Appendix J-1

Fire Behavior Analysis and Report

Fire Behavior Analysis and Report
Gateway Village

Prepared for:

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Date: 12/30/24

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FIRE BEHAVIOR ANALYSIS AND REPORT
Irvine, California

Purpose and Scope of Report

Firesafe Planning Inc. (Firesafe) assessed the wildland fire-related risks to establish the appropriate criteria for the design of a performance-based Fuel Modification Zones (FMZ)/defensible space system and maintenance program that will reduce the intensity of a wildfire approaching the Gateway Village project site. This report provides the results of that assessment and objective, defensible space criteria for this project site that is equal to or greater than the risk which would be encountered in a worst-case scenario. The study takes into consideration existing/future vegetative interface fuels, topography, and weather conditions during a fire. The report provides results of computer calculations that measured the fire intensity and flame lengths from a worst-case scenario wildfire in both the extreme (Santa Ana wind) and the predominant (Onshore wind) wind conditions. The results of fire behavior calculations have been incorporated into the Fuel Modification Zone designs, which will be applied to the wildland interfaces of the project site.

Project Overview

General Geographic Description

The Gateway Village Project site is located within the City of Irvine, in the County of Orange, California. The approximately 120-acre project site is in north Irvine, at the northeast corner of Portola Parkway and Jeffrey Road. The site is bounded by Portola Parkway to the south, Jeffrey Road/Hicks Haul Road to the northwest, and Bee Canyon Access Road to the east, Hicks Canyon Wash to the north. (Figure 1, below, and Figure 2 and 3 on the next page).

