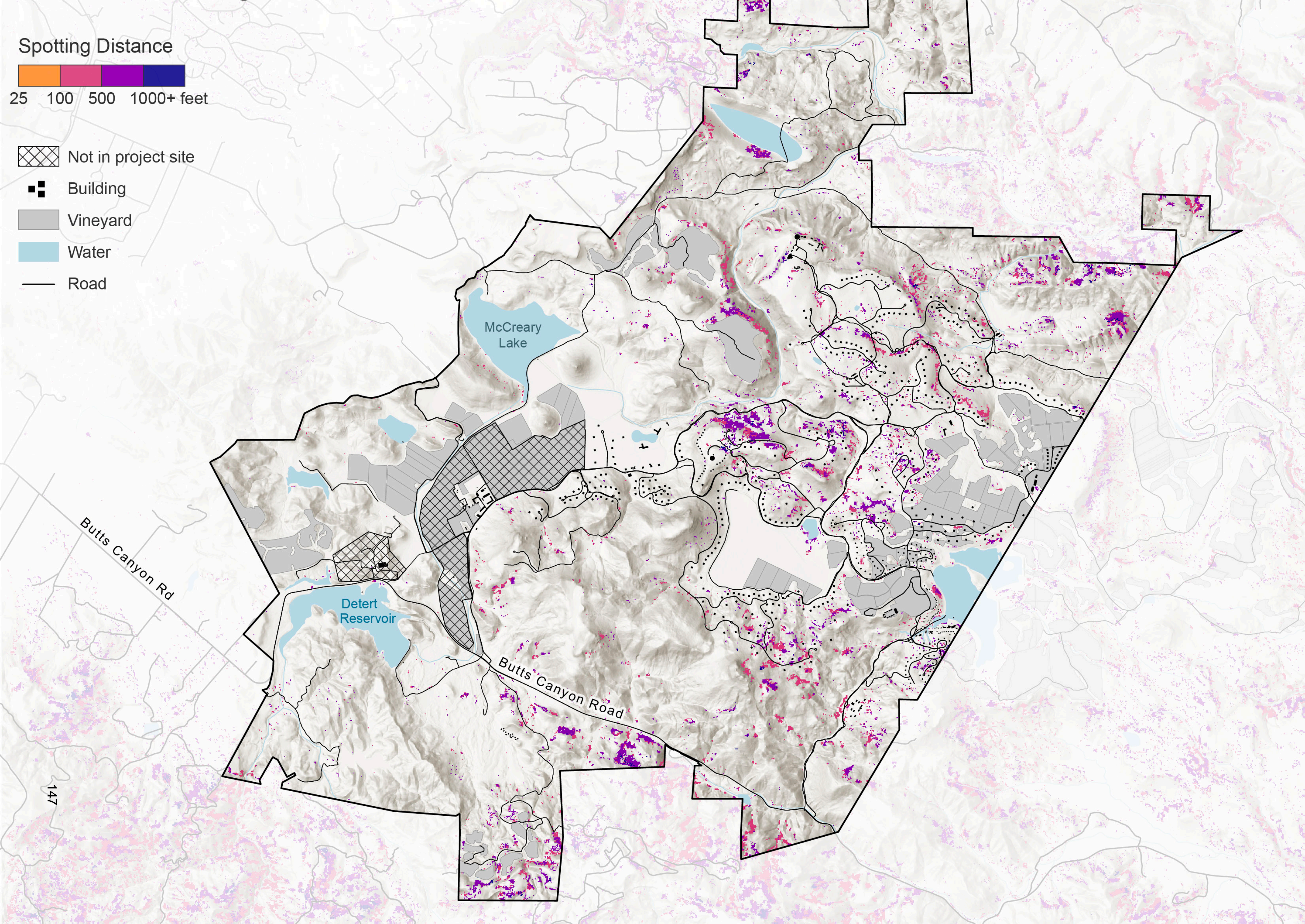
Case II: Spotting Distance

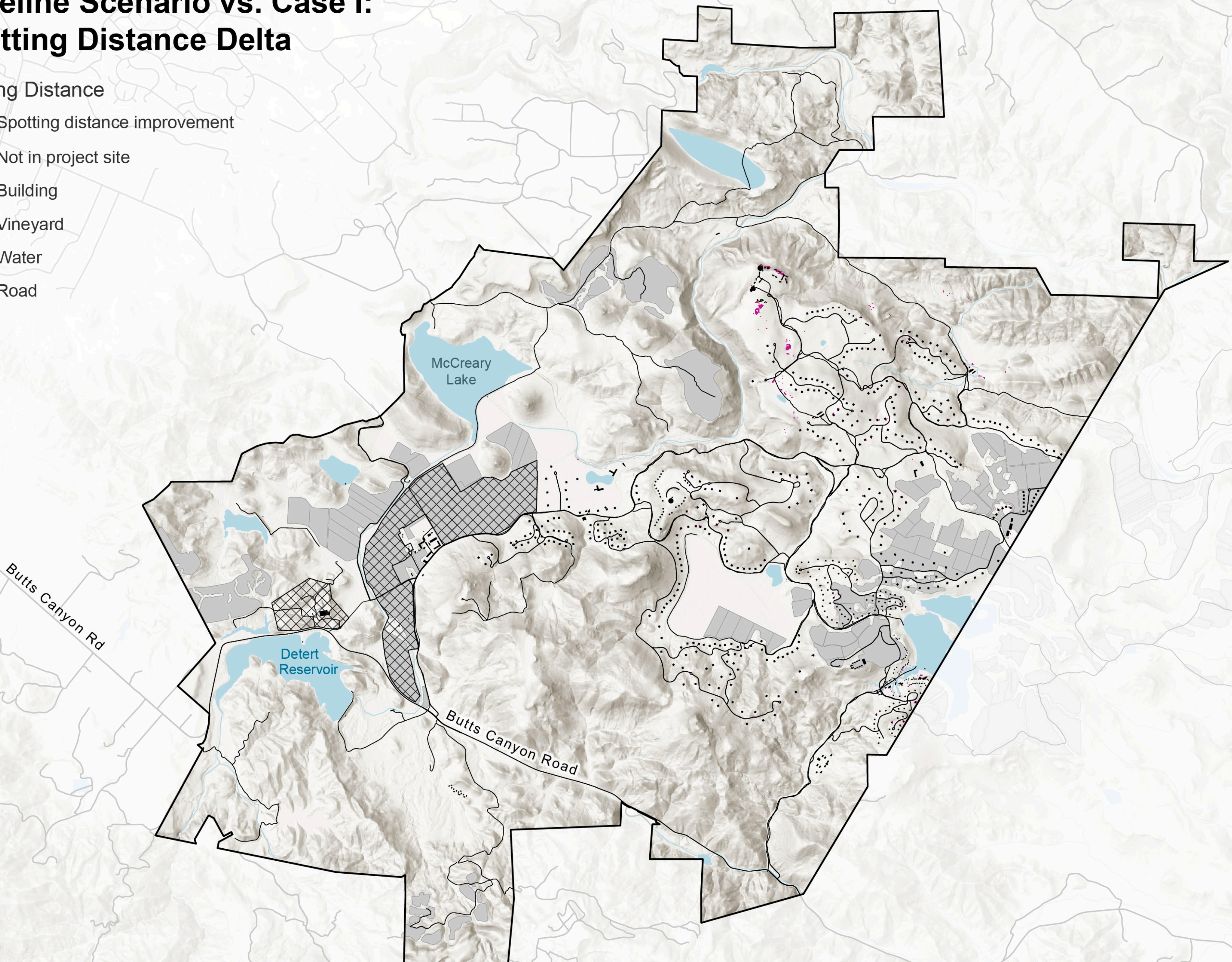


EAST

Baseline Scenario vs. Case I: Spotting Distance Delta

Spotting Distance

- Spotting distance improvement
- Not in project site
- Building
- Vineyard
- Water
- Road



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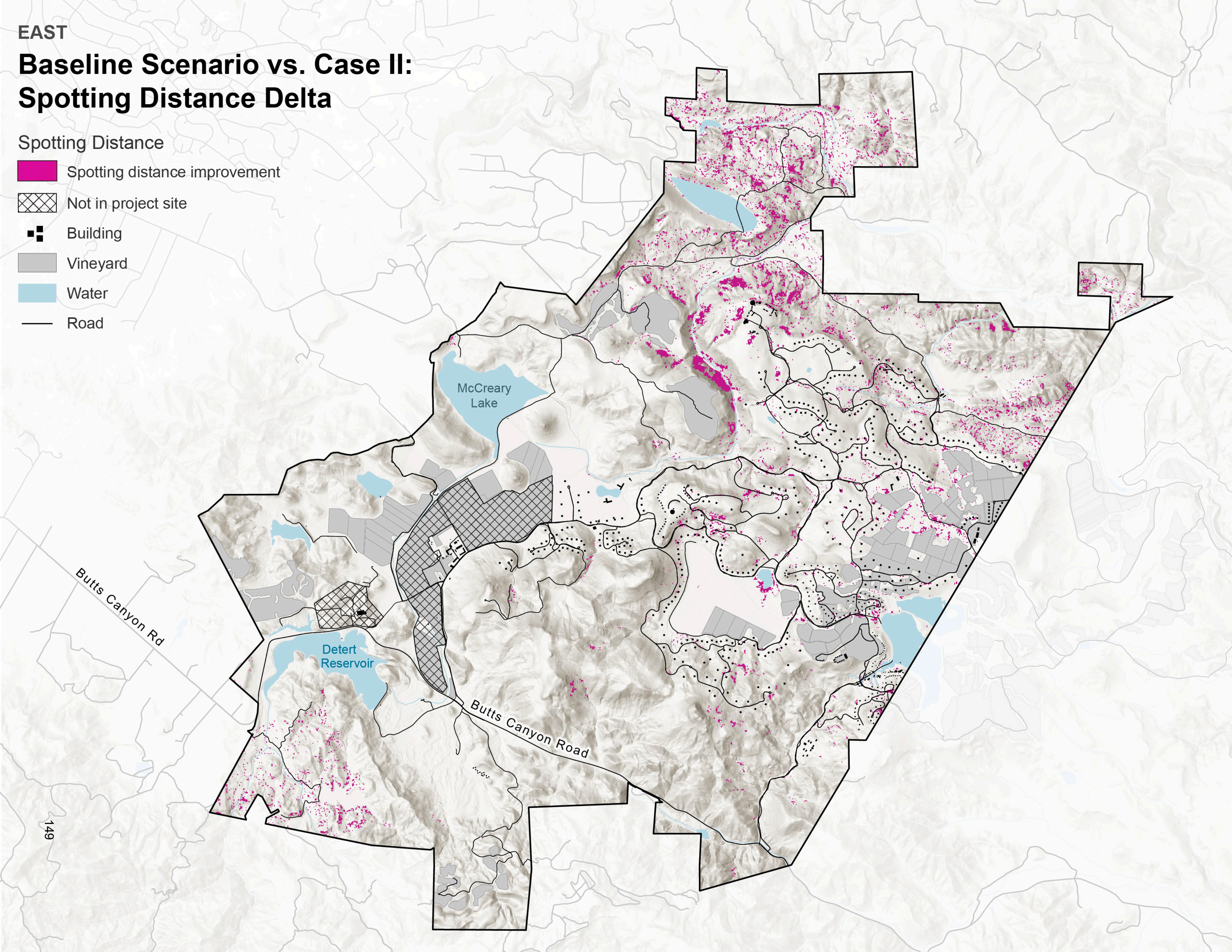
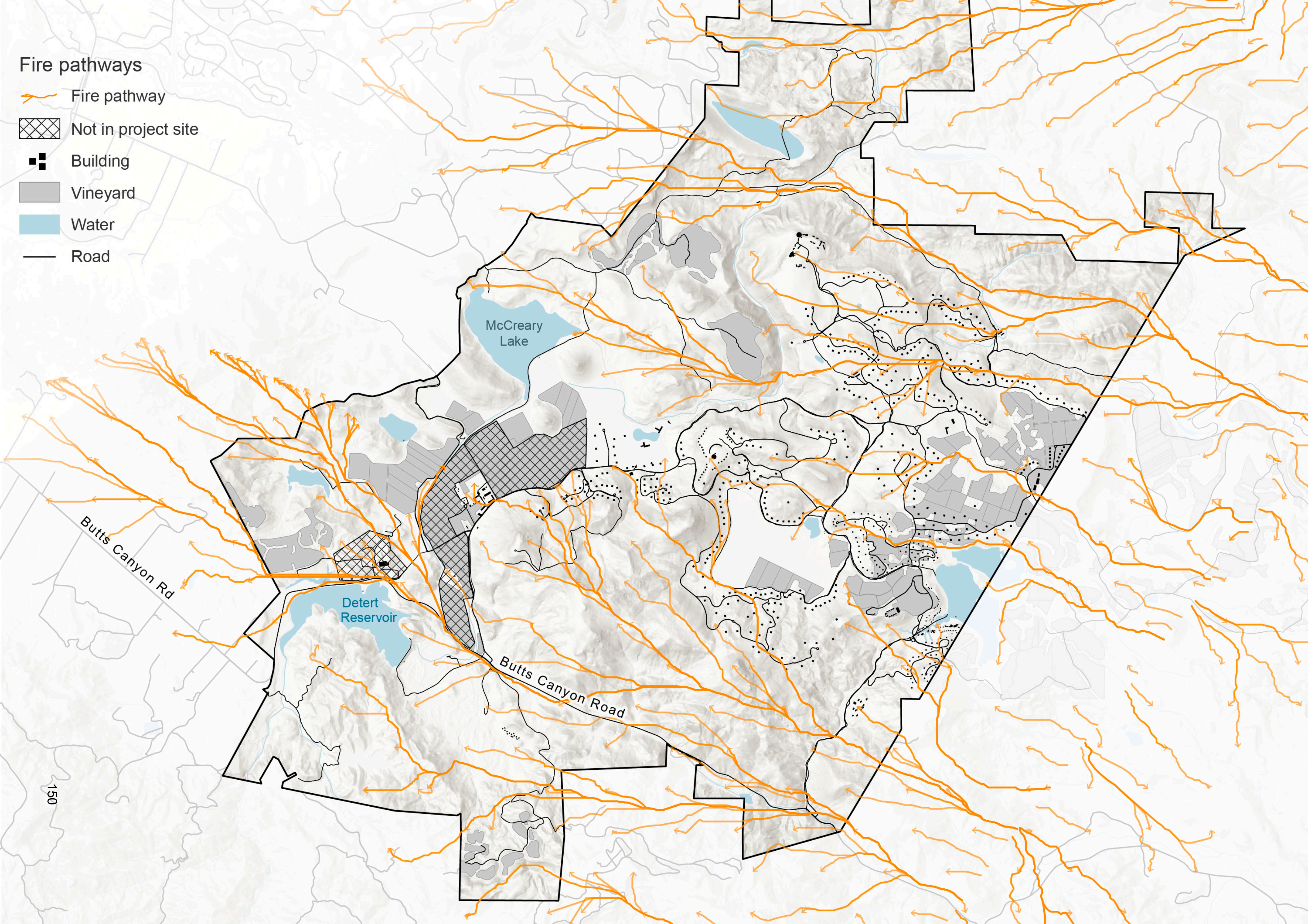
Baseline Scenario vs. Case II: Spotting Distance Delta



EAST

Baseline Scenario: Fire Pathways



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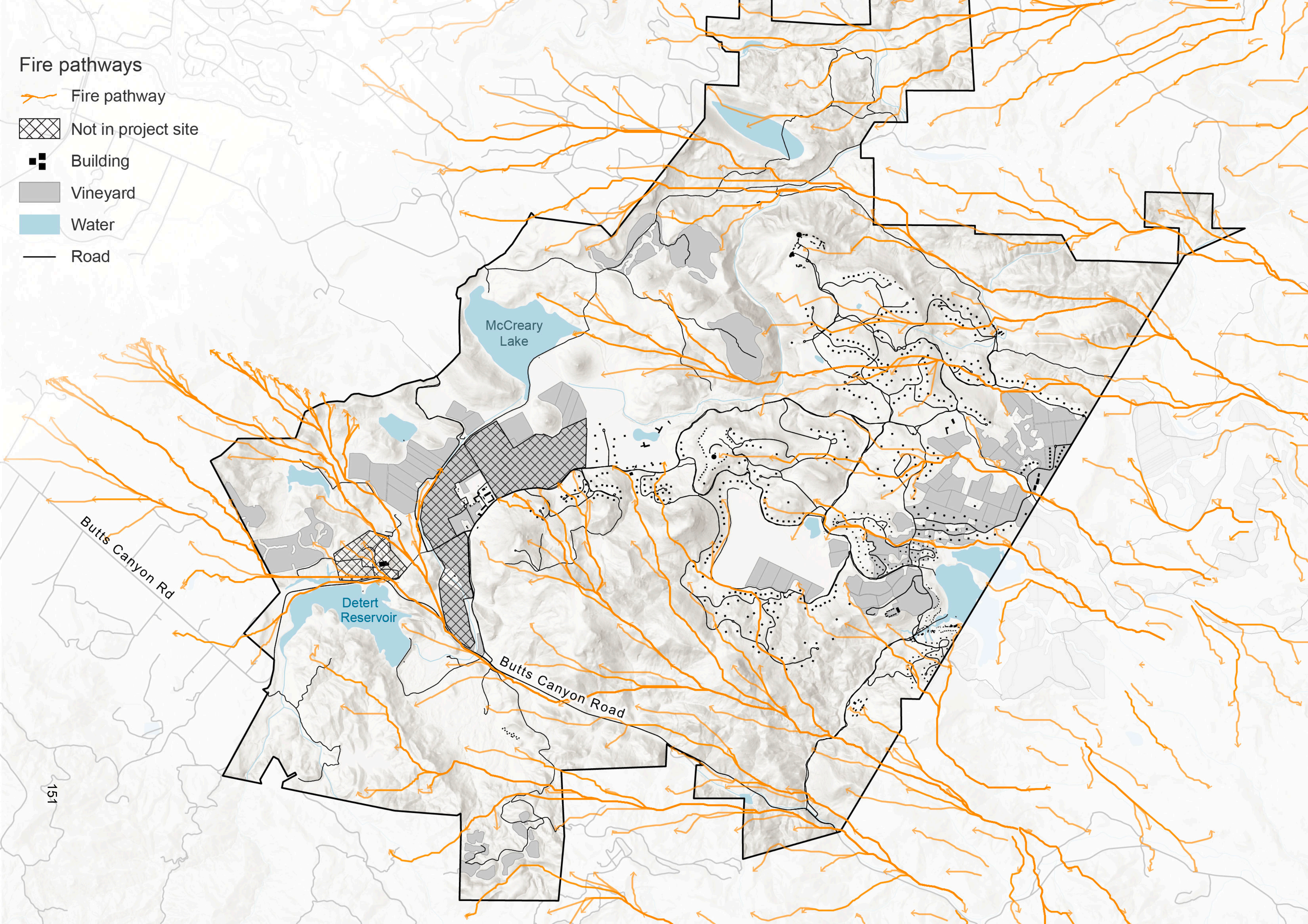
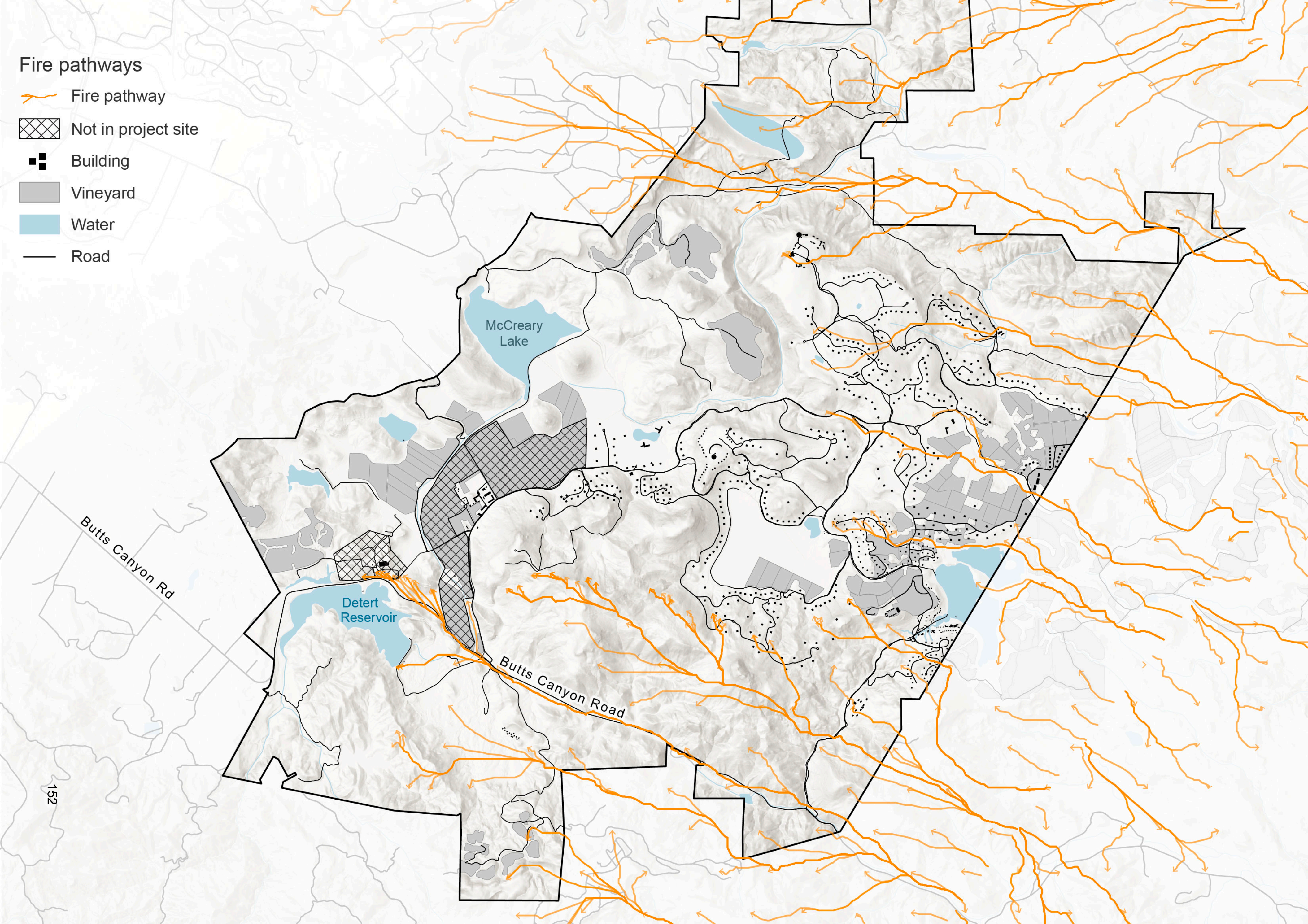
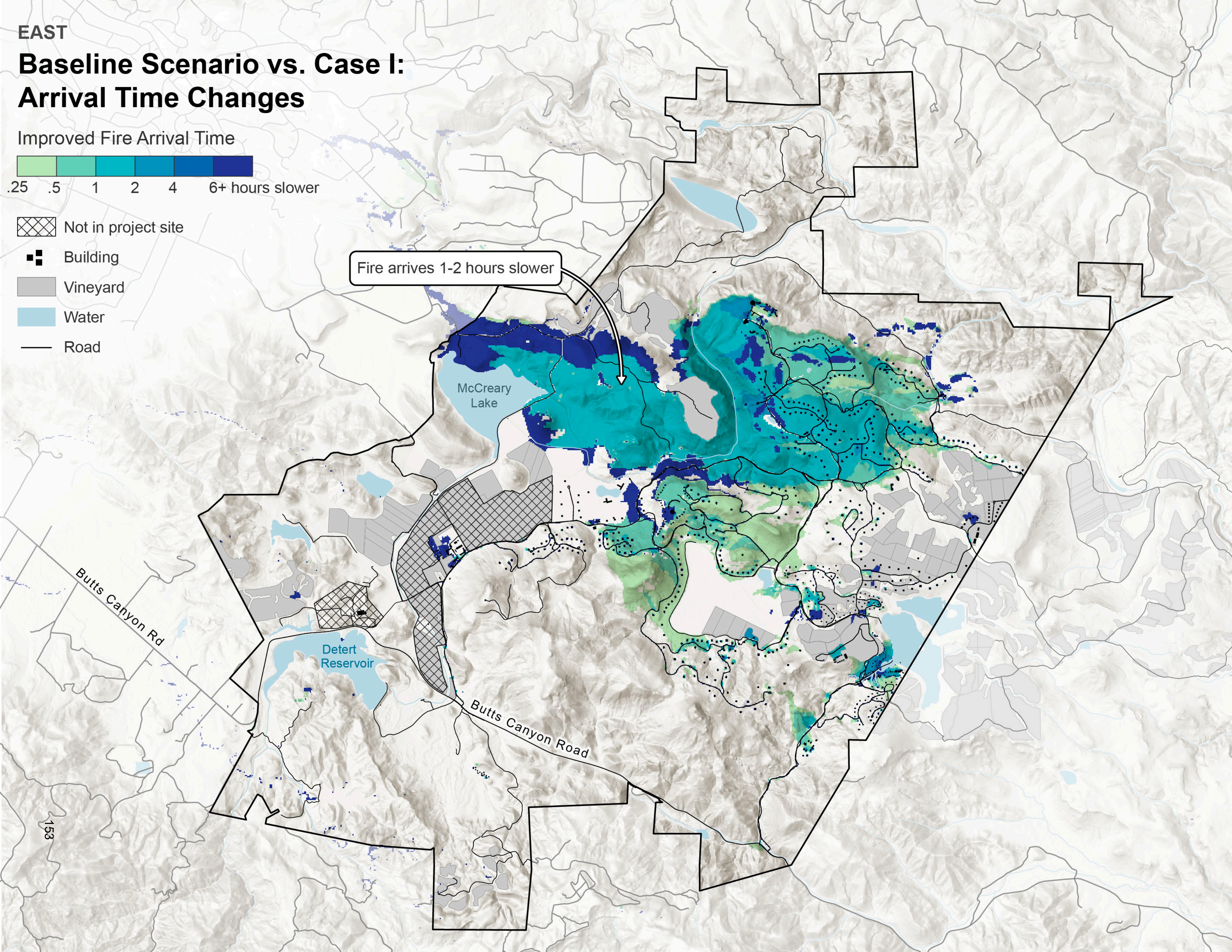
Case I: Fire Pathways



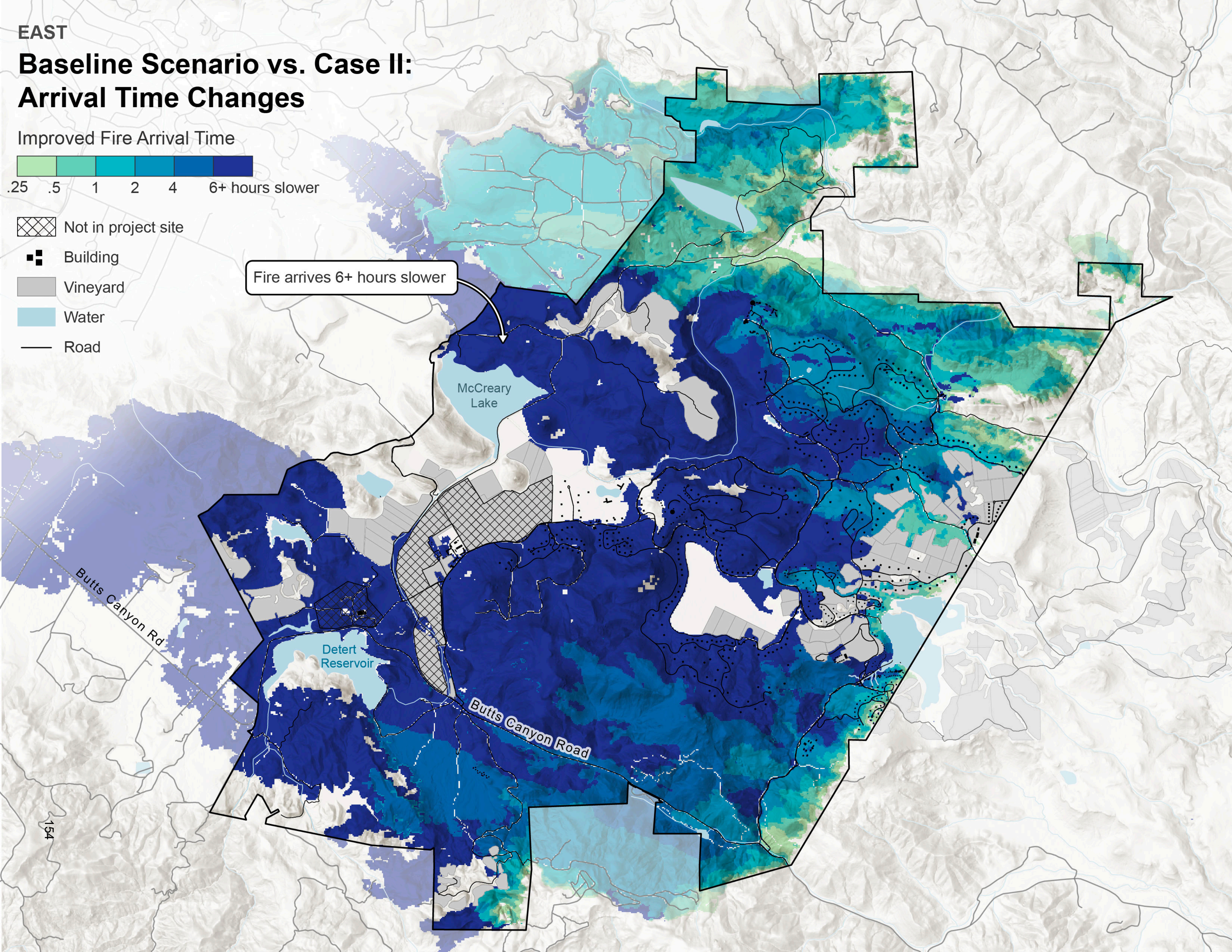
EAST

Case II: Fire Pathways



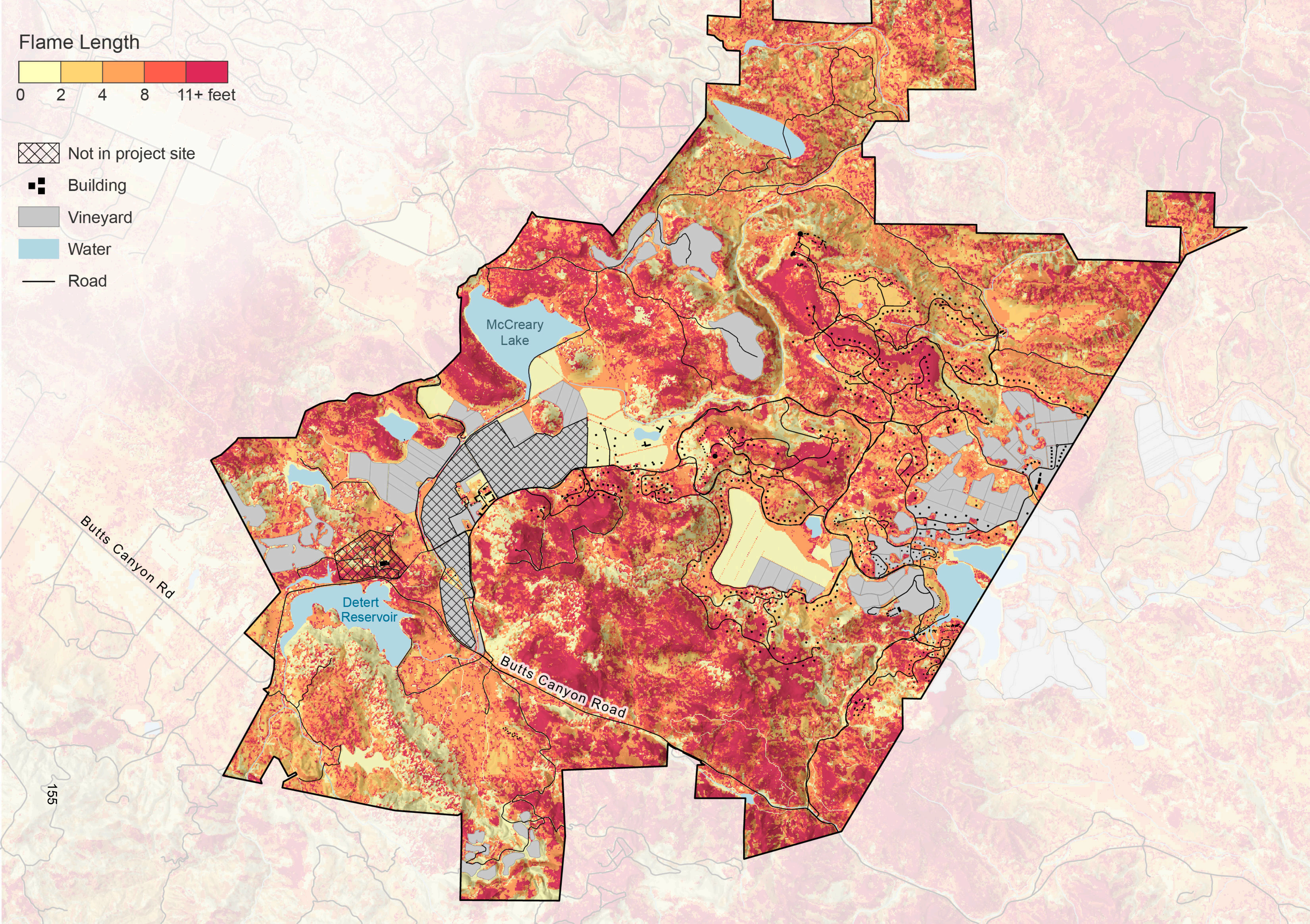


EAST
Baseline Scenario vs. Case I: Arrival Time Changes
Improved Fire Arrival Time
.25
.5
1
2
4
6+ hours slower
Not in project site
Building
Vineyard
Water
Road
Fire arrives 1-2 hours slower
McCreary Lake
Detert Reservoir
Butts Canyon Rd
Butts Canyon Road
153

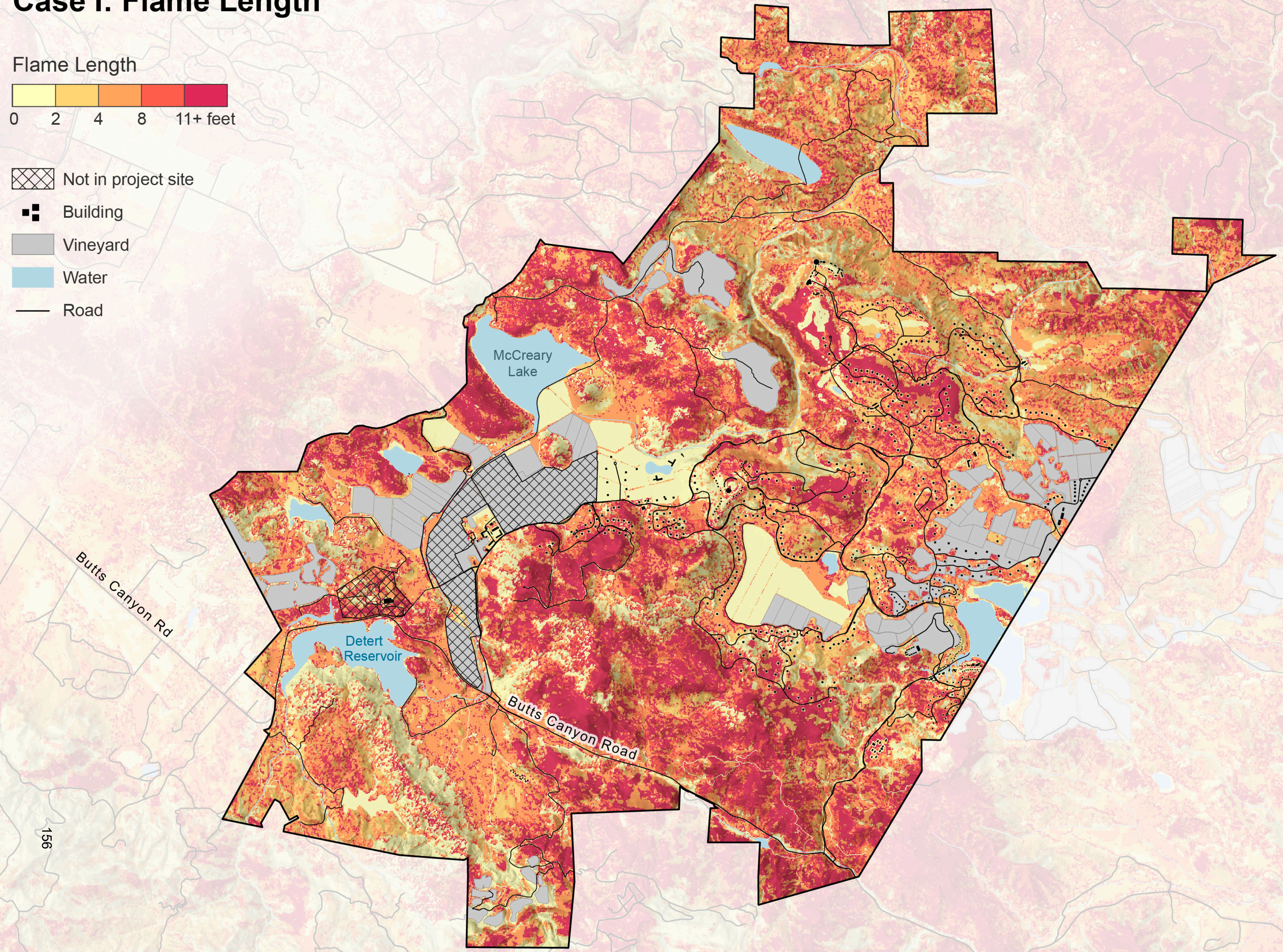

EAST
Baseline Scenario vs. Case II: Arrival Time Changes
Improved Fire Arrival Time
.25
.5
1
2
4
6+ hours slower
Not in project site
Building
Vineyard
Water
Road
Fire arrives 6+ hours slower
McCreary Lake
Detert Reservoir
Butts Canyon Rd
Butts Canyon Road
154