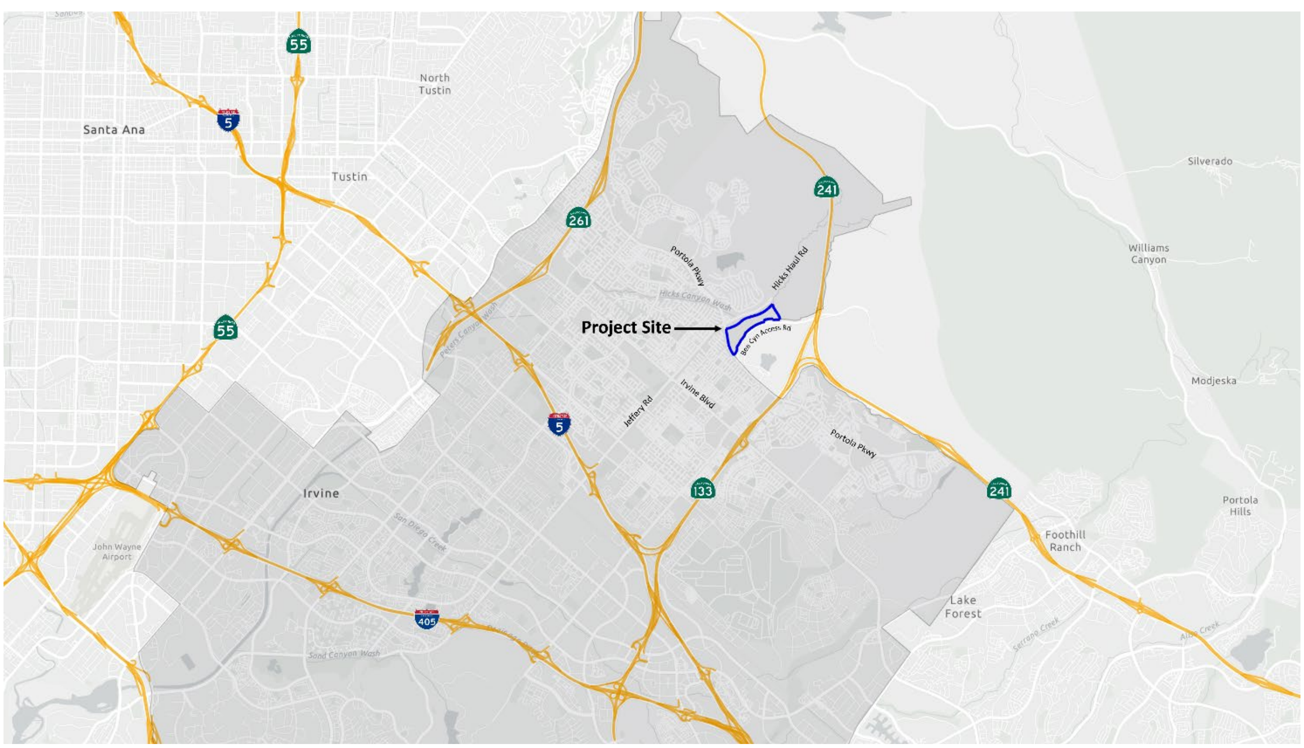


Figure 1 - Vicinity Map

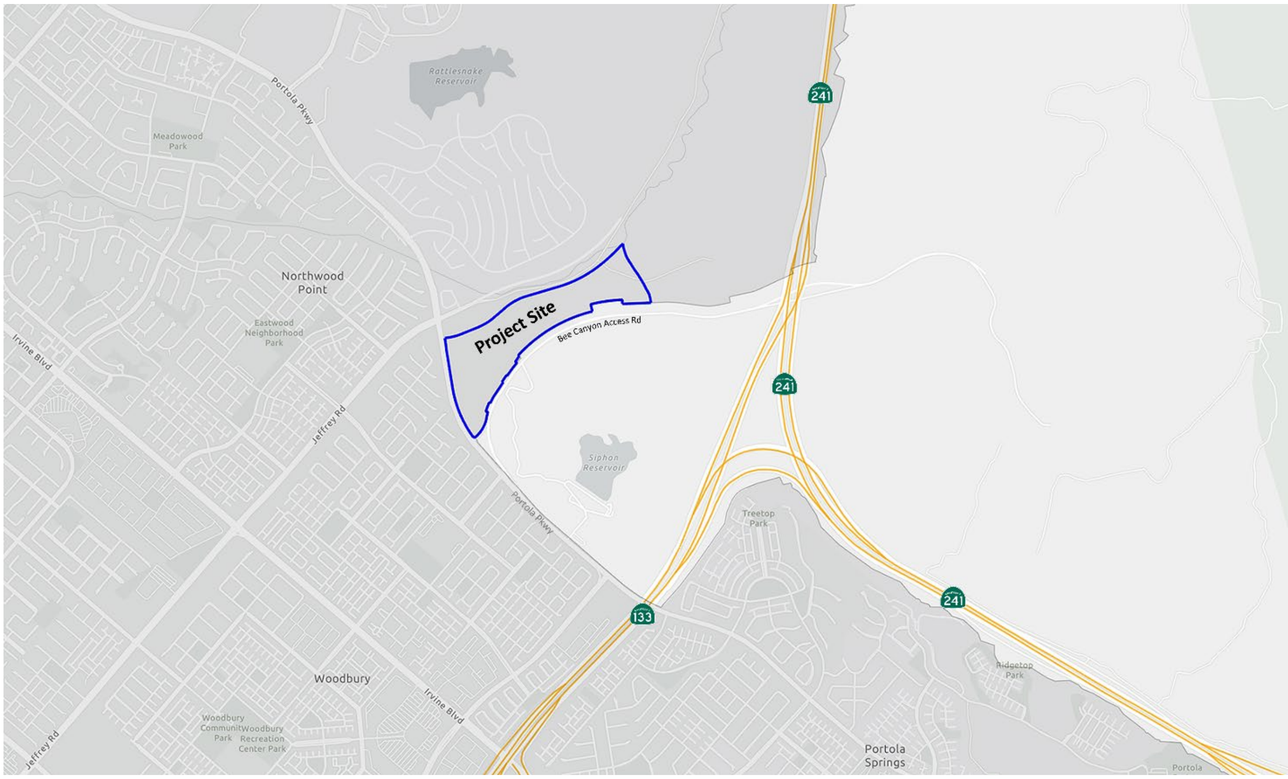


Figure 2 - Location Map

Figure 3 – Project Site Map

To the northeast of the project site is the Irvine Ranch Conservancy Native Seed Farm featuring two shade-houses, a seed processing facility, two cold storage bins for seed, a dedicated seed drying area, an onsite office and a shaded staging area. The Farm currently produces around 1,000 pounds of seed annually, while also growing and nurturing over 50 native plant species. This specific interface will be discussed later in this report.