WEST

Baseline Scenario - Flame Length

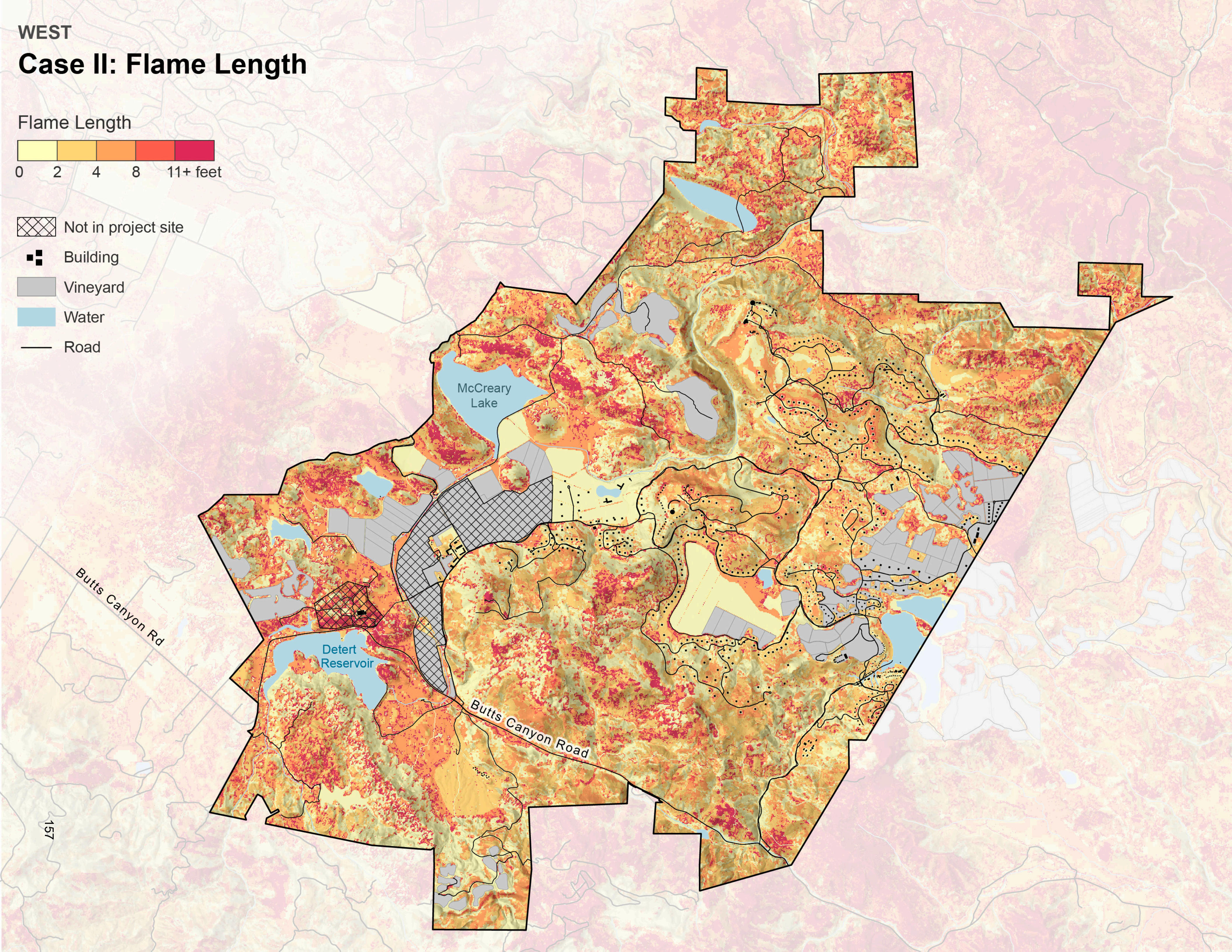


Case I: Flame Length



WEST

Case II: Flame Length



WEST

Baseline Scenario vs. Case I: Flame Length Delta

Flame Length

-8 -4 -2 -1 feet

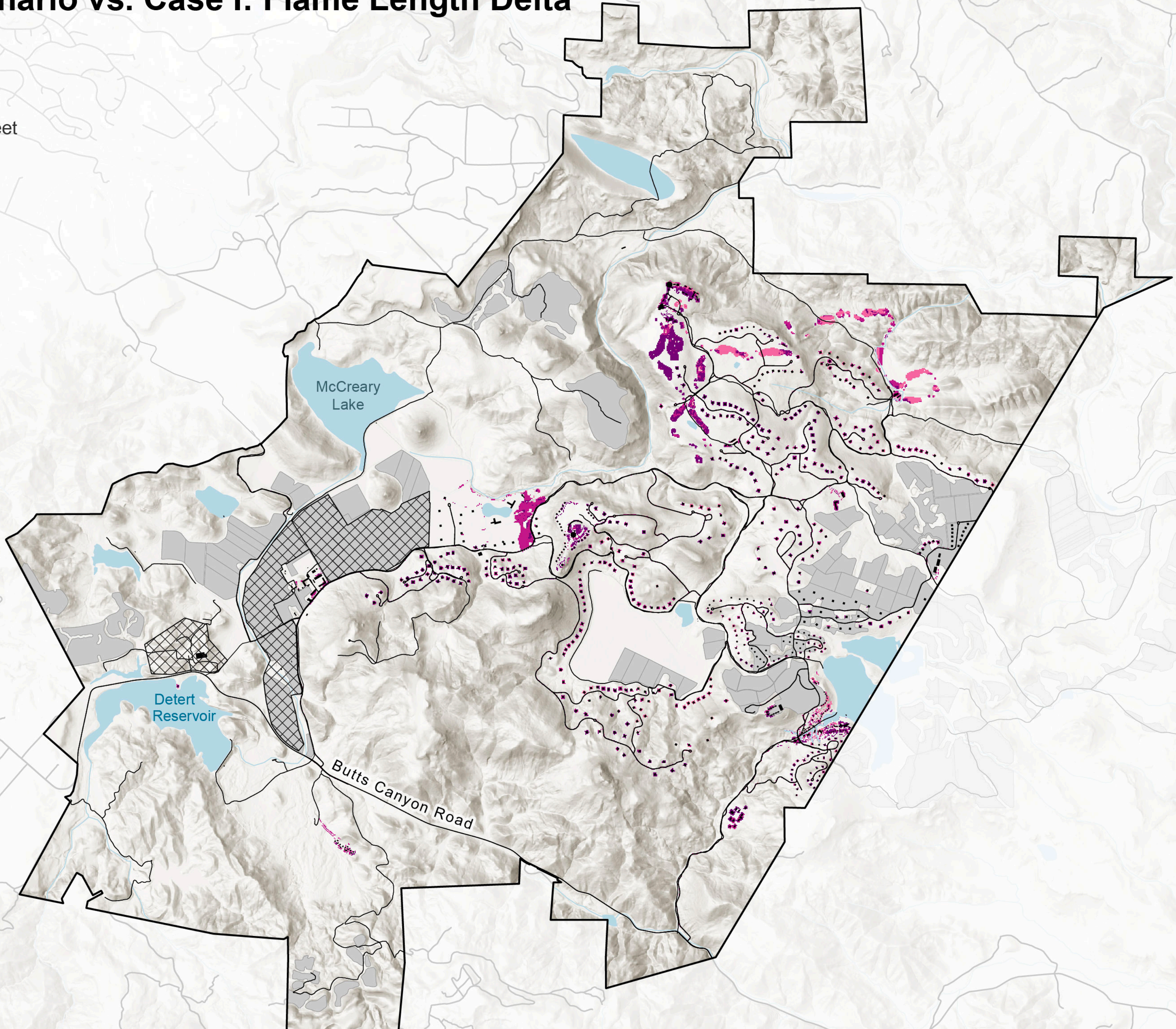
Not in project site

Building

Vineyard

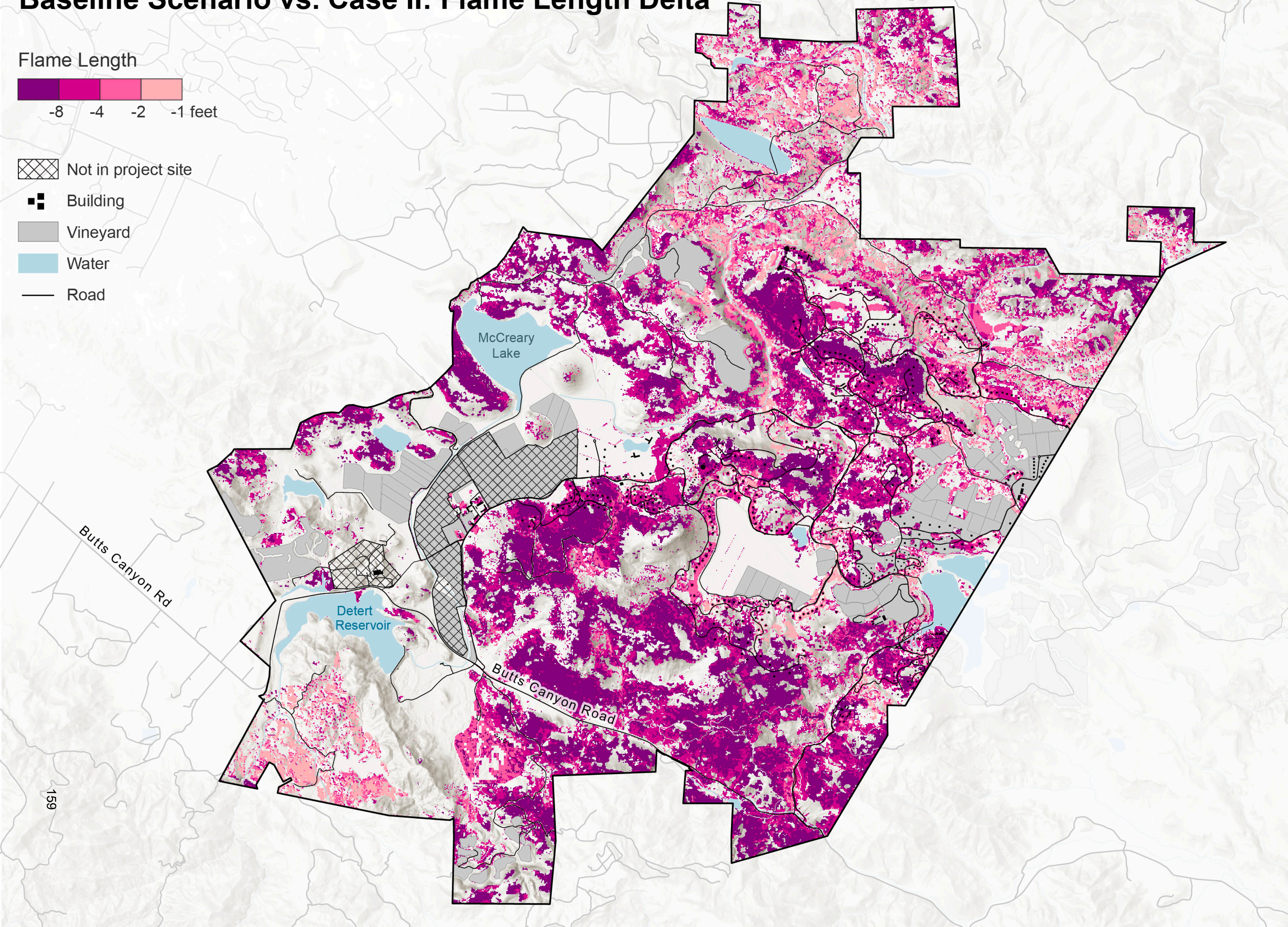
Water

Road



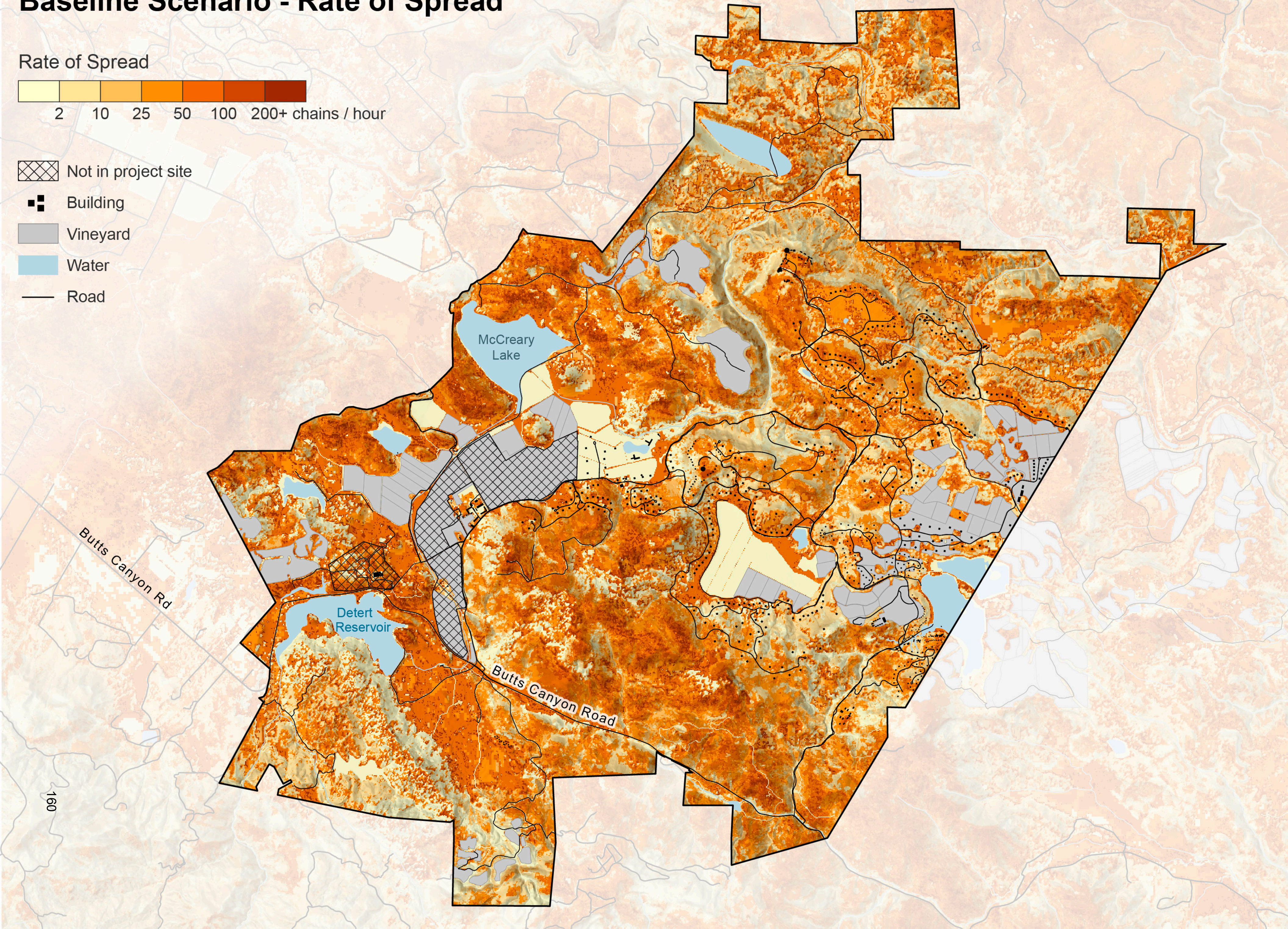
WEST

Baseline Scenario vs. Case II: Flame Length Delta



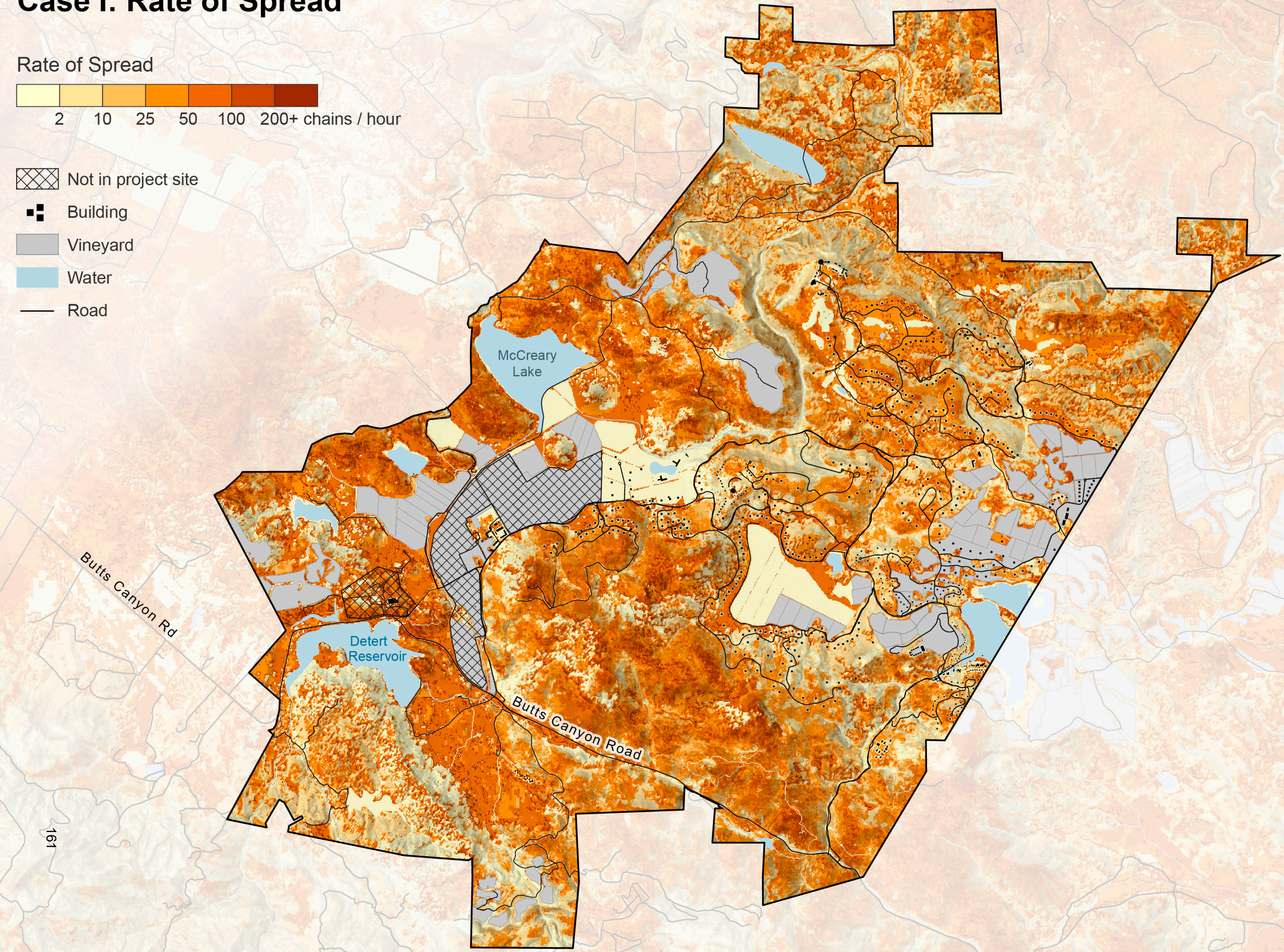
WEST

Baseline Scenario - Rate of Spread



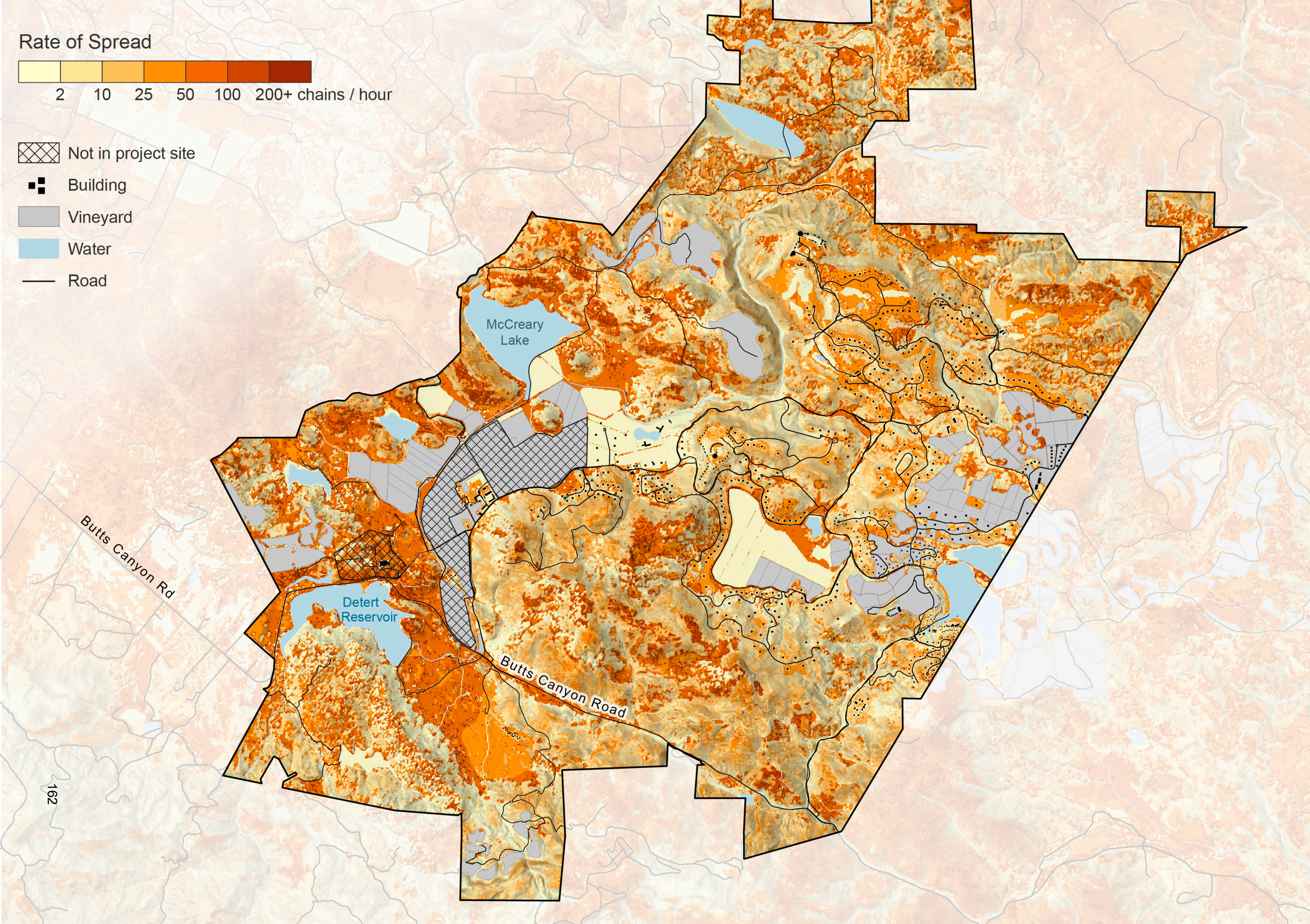
WEST

Case I: Rate of Spread



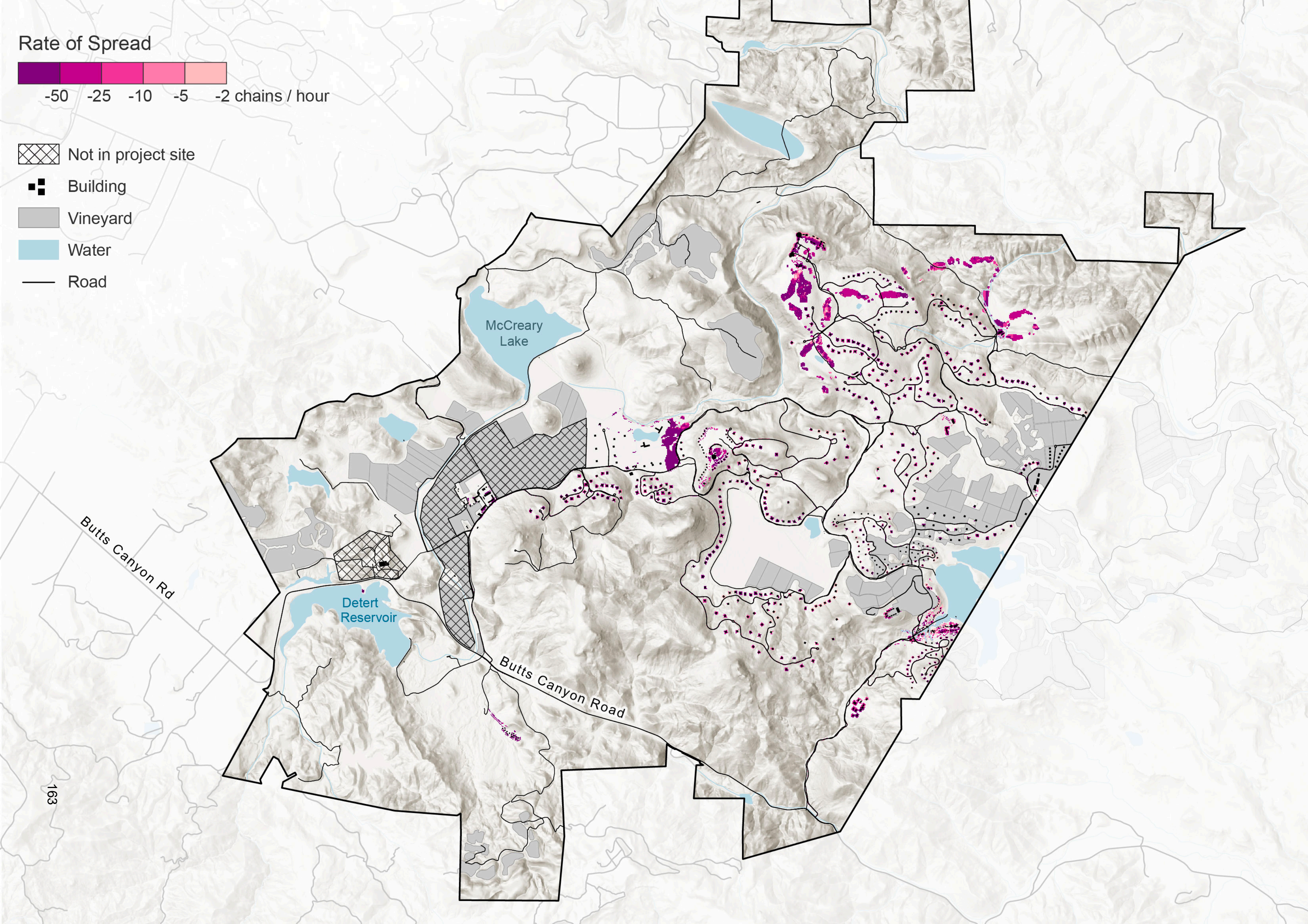
WEST

Case II: Rate of Spread



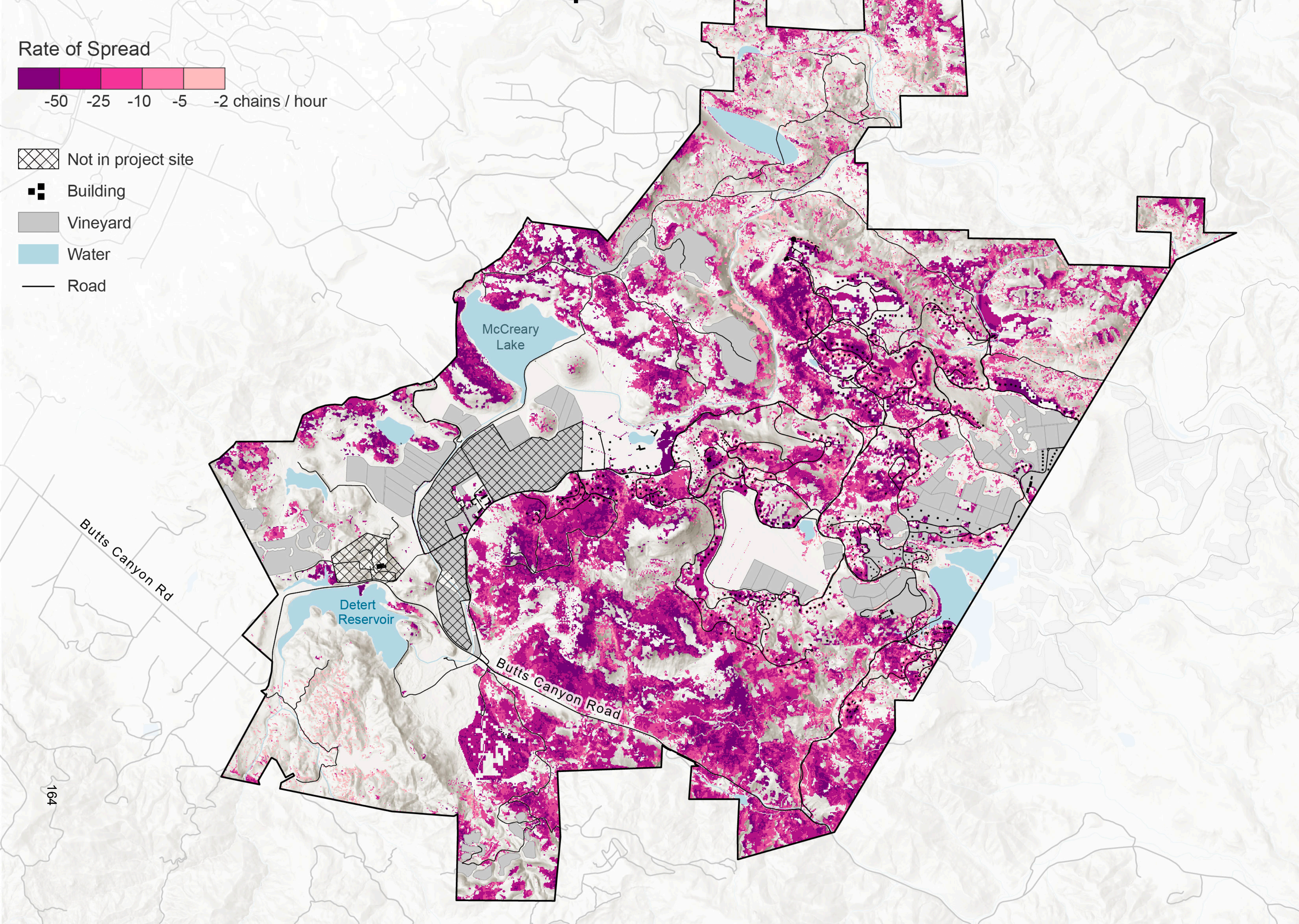
WEST

Baseline Scenario vs. Case I: Rate of Spread Delta



WEST

Baseline Scenario vs. Case II: Rate of Spread Delta

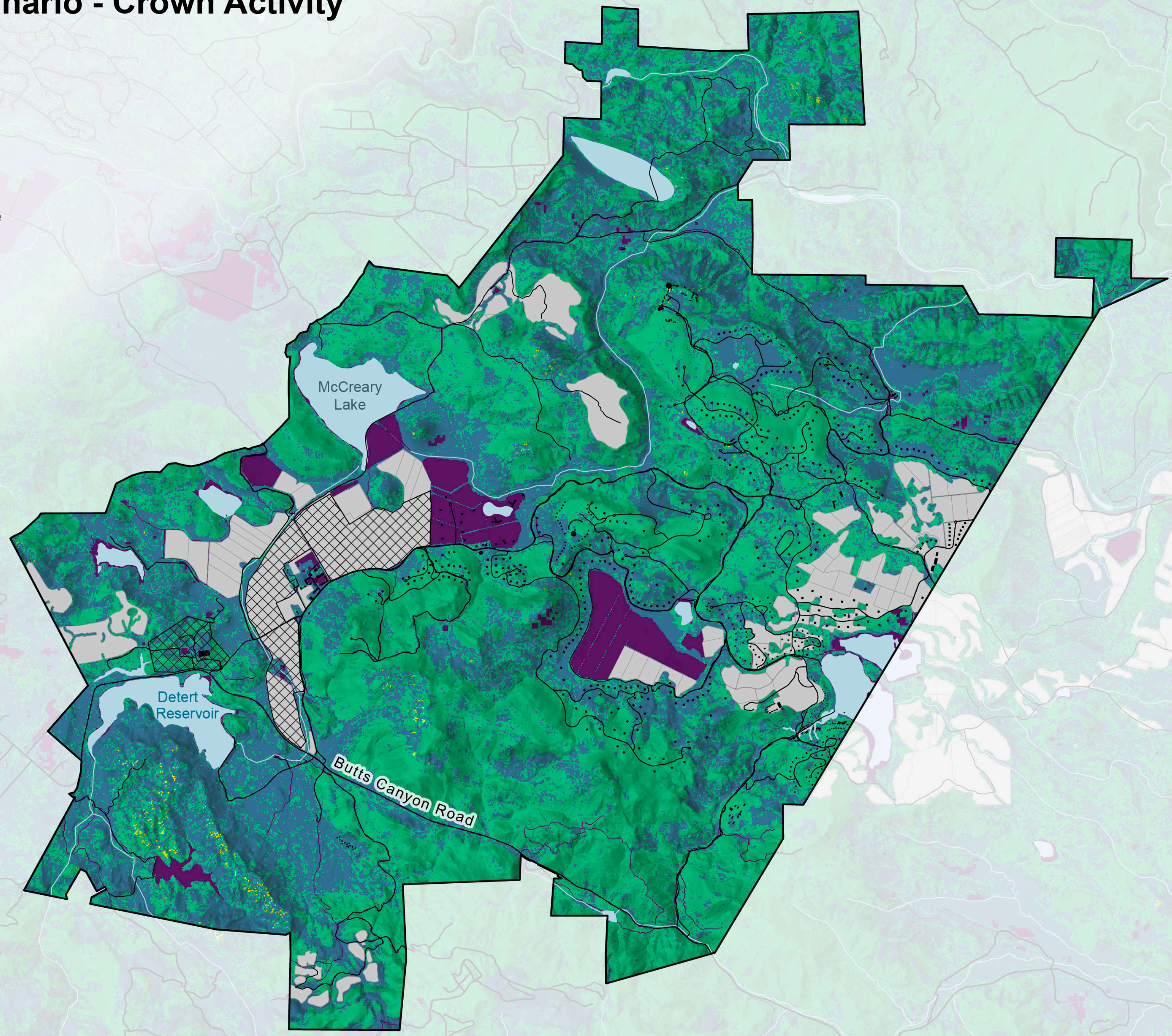


WEST

Baseline Scenario - Crown Activity

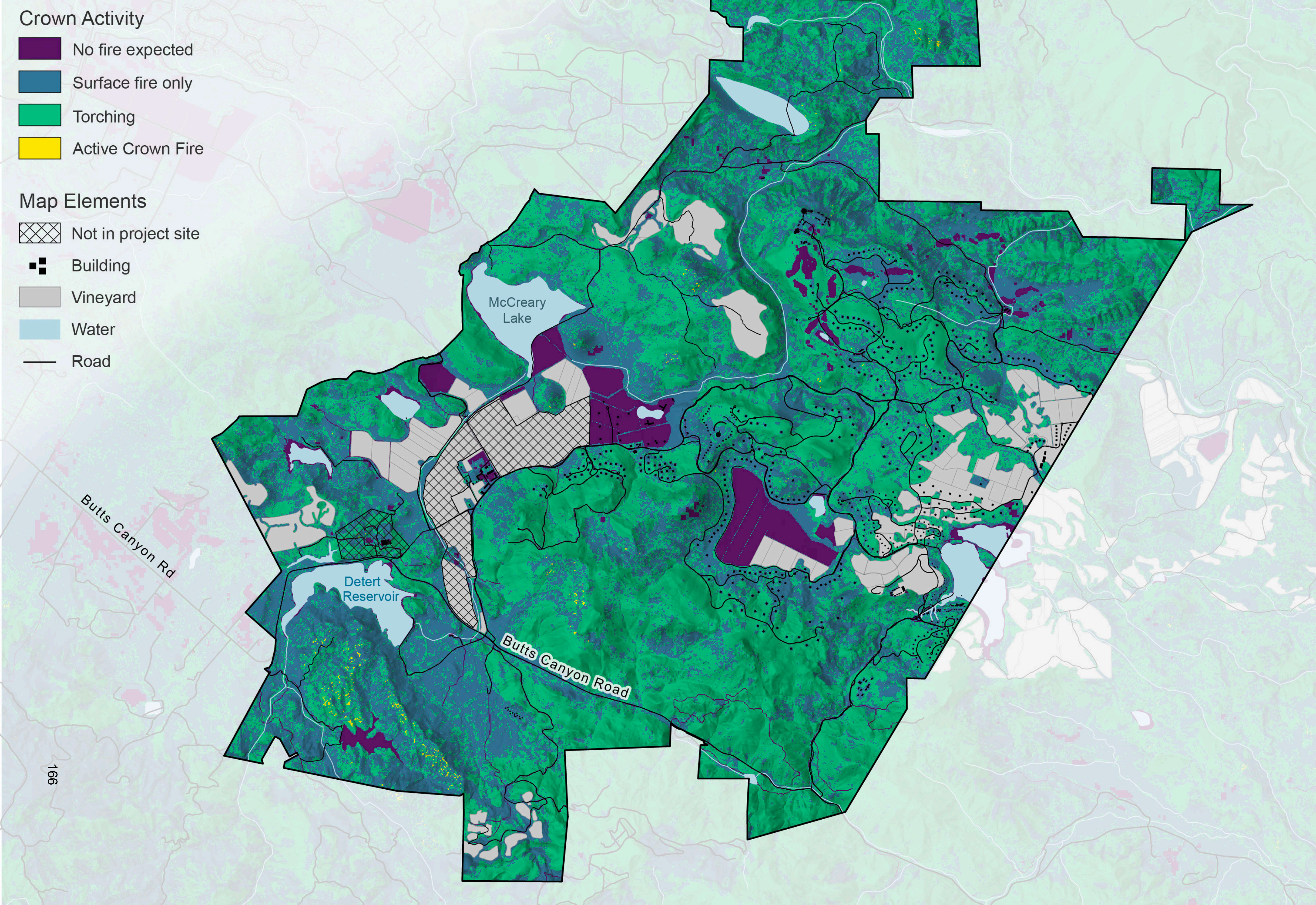
Crown Activity
- No fire expected
- Surface fire only
- Torching
- Active Crown Fire