The Gateway Village project site will take its access off of Portola Parkway from the west and off od Jeffery Road from the north with a secondary access point of the Hicks Canyon Wash access roadway on the northeast edge of the project site, which travels back to Jeffery Road.

The project site is within LRA (Local Responsibility Area) as it is within an incorporated city limit. The Gateway Village Project site is located partially within and adjacent to CalFire Very High Fire Hazard Severity Zones, and the City of Irvine adopted Fire Severity Zones as shown below in Figure 4.

The Fire Severity Zones are geographical areas designated pursuant to California Public Resources Code Sections 4201 through 4204. They are classified as Very High, High, or Moderate in State Responsibility Areas (SRA) or as Local Agency Very High Fire Hazard Severity Zones designated pursuant to California Government Code sections 51175 through 51189.

CalFire Fire Hazard Severity Zones Map – Local Responsibility Areas

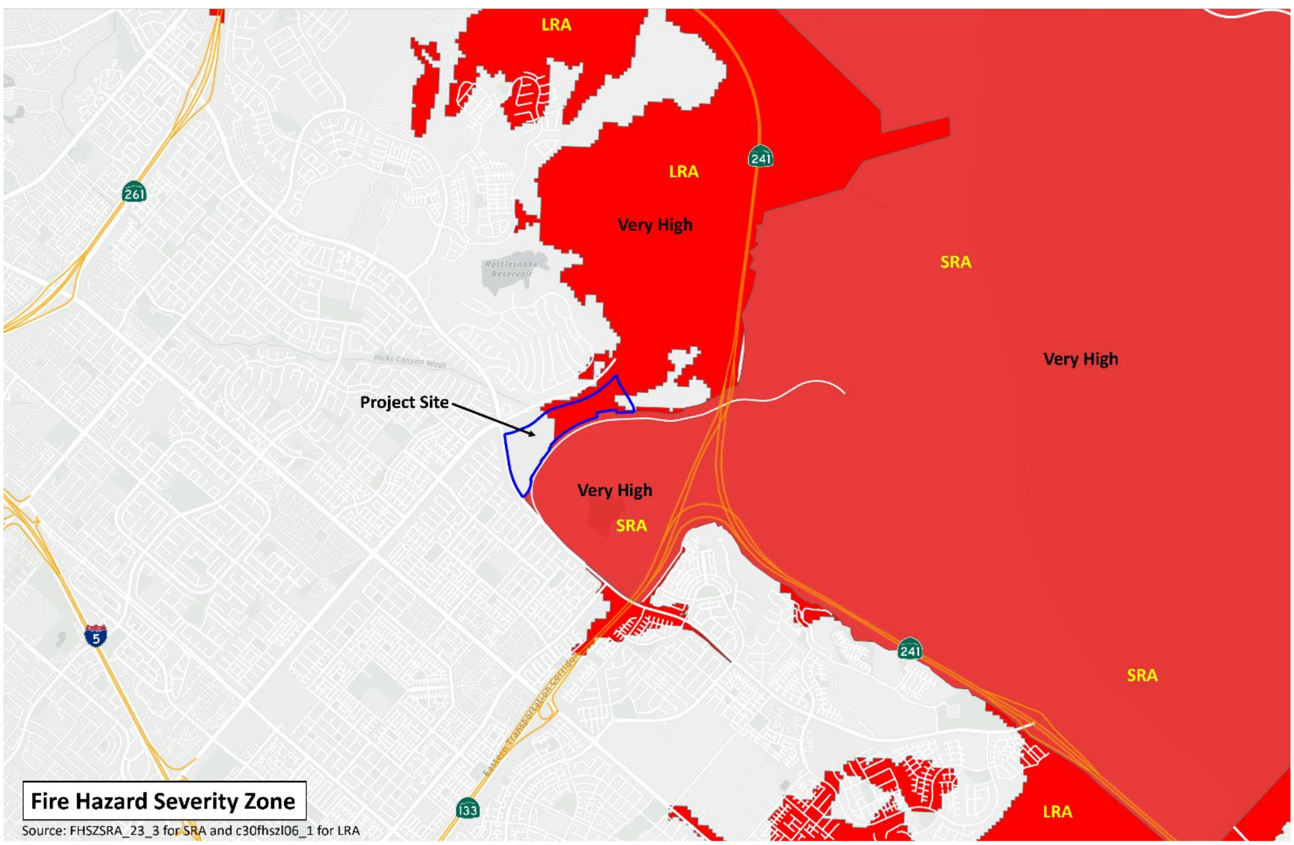


Figure 4 - Fire Hazard Responsibility Areas

All areas within Fire Hazard Severity Zones in either SRA or LRA areas are required by state code to comply with Chapter 7A of the California Building Code, Chapter 49 of the California Fire Code, and Section R337 of the California Residential Code as adopted and amended by the local agency (Orange County Fire Authority and the City of Irvine for this project site). Areas within High and Moderate Zones within LRA areas are also required to comply with similar code requirements as established by the hazard zone adoption process in each jurisdiction. LRA zones are currently under revision (previously on Very High LRA zones had to be adopted) and draft zones are expected in early 2025. It is expected that the balance of the project site will be placed into a fire hazard severity zone with most if not all of the project site being zoned "Very High".

Fire Risk Assessment

Fire risk assessment is based on several factors. These include the fire history of the development area and the surrounding areas; the vegetation (fuel) that surrounds the project site; the weather history for the general area and the specific site; the topography of the project site (slope and aspect); and the placement of structures relative to the factors listed above.

The fire behavior analysis for this project site was completed to develop a performance-based fire protection system based on the modeling results (based on a worst-case scenario) for the Gateway Village project site. By using the worst-case scenario fire conditions, it is expected that any future fires will be equal to or less extreme than those modeled here and would produce fire behavior spread/intensity at was within the risks analyzed and, therefore, be safe.

Firesafe completed the fire hazard assessment and expected wildland fire behaviors in order to provide design criteria and maintenance program standards for the fuel modification zones at this specific site that will provide the necessary protection in the event of a wildland fire. Any revision to the approved Fuel Modification Plan must be reviewed/approved by the Orange County Fire Authority prior to any changes within the wildland interface of the project site.

Fire History

A review of the CalFire database (FRAP), which maintains a statewide spatial database of fire perimeters from BLM, NPS, and USFS fires 10 acres and greater in size, and CAL FIRE fires 300 acres and greater in size since 1980, is shown on page 8 (Figure 7). Collection criteria for CAL FIRE fires changed in 2002 to include timber fires greater than 10 acres, brush fires greater than 50 acres, grass fires greater than 300 acres, fires destroying three or more structures, and fires causing $300,000 or more damage. In 2008, the collection criteria for CAL FIRE fires eliminated the monetary criterion and redefined the definition of structures.

The Gateway Village Project site is outlined in blue in the figures on the next page (Figures 5 and 6). The fire perimeters are shown in red with a shading effect that allows the overlap between fire perimeters to be seen. The overlap areas are more highly shaded so that it is possible to see the areas that have had more fire activity and the extent of each of the perimeters without having to provide separate graphics for each. As shown in the graphics, there have been five large fires near the project site where records have been kept (105 years) and one small fire. In fact, the areas to the north, south, and east of the project site have significant large fire history and are considered to be "historic fire corridors". Fires are likely to continue to burn within the areas to the north, east, and south as these areas are designated as "open space" and are intended to remain so in perpetuity.