Map Elements
- Not in project site
- Building
- Vineyard
- Water
- Road



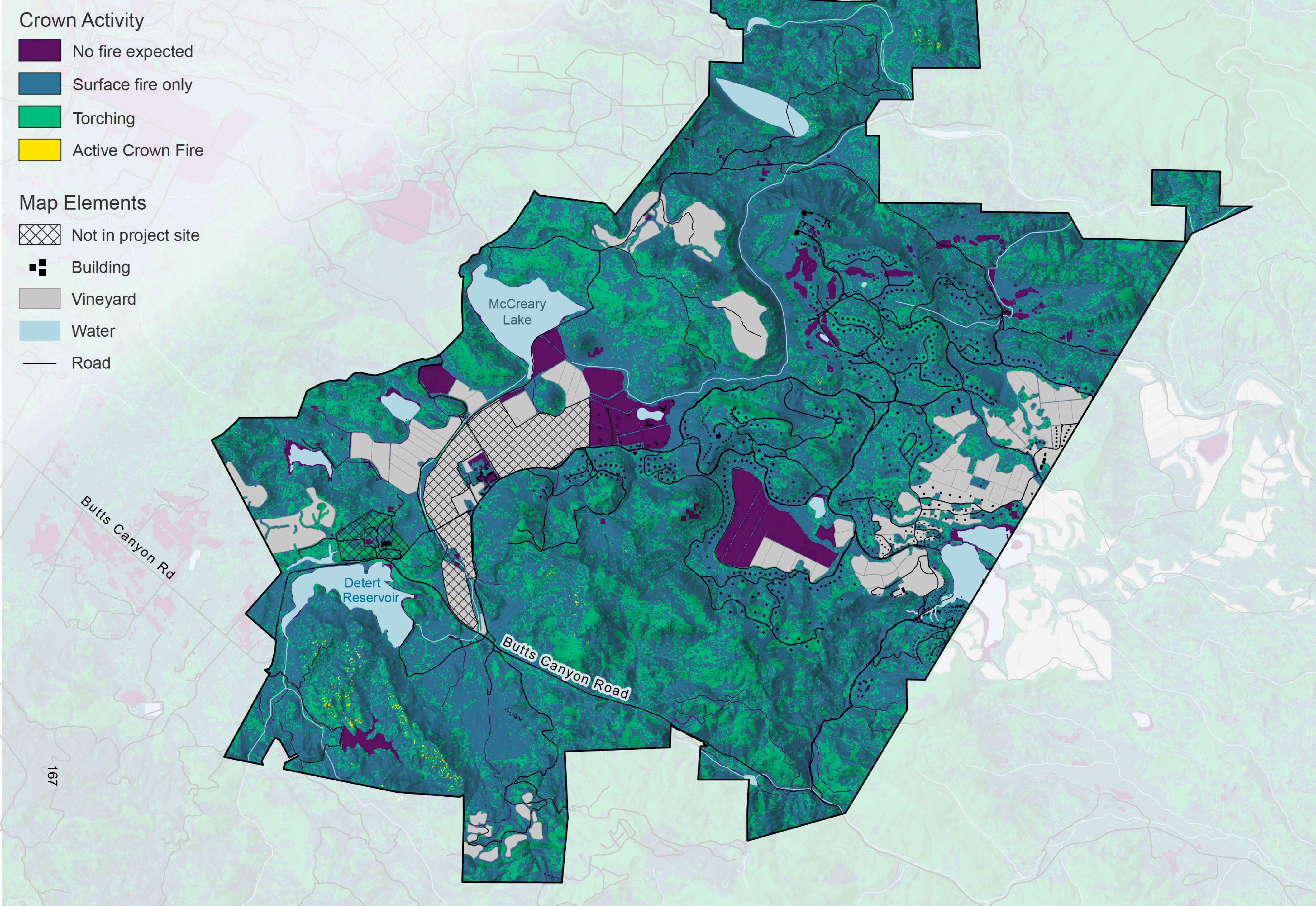
WEST

Case I: Crown Activity



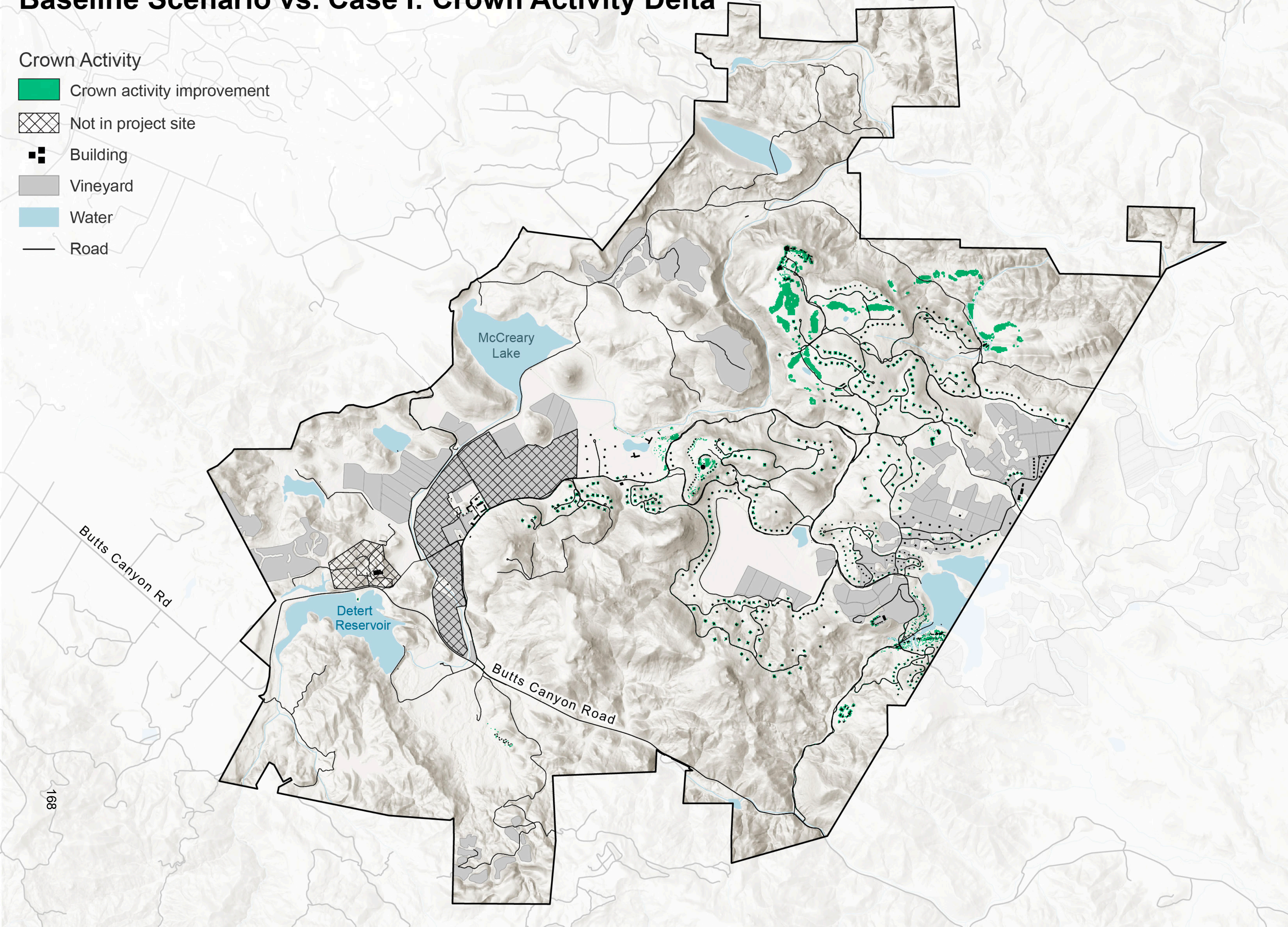
WEST

Case II: Crown Activity



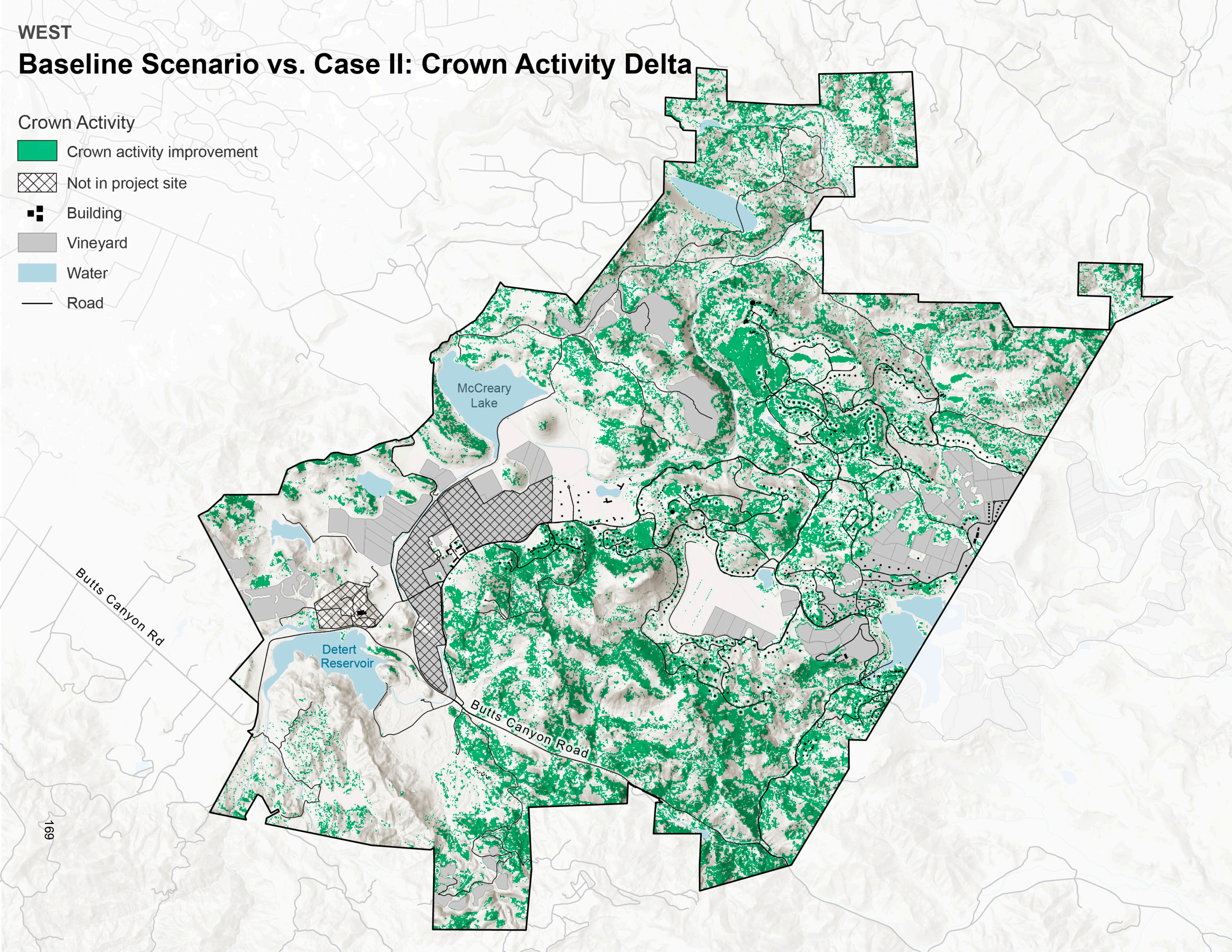
WEST

Baseline Scenario vs. Case I: Crown Activity Delta



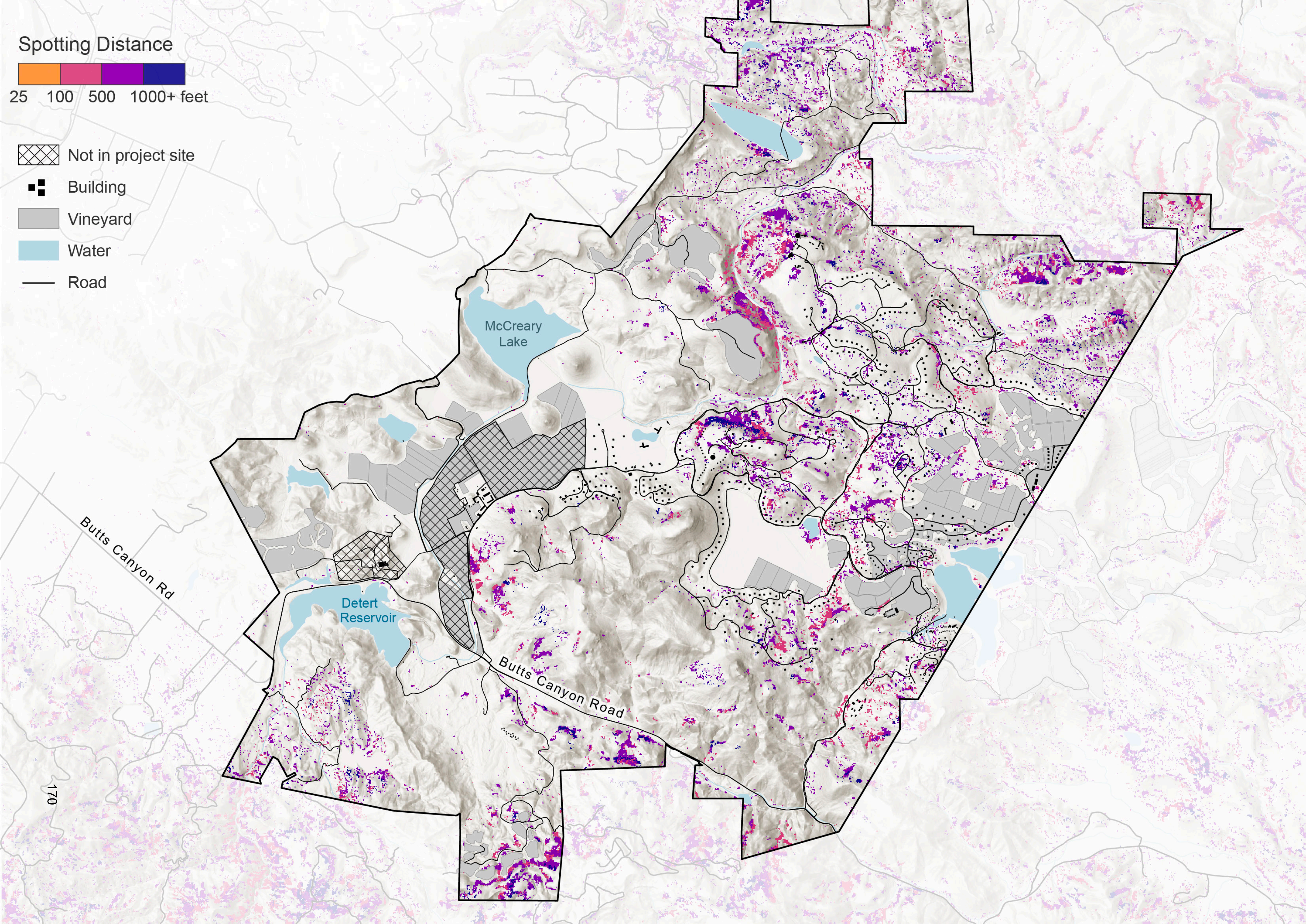
WEST

Baseline Scenario vs. Case II: Crown Activity Delta

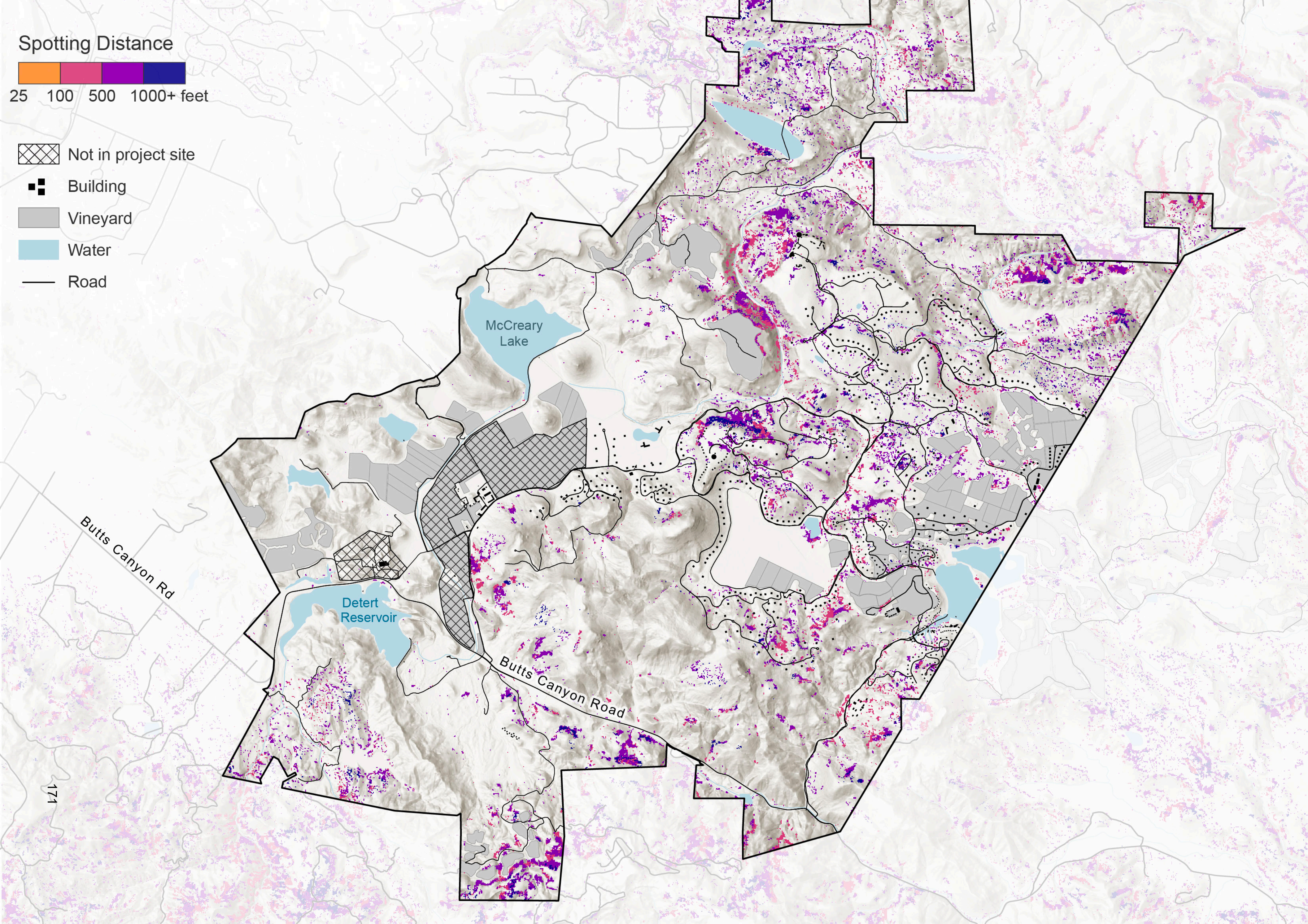


WEST

Baseline Scenario - Spotting Distance

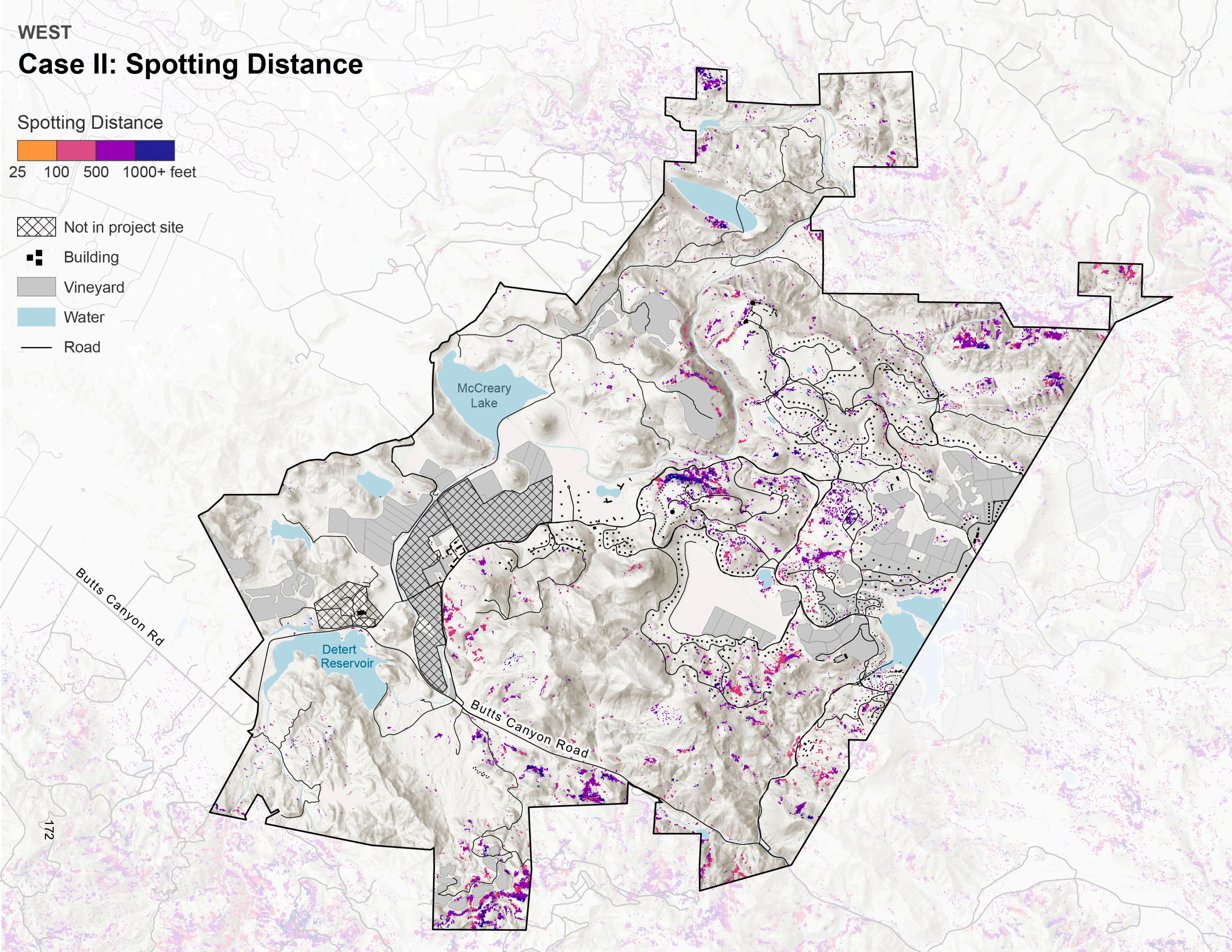


Case I: Spotting Distance



WEST

Case II: Spotting Distance

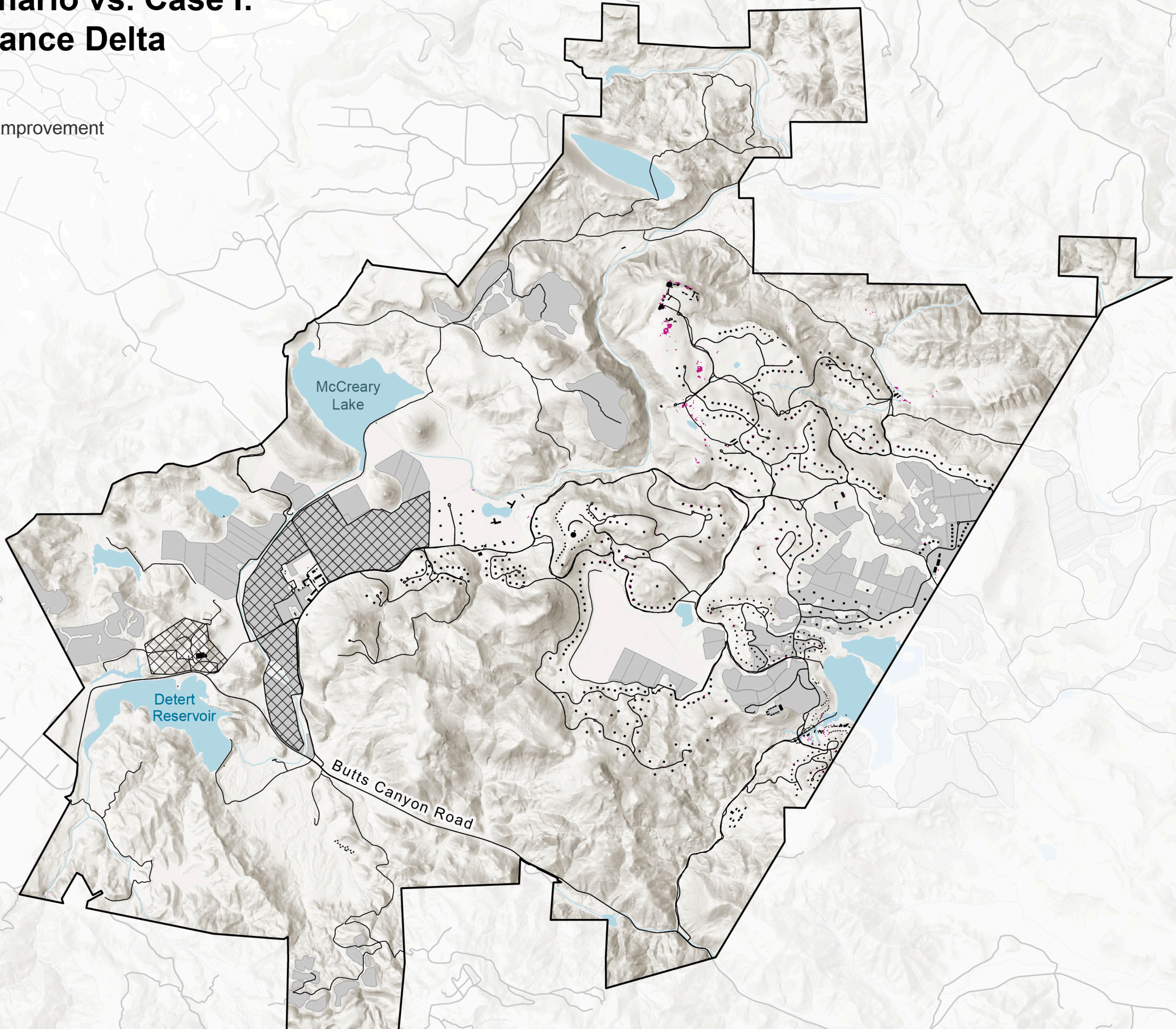


WEST

Baseline Scenario vs. Case I: Spotting Distance Delta

Spotting Distance

- Spotting distance improvement
- Not in project site
- Building
- Vineyard
- Water
- Road