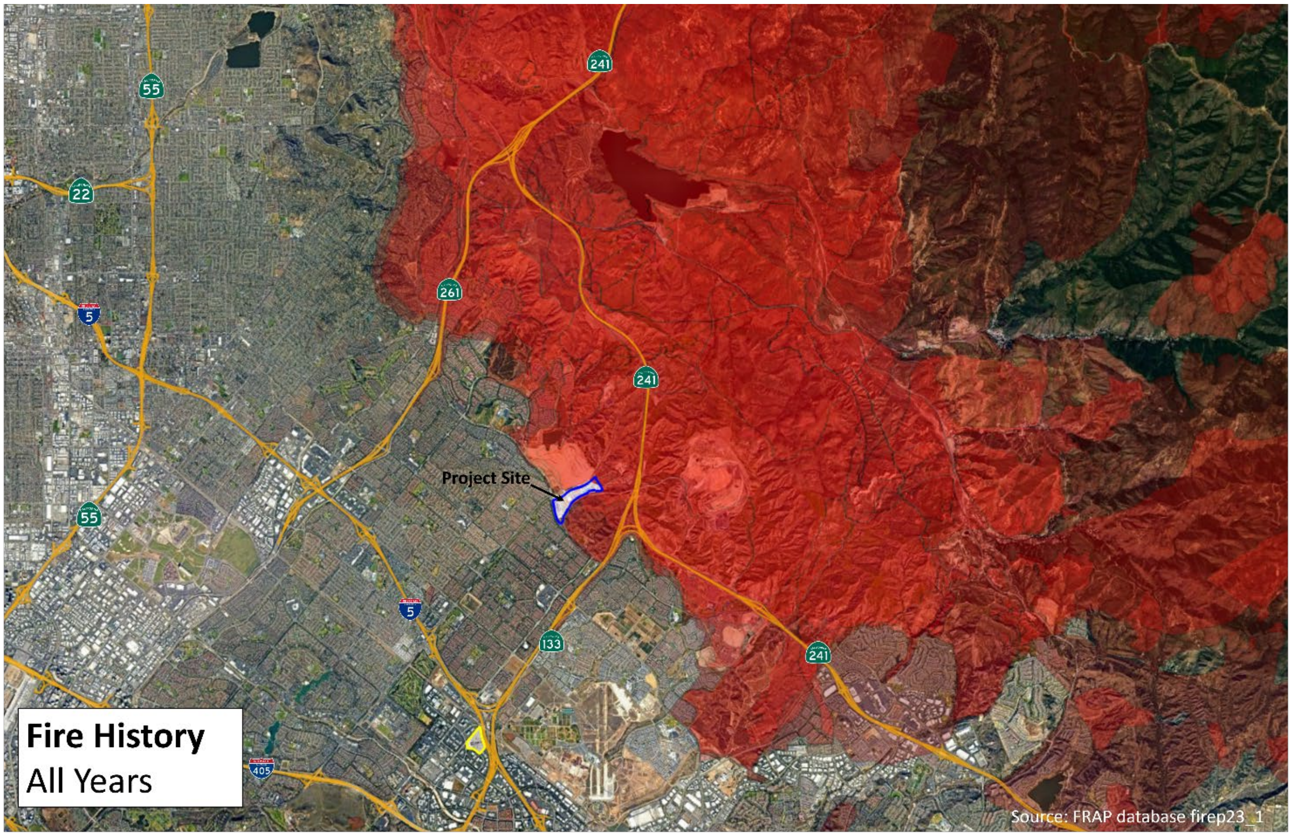


Figure 5 – Fire History Map (All years)

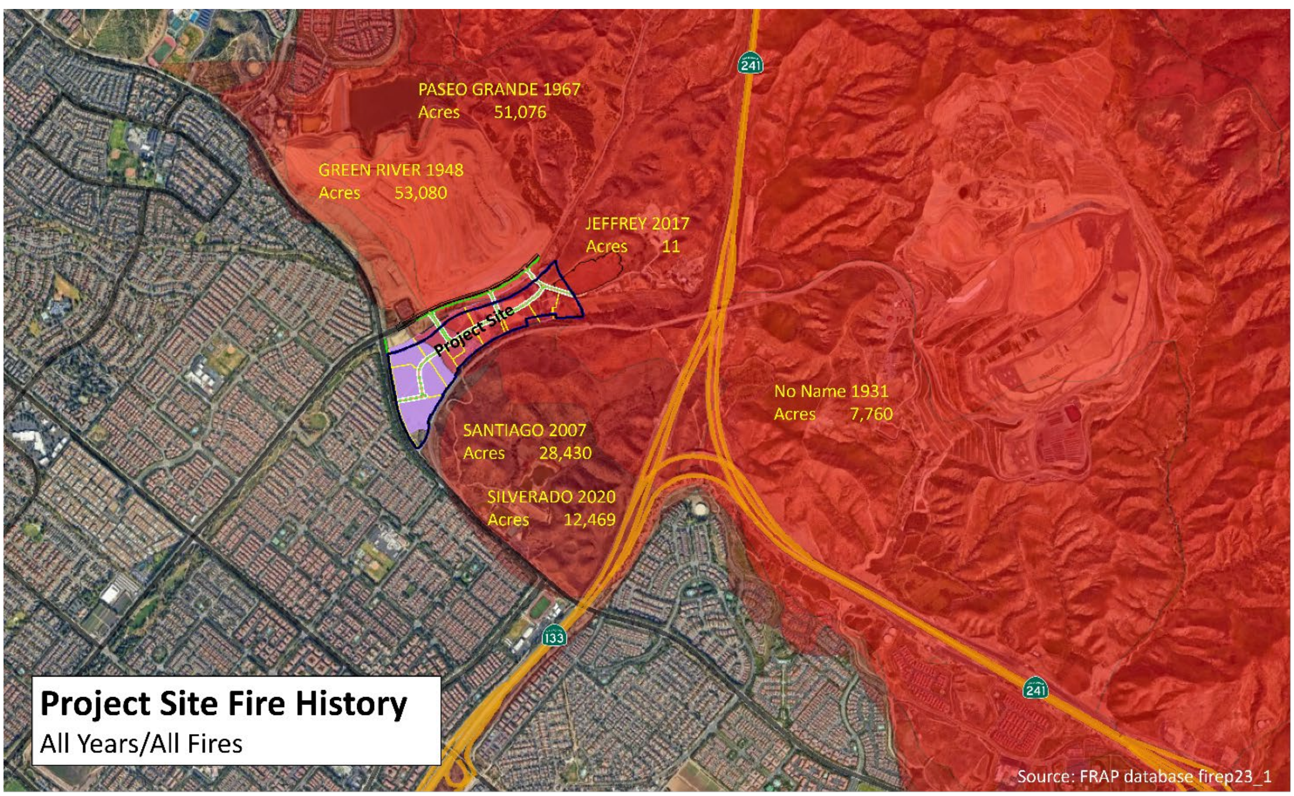


Figure 6 – Site Fire History Map

All of the fires near the project site with the exception of the Jeffery Fire in 2017 have been large fires (greater than 7,000 acres) which have burned into the area from origins in other areas of the county. All of the large fires have stopped or been stopped at what is now Portola Parkway. In 1931, 1948, and 1967, this area would have been strictly agricultural groves. The fires likely stopped due to the change in, or lack of wildland fuels coupled with the changes in topography (flat as opposed to hillside), which no longer channeled or accelerated the winds from the N/NE (traditional direction of strong winds during fires in the region). The 2017 fire (Jeffery Fire) was held to a single hillside alongside the Hicks Wash access road (Figure 7, below).