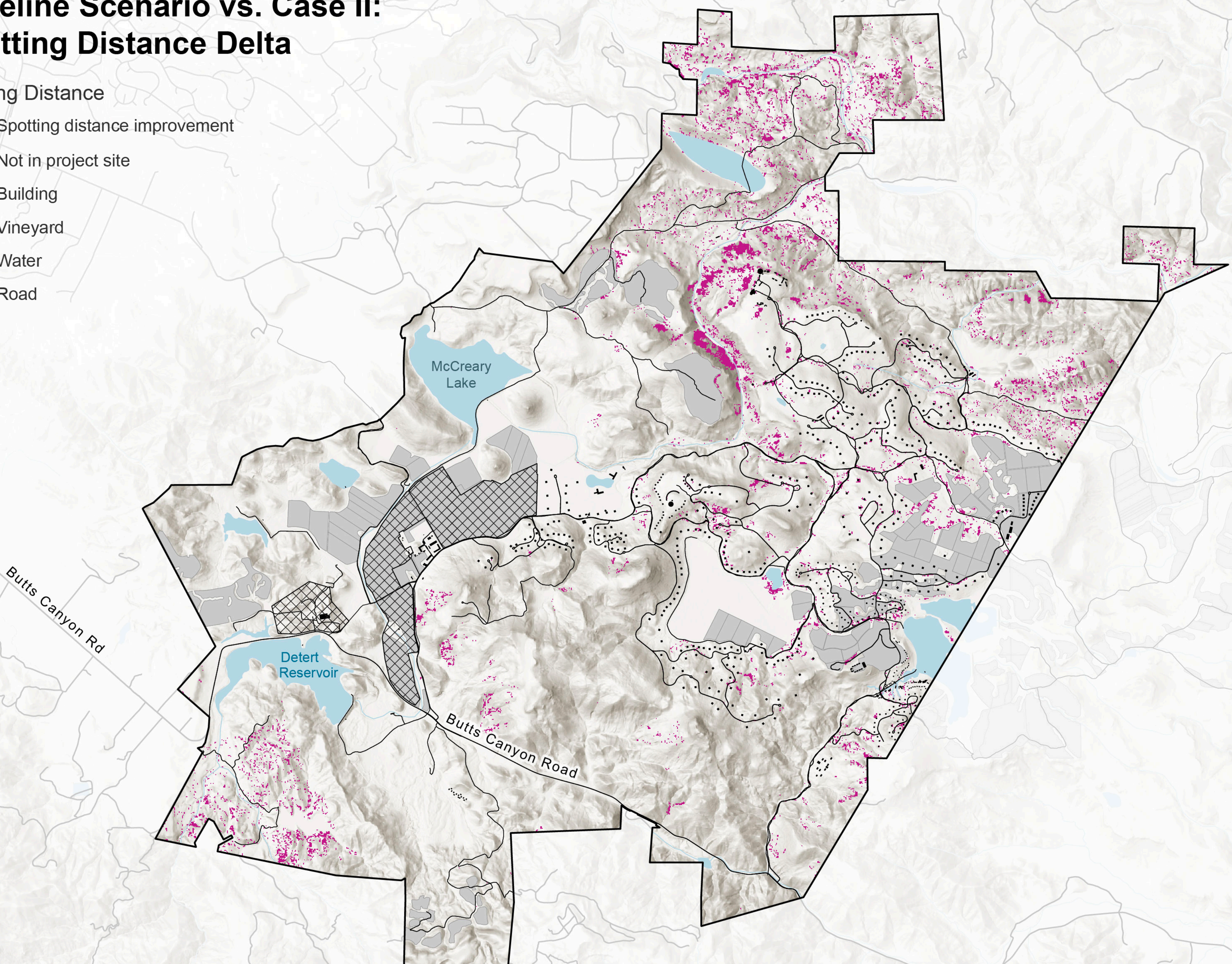


WEST

Baseline Scenario vs. Case II: Spotting Distance Delta

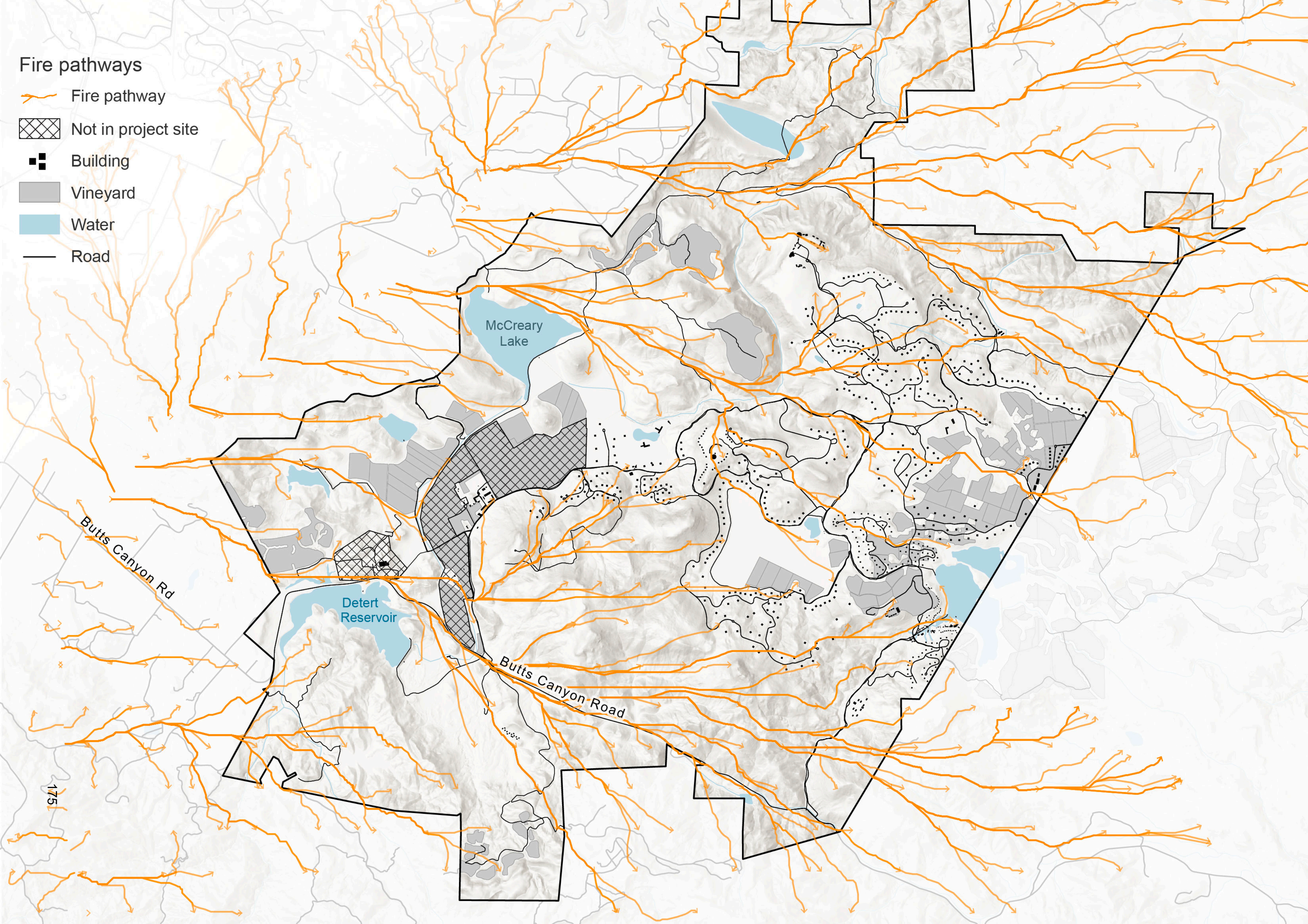
Spotting Distance

- Spotting distance improvement
- Not in project site
- Building
- Vineyard
- Water
- Road