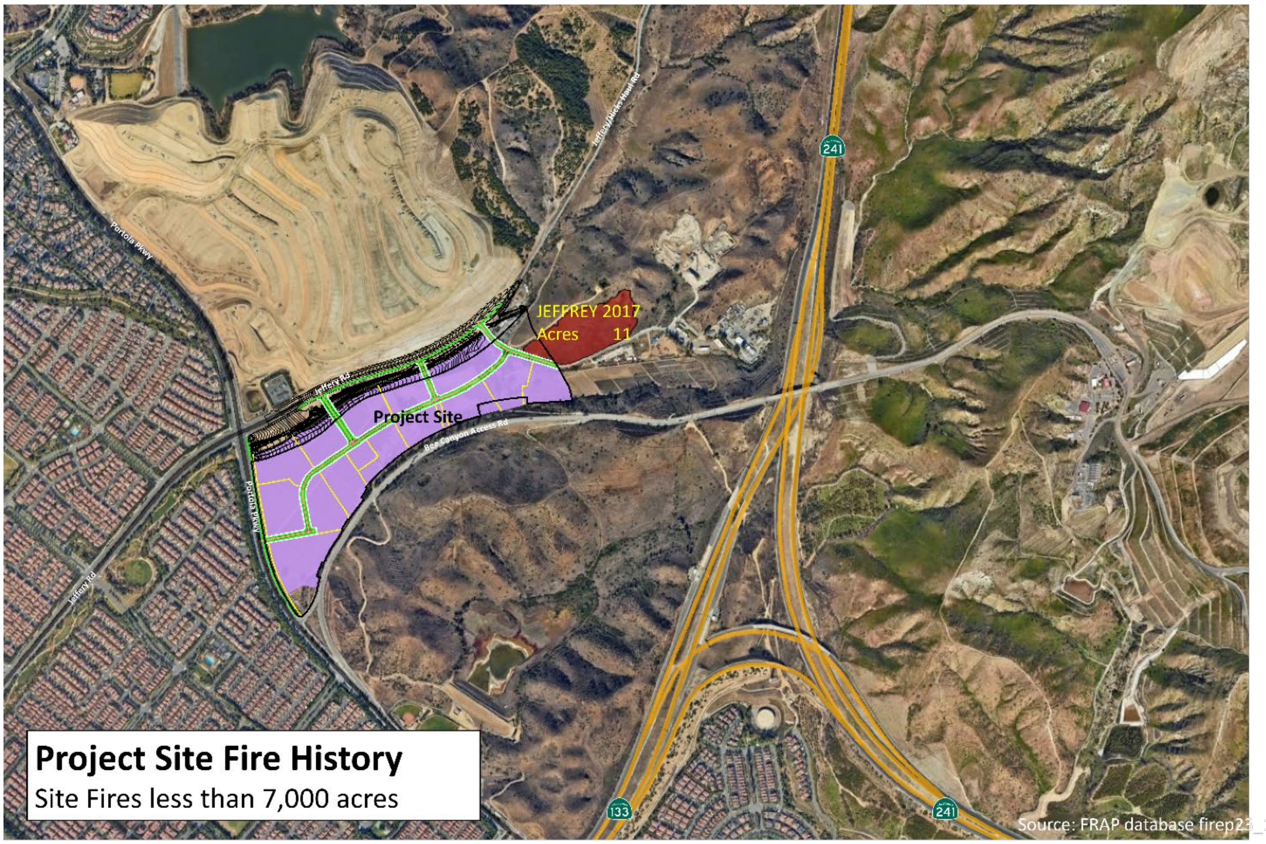


Figure 7 – Project Site Fire History without Large Fires

Fire Behavior Analysis (BehavePlus)

The BehavePlus, Fire Behavior Prediction and Fuel Modeling System is the most popular and accurate method for predicting wildland fire behavior in prefire defense planning. The BehavePlus fire behavior computer modeling system is utilized by wildland fire experts nationwide. Because the model was designed to predict the spread of a fire, the fire model describes the fire behavior only within the flaming front. The primary driving force in the fire behavior calculations is the dead fuel less than ¼" in diameter; these are the fine fuels that carry the fire. Fuels larger than ¼" contribute to fire intensity but not necessarily to fire spread. The BehavePlus fire model describes a wildfire spreading through surface fuels, which are burnable materials within 6' of the ground and contiguous to the ground. This type of modeling demonstrates the potential of a wind driven fire that could potentially enter the Special Maintenance Area from the adjacent wildland areas.

Weather Inputs and Wind Patterns

After a review of the weather data, the most extreme wind patterns and speeds relating to wildfires were entered into the modeling programs (BehavePlus and Wind Ninja, which is a computational fluid dynamics wind model software funded by the US Forest Service, Joint Fire Science Program and the Center for Environmental Management of Military Lands at Colorado State University). All other lesser wind patterns and wind speeds typically produce less fire intensity based on a fire in wildland fuels and have not been analyzed for this report. A Remote Weather Site (RWS) is found on the project site (Figure 8 below). Data from this site was also used to validate the wind speeds and other BehavePlus input modeling for the site. The site is managed by Southern California Edison (SCE) for its Wildfire Safety Programs under the Public Safety Power Shutoffs (PSPS) decision process to reduce the risk during fire weather events. The SCE site located on the project site)SE136) has 5.8 years of data available at the time of this report. The site was placed into service on 3/8/19 and has been running continuously.