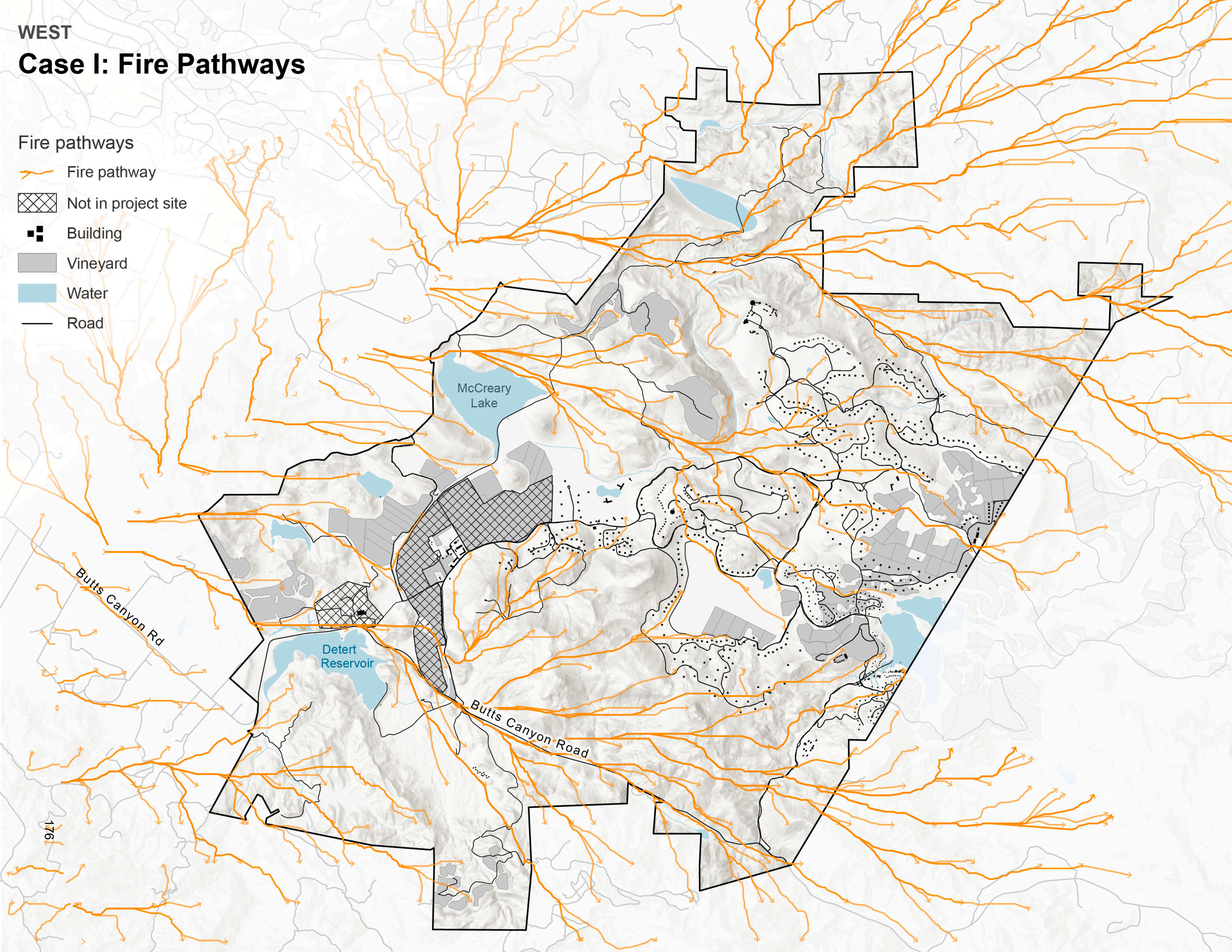


WEST

Baseline Scenario: Fire Pathways

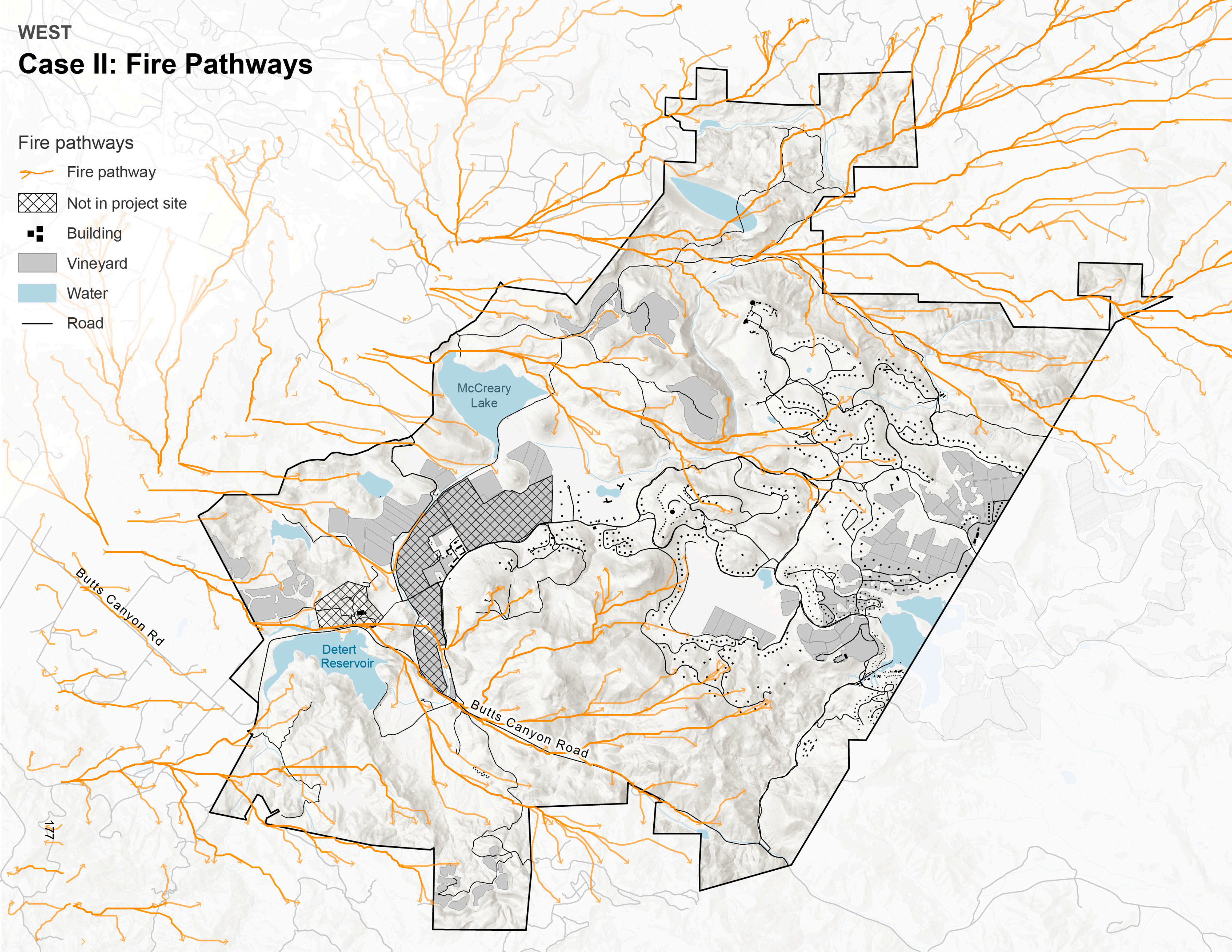


Case I: Fire Pathways



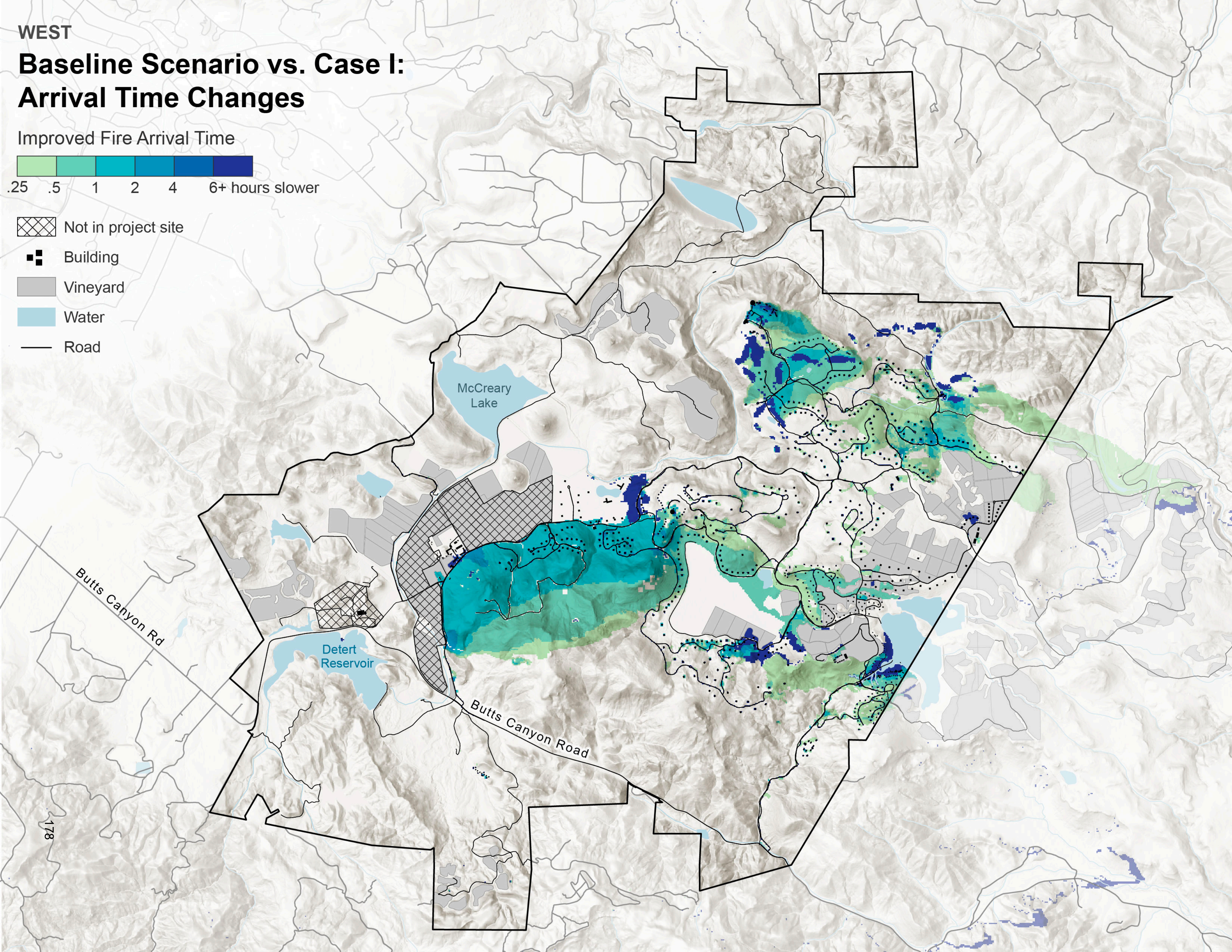
WEST

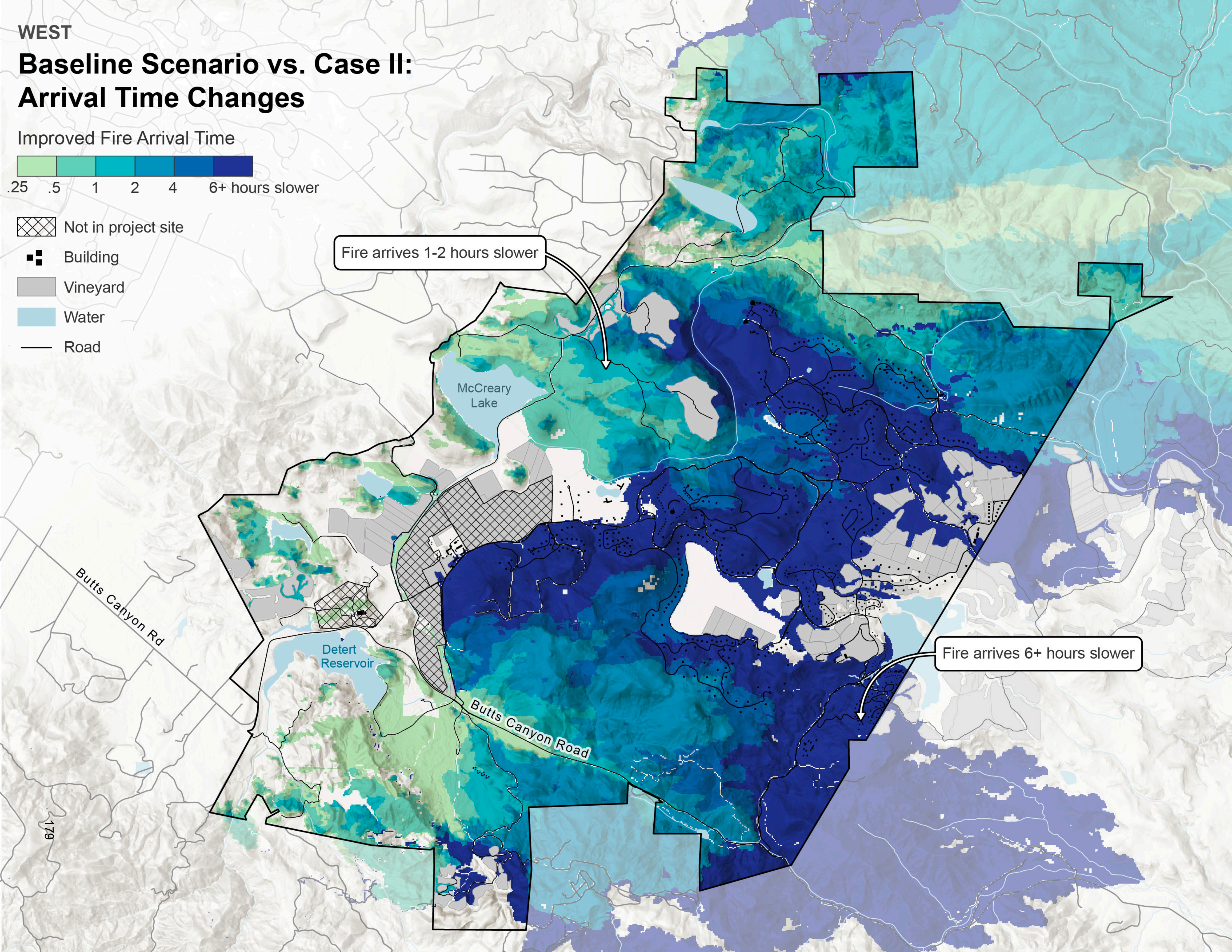
Case II: Fire Pathways



WEST

Baseline Scenario vs. Case I: Arrival Time Changes




WEST
Baseline Scenario vs. Case II: Arrival Time Changes
Improved Fire Arrival Time
.25
.5
1
2
4
6+ hours slower
Not in project site
Building
Vineyard
Water
Road
Fire arrives 1-2 hours slower
Fire arrives 6+ hours slower
McCreary Lake
Detert Reservoir
Butts Canyon Rd
Butts Canyon Road
179

Appendix W.1.B: Fuel Model Descriptions

Fuel Model Number	Fuel Model Code	Fuel Model Name	Description
91	NB1	Urban/Suburban	Land covered by urban and suburban development with no wildland fire spread.
92	NB2	Snow/Ice	Land covered by permanent snow or ice.
93	NB3	Agricultural Field	Agricultural land maintained in a non-burnable condition, such as irrigated crops or mowed orchards.
98	NB8	Open Water	Open bodies of water such as lakes, rivers, and oceans.
99	NB9	Bare Ground	Land with insufficient fuel for wildland fire spread, such as deserts, beaches, or rock outcroppings.
101	GR1	Short Sparse Dry Climate Grass	The primary carrier of fire is sparse grass, though small amounts of fine dead fuel may be present. The grass in GR1 is generally short, either naturally or by heavy grazing, and may be sparse or discontinuous.
102	GR2	Low Load Dry Climate Grass	Moderately coarse continuous grass, average depth about 1 foot.
103	GR3	Low Load Very Coarse Humid Grass	Humid climate grass with coarse, continuous fuelbed; shrubs do not affect fire behavior.
104	GR4	Moderate Load Dry Climate Grass	Moderately coarse continuous grass, average depth about 2 feet.
105	GR5	Low Load Humid Climate Grass	Humid climate grass with greater load than GR3, fuelbed depth 1-2 feet.
106	GR6	Moderate load humid climate grass	The primary carrier of fire is continuous humid-climate grass. Load is greater than GR5 but depth is about the same. Grass is less coarse than GR5.
107	GR7	High Load Dry Climate Grass	Primary carrier is continuous dry-climate grass. Load and depth greater than GR4. Grass about 3-feet tall.

108	GR8	High load very coarse humid climate grass	The primary carrier of fire is continuous, very coarse, humid-climate grass. Load and depth are greater than GR6.
109	GR9	Very high load humid climate grass-shrub	The primary carrier of fire is dense, tall, humid-climate grass. Load and depth are greater than GR8, about 6-feet tall.
121	GS1	Low load dry climate grass-shrub	The primary carrier of fire is grass and shrubs combined. Shrubs are about 1 foot high, grass load is low.
122	GS2	Moderate Load Dry Climate Grass-Shrub	Primary carrier is grass and shrubs combined. Shrubs are 1-3-feet high, grass load is moderate.
123	GS3	Moderate load humid climate grass-shrub	The primary carrier of fire is grass and shrubs combined. Shrubs are about 1 foot high, grass load is low. The primary carrier of fire is grass and shrubs combined. Moderate grass/shrub load, average grass/shrub depth less than 2-feet.
141	SH1	Low load dry climate shrub	The primary carrier of fire in SH1 is woody shrubs and shrub litter. Low shrub fuel load, fuelbed depth about 1 foot; some grass may be present.
142	SH2	Mod. load dry climate shrub	The primary carrier of fire in SH2 is woody shrubs and shrub litter. Moderate fuel load (higher than SH1), depth about 1 foot, and no grass fuel present.
143	SH3	Mod. load humid climate shrub	The primary carrier of fire in SH3 is woody shrubs and shrub litter. Moderate shrub load, possibly with pine overstory or herbaceous fuel, fuel bed depth 2-3-feet.
144	SH4	Low load humid climate timber-shrub	The primary carrier of fire in SH4 is woody shrubs and shrub litter. Low to moderate shrub and litter load, possibly with pine overstory, fuel bed depth about 3-feet.
145	SH5	High load dry climate shrub	The primary carrier of fire in GS4 is grass and shrubs combined. Heavy grass/shrub load, depth greater than 2-feet.
146	SH6	Low load humid climate shrub	The primary carrier of fire in SH6 is woody shrubs and shrub litter. Dense shrubs, little or no herbaceous fuel, fuelbed depth about 2-feet.

147	SH7	Very high load dry climate shrub	The primary carrier of fire is woody shrubs and shrub litter. Very heavy shrub load, depth 4-6-feet.
148	SH8	High load humid climate shrub	The primary carrier of fire in SH8 is woody shrubs and shrub litter. Dense shrubs, little or no herbaceous fuel, fuel bed depth about 3-feet.
149	SH9	Very high load humid climate shrub	The primary carrier of fire in SH9 is woody shrubs and shrub litter. Dense, finely branched shrubs with significant fine dead fuel, about 4-6-feet tall; some herbaceous fuel may be present.
161	TU1	Light load dry climate timber-grass-shrub	The primary carrier of fire in low-load of grass and/or shrub with litter.
162	TU2	Moderate load humid climate timber-shrub	The primary carrier of fire in TU2 is moderate litter load with shrub component.
163	TU3	Moderate load humid climate timber-grass-shrub	The primary carrier of fire in TU3 is moderate forest litter with grass and shrub components.
164	TU4	Dwarf conifer with understory	The primary carrier of fire is grass, lichen or moss understory plants.
165	TU5	Very high load dry climate timber-shrub	The primary carrier of fire in TU5 is heavy forest litter with a shrub or small tree understory.
181	TL1	Low load compact conifer litter	The primary carrier of fire is compact forest litter. Light to moderate load, fuels 1-2 inches deep. May be used to represent a recently burned forest.
182	TL2	Low load broadleaf litter	The primary carrier of fire is broadleaf (hardwood) litter. Low load, compact litter.
183	TL3	Moderate load conifer litter	The primary carrier of fire is moderate load conifer litter, light load of coarse fuels.
184	TL4	Small downed logs	The primary carrier of fire is moderate load of fine litter and coarse fuels. Includes small diameter downed logs
185	TL5	High load conifer litter	The primary carrier of fire is High load conifer litter; light slash or mortality fuel.

186	TL6	Moderate load broadleaf litter	The primary carrier of fire is moderate load broadleaf litter, less compact than TL2.
187	TL7	Large downed logs	The primary carrier of fire is heavy load forest litter, including larger diameter downed logs.
188	TL8	Long-needle litter	The primary carrier of fire in is moderate load long-needle pine litter, may include small amounts of herbaceous load.
189	TL9	Very high load broadleaf litter	The primary carrier of fire is very high load, fluffy broadleaf litter. Can also be used to represent heavy needle-drape.
201	SB1	Low load activity fuel	The primary carrier of fire is light dead and down activity fuel. Fine fuel load is 10 to 20 t/ac, weighted toward fuels 1-3 in diameter class, depth is less than 1 foot.
202	SB2	Moderate load activity or low load blowdown	The primary carrier of fire is moderate dead and down activity fuel or light blowdown. Fine fuel load is 7 to 12 t/ac, evenly distributed across 0-0.25, 0.25-1, and 1-3 inch diameter classes, depth is about 1 foot. Blowdown is scattered, with many trees still standing.
203	SB3	High load activity fuel or moderate load blowdown	The primary carrier of fire is heavy dead and down activity fuel or moderate blowdown. Fine fuel load is 7 to 12 t/ac, weighted toward 0-0.25 inch diameter class, depth is more than 1 foot. Blowdown is moderate; trees compacted to near the ground.
204	SB4	High load blowdown	The primary carrier of fire is heavy blowdown fuel. Blowdown is total, fuelbed not compacted, most foliage and fine fuel still attached to blowdown.

Appendix W.1.C: Fuel Model Conversion Logic

Initial Fuel Model	Roadside Clearance	Active Vegetation Management	Defensible Space (Zone 1)	Defensible Space (Zone 2)	Grazing	Conversion to Agriculture
101	101	101	101	101	101	93
102	102	102	222*	102	101	93
103	102	103	222*	102	102	93
104	102	102	222*	102	102	93
105	103	105	103	103	101	93
106	105	106	222*	102	102	93
107	105	104	222*	102	102	93
108	102	105	222*	102	102	93
121	121	121	101	101	121	93
122	121	121	121	121	121	93
123	122	122	121	121	121	93
124	122	122	121	121	121	93
141	183	141	183	183	141	93
142	141	142	141	141	141	93
143	143	142	242*	142	142	93
144	141	141	143	143	142	93
145	122	121	121	121	121	93
146	142	146	143	143	121	93
147	145	147	242*	142	121	93
148	142	148	222*	102	121	93
149	122	147	122	122	122	93
161	161	161	183	183	161	93
162	183	183	183	183	162	93
163	162	162	162	162	163	93
165	142	165	162	162	165	93
181	181	181	181	181	181	93
182	182	182	181	181	182	93
183	183	183	181	181	183	93
184	183	183	182	182	184	93
185	185	161	183	183	185	93
186	185	185	183	183	186	93

187	184	184	162	162	187	93
188	186	186	185	185	188	93
189	186	186	185	185	189	93
201	142	142	184	184	201	93
202	202	201	121	121	202	93

A (*) in the table above indicates a custom fuel model. Custom fuel models in this study are used to represent the role of irrigation in increasing fuel moisture.

Custom fuel model 222 represents irrigated grass. Structurally, fuel model 222 is the same as GR2 (low-load dry climate grass); however, this study applied a much higher moisture content to both dead and live herbaceous fuel components. Custom fuel model 242 represents irrigated shrubs. It is structurally identical to SH2 (Moderate load dry climate shrub) and custom fuel model 244 represents irrigated timber litter, which is structurally identical to TL2 (low load broadleaf litter).

Appendix W.1.D: Canopy Cover Conversion Logic

Initial Canopy Cover	Roadside Clearance	Active Vegetation Management	Defensible Space (Zone 1)	Defensible Space (Zone 2)	Grazing	Conversion to Agriculture
10	-	-	0	10	-	0
20	-	-	0	20	-	0
30	-	-	0	25	-	0
40	-	-	0	25	-	0
50	-	-	0	25	-	0
60	-	-	0	25	-	0
70	60	60	0	25	-	0
80	70	70	0	30	-	0
90	80	80	0	40	-	0
100	80	80	0	50	-	0

Appendix W.1.E: Treatment Activity Descriptions

	IFTDSS Simulated Treatment	Activity Description	Ladder Fuel Removal
Roadside Clearance	Moderate Intensity Masticate	IFTDSS Thin + Masticate: This treatment assumes 25%-75% of the area affected by an understory thinning treatment cutting 75% of all material up to a 6” diameter and leaves it on site as masticated material. Trees are limbed to raise the height to live crown.	To 12 feet
Active Vegetation Management	Low-Intensity Thinning	IFTDSS Thin and Burn: The first phase of this treatment assumes an understory thinning treatment, applied to <25% of the area; thinning the stand to 80% of current density by thinning up to a 6" diameter. Subsequent pile burning assumes thinned material is removed by burning 70% of the area at 80% consumption for each pile. An additional 20% mortality is assumed in <5” diameter size classes as a result of thinning and subsequent pile burning. Trees are limbed to raise the height to live crown.	To 8 feet
Grazing	n/a	Use of domestic livestock to reduce plant populations thereby reducing fire fuels or competition of desired plant species. Achieved by grazing or browsing by cows, goats, or sheep.	None
Conversion to Irrigated Agriculture	n/a	Land is fully converted to vineyard, orchard, or other irrigated and maintained	Overstory is removed during conversion.

		land-use.	
Defensible Space (Zone 1)	Moderate Intensity Thinning	IFTDSS Thin and Burn: The first phase of this treatment assumes an understory thinning treatment, applied to 25-75% of the area; thinning the stand to 35% of current density with no upper diameter limit. Subsequent pile burning assumes thinned material is removed by burning 70% of the area at 80% consumption for each pile. An additional 20% mortality is assumed in <5" diameter size classes as a result of thinning and subsequent pile burning. Trees are limbed to raise the height to live crown.	To 12 feet
Defensible Space (Zone 2)	Moderate Intensity Thinning	IFTDSS Thin and Burn: The first phase of this treatment assumes an understory thinning treatment, applied to 25-75% of the area; thinning the stand to 35% of current density with no upper diameter limit. Subsequent pile burning assumes thinned material is removed by burning 70% of the area at 80% consumption for each pile. An additional 20% mortality is assumed in <5" diameter size classes as a result of thinning and subsequent pile burning. Trees are limbed to raise the height to live crown.	To 8 feet

Appendix W.2: Fire Station Service Time Estimates

FIRE STATION SERVICE TIME ESTIMATES

MAHA GUENOC PROPOSED DEVELOPMENT, LAKE/NAPA COUNTIES

Report Prepared for:

Wildland Res Mgt

Prepared by:

Digital Mapping Solutions

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530-386-2368, mandeno@digitalmappingsolutions.com

Friday, December 20, 2024

SUMMARY

Digital Mapping Solutions was tasked with providing estimated driving times from four fire station locations within southeastern Lake County. Three existing fire stations (two staffed, one volunteer) and one proposed emergency center was used in this service time estimate analysis. Road data was compiled from publicly available county GIS data using speed limit estimated from road class. Results are provided in map-format and geospatial data. A short discussion is provided.

PURPOSE

Located in a rural area in Northern California, the Maha Guenoc proposed development is entirely within Lake County abutting Napa County. The closest fire stations that service the proposed development site were initially estimated as outside their core service areas. The map below shows that the Maha Guenoc area is over twenty-five (25) minutes away from the nearest fire station (origin of their analysis which was in Hidden Valley).

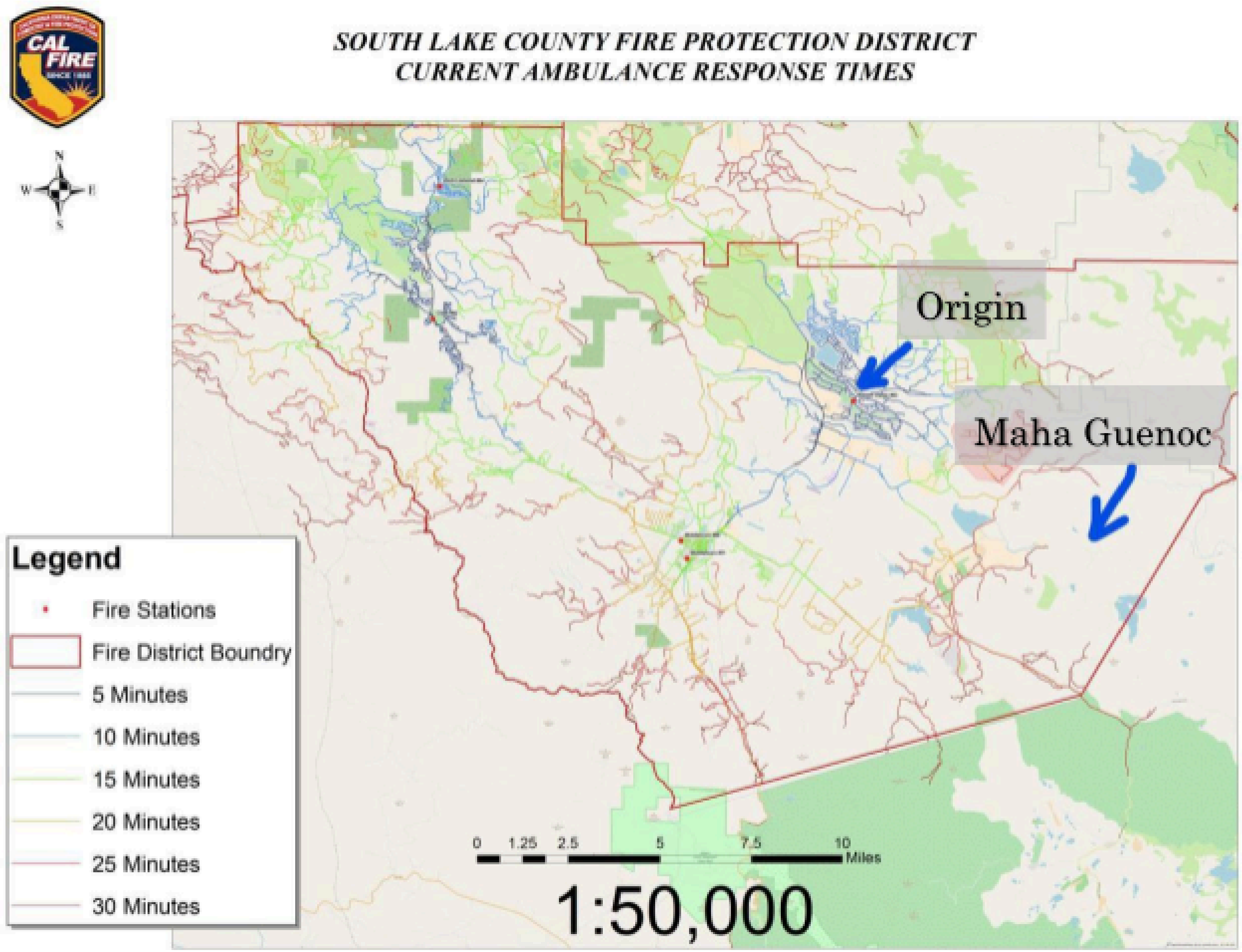


Figure 1 - Old (year unknown) CAL FIRE Ambulance response time estimates for South Lake County near the proposed development.

The purpose of this analysis is to determine the estimated driving time between existing and proposed fire stations surrounding the Maha Guenoc proposed development in Lake County including the proposed new road system.

Based on these estimates, a numerical comparison was made between the two scenarios (one without the proposed fire station and one with the proposed fire station) to determine the relative improvement of service to the Maha Guenoc new development.

A comparison between these results and the CAL FIRE Ambulance Response Times is not presented in this document for two reasons: (1) The base road data used in the CAL FIRE analysis is unknown, and (2) the speed limit assumptions for each line segment used by the CAL FIRE analysis is unknown.

So, in short, three results will be presented here:

1. Scenario 1: Existing Fire Stations,
2. Scenario 2: Existing Fire Stations with Proposed Emergency Center, and
3. Time Difference between the above two scenarios.

METHODOLOGY

We used ArcGIS Pro's Network Analyst as the basis for this service time estimate.

Network Analyst is a toolbox within ArcGIS Pro (a Geographic Information Systems analytical software) that can perform network analysis and network dataset maintenance. A network dataset models transportation networks and can perform route, closest facility, service area, origin-destination cost matrix, vehicle routing, and location-allocation network analyses on transportation networks.

For this analysis, we used the **Service Area** functions within Network Analyst to estimate **travel time** from four locations. The time estimates were calculated from Facilities (the fire stations) out along all roads in the specified project area (map below) up to four time cuts offs: 5 minutes, 10 minutes, 15 minutes, and 30 minutes. Details on the fire stations and the roads are provided below.

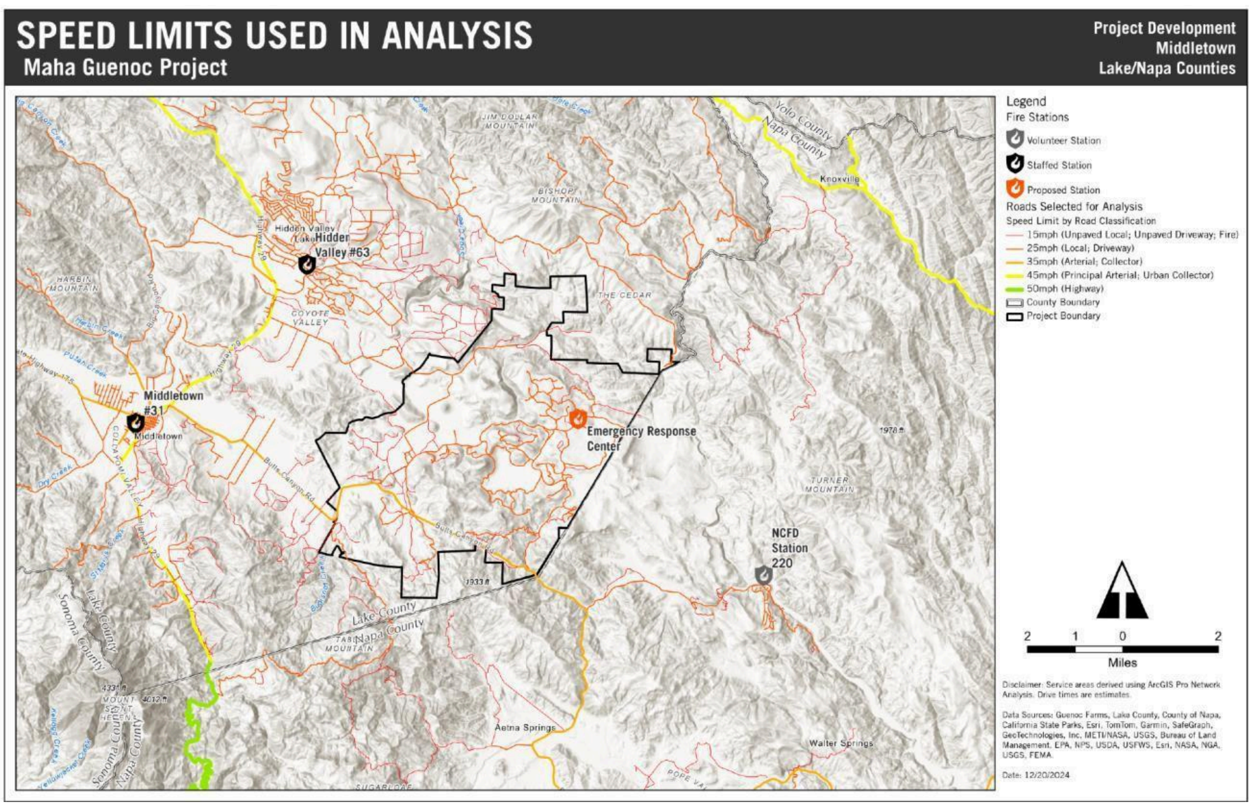


Figure 2 - Model area showing roads used in shades from red to green (color coded by speed limit used).

FIRE STATIONS (FACILITIES)

Three fire stations were included in this analysis. These three are the closest to the Maha Guenoc Development project area. The table below lists all three. Hidden Valley Fire Station (FS) is located in Hidden Valley northwest of the project area. Middletown FS is located west of the project area. And the volunteer NCFD Station on Stagecoach Canyon Rd was also included though it is not staffed and response this from station is limited.

Facility Name	Hidden Valley FS	Middletown FS	NCFD Station 220
CAD Name	MDT Hidden Valley FS	LNU Middletown FS	
AKA	Station 63	Station 31	Station 220
Facility Type	Fire Station - Schedule A	Fire Station - Schedule B	Fire Station - Other
Unit	LNU	LNU	XNA
County	Lake	Lake	Napa
Owner	Fire District Owned	State Owned	County Owned
Funding	Schedule A	Schedule B	Schedule A
Staffing	Paid	Paid	Volunteer
Address	19287 Hartman Rd	15522 Lake St., P.O. Box 428	2386 Stagecoach Canyon Rd
City	Hidden Valley Lake	Middletown	Pope Valley
ZIP	95461	95461	94567
Phone	707-785-3349	707-987-3122	707-965-2944
Latitude	38.796707	38.748312	38.702318
Longitude	-122.554144	-122.620158	-122.376741

Table 1 – Fire stations used as facilities in the network service area analyses.

The Proposed Emergency Response Center is in the center of the proposed development (show in Figure 2 in orange). This was added to the second service area scenario.

ROADS

The network used in this analysis was cobbled together from various data sources that included: the Lake County public GIS road geodatabase, the Napa County public GIS road geodatabase, and the Yolo County GIS road geodatabase (all available via ArcGIS Online REST services).

None of these layers had reliable speed limit data, but the roads were classed (though in differing classification systems). Based on these classes, the following speed limits were assigned to each road segment.

Road Class	Speed Limit
Highway	50 mph
Urban Collector; Rural Principal Arterial	45 mph
Rural Arterial, Rural Major Collector, Rural Collector, Rural Minor Collector	35 mph
Local, Driveway	25 mph
Unpaved Local, Unpaved Driveway, Fire	15 mph

Table 2 – Speed limits assigned to road classifications.

To this aggregated layer, two additional sources of road segments were added. One involved digitized road segments shown on Figure 1 from CAL FIRE's original analysis. Road segments that were on their map, but not in the county database were screen digitized, labeled as "Dirt Roads" and assigned a speed limit of 15 mph.

The second involved the project area's proposed road system, which included both paved and unpaved roads. The paved roads were labeled "Maha Guenoc Paved Rds" and given a speed limit of 25 mph. And the unpaved roads were labeled "Maha Guenoc Unpaved Rd" and given a speed limit of 15 mph.

The data layer was then planarized and the topology cleaned to inclusion into a network dataset. The following attributes are critical for the proper use of the network dataset: Speed Limit (described above), One Way (an indication of the direction of travel, all roads were assumed to have two-way directional travel), Road Class (for the network direction compilation, this is not the same as the Road Class presented in Table 2), and Street Name (if known from county databases).

MODEL PARAMETERS

The aim of this analysis is quite simple. It's just an additive process of calculating the time of travel along all road segments stemming from each facility (or Fire Station). The cumulative time is calculated by DRIVING TIME away from the facilities (or Fire Stations). The times were "dissolved" for each station, meaning all station times are merged for overlapping segments.

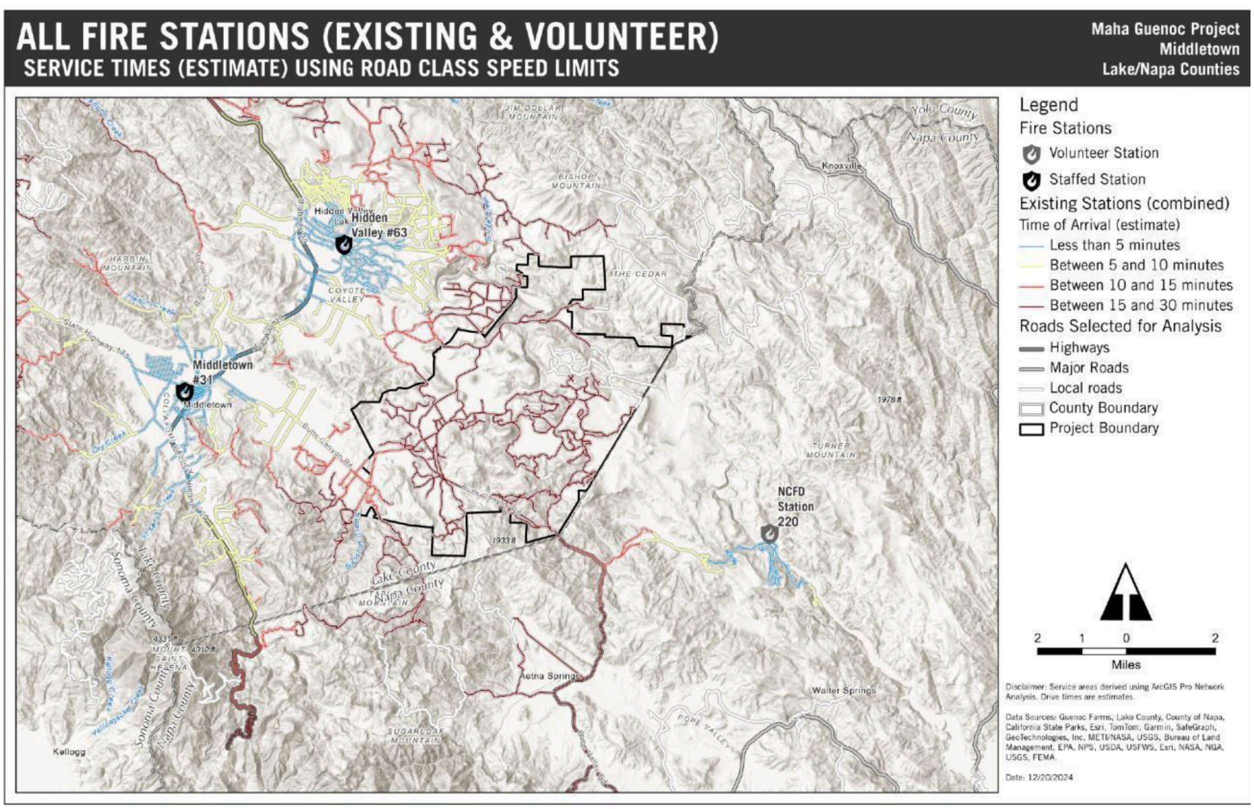
Time is added for both the FROM end of a road segment and the TO end of each road segment. Cut offs are shown for the TO end of each road segment at 5 minutes, 10 minutes, 15 minutes, and 30 minutes.

RESULTS

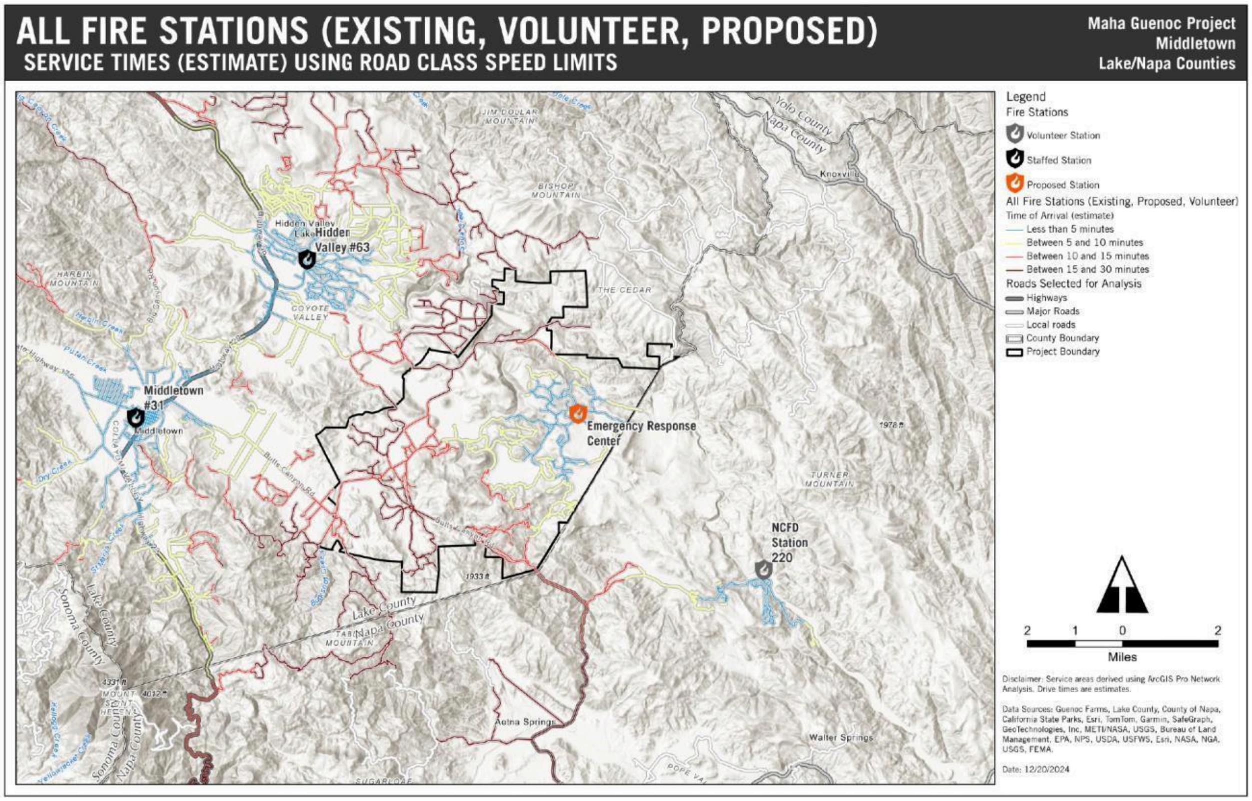
As previous stated, two scenarios were developed. The first included just the three existing fire stations (including the volunteer station in Napa County). And the second included the proposed Emergency Response Center.

The results of each are shown in the following figures.

SCENARIO 1: EXISTING FIRE STATIONS



SCENARIO 2: EXISTING FIRE STATIONS WITH PROPOSED FIRE STATION

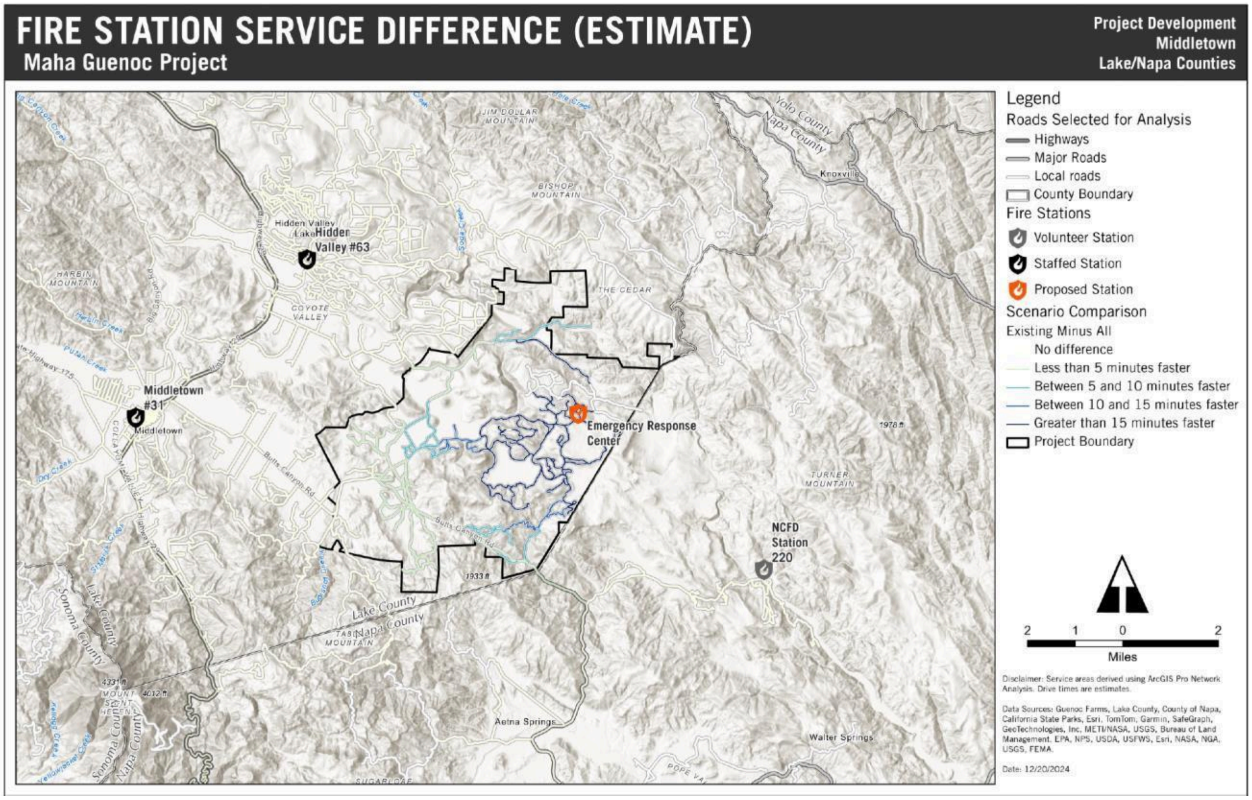


TIME DIFFERENCE BETWEEN SCENARIOS

Since not all road segments were included in each scenario above (due to the fact that not all road segments were reached within the time constraint), a direct comparison is not possible.

However, we could take the segments that were solved for each scenario within the Proposed Scenario (with the shortest estimated times for the Maha Guenoc development area) and subtract that from the Existing scenario (with the longest estimate times for the Maha Guenoc development area) to determine the estimated improvement in service time.

This is shown on the next map on the proceeding page.



DISCUSSION

Given the speed limits used, the results from Scenario 1 show that most of the roads within the Maha Guenoc development project area can be reached within 30 minutes from either three existing FS stations.

Scenario 2 shows a remarkable improvement in that estimated service time due to the fact that the Emergency Response Center is located at almost the center of the proposed development. Under this scenario, of course, most streets within the development are reached under 15 minutes.

For the streets immediately closest to the proposed Emergency Response Center, there is a reduction of service time of up to 28 minutes.