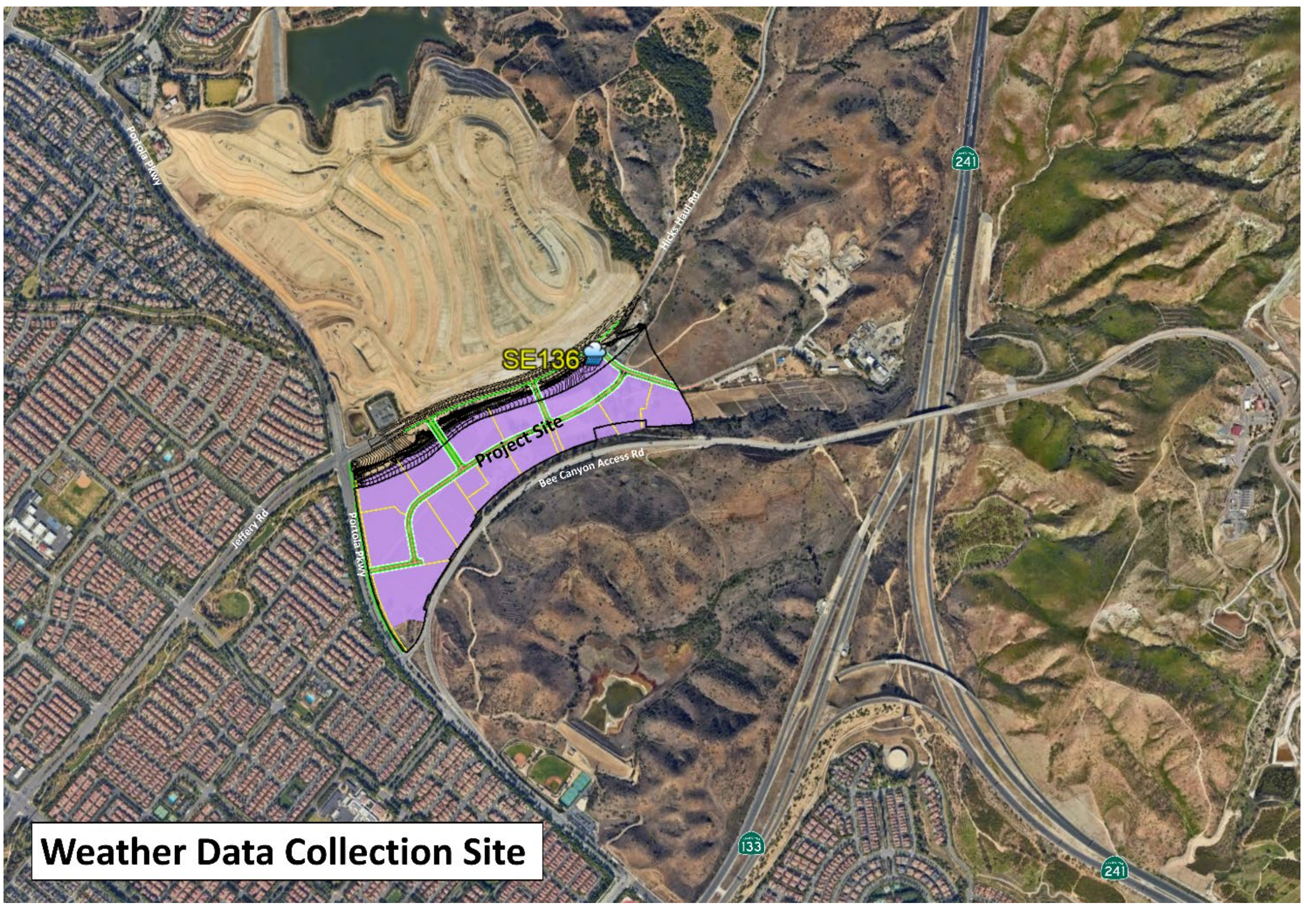


Figure 8 – Remote Weather Site Location

On the following page, (Figure 9), the compass rose is superimposed onto the project site so that the orientation of the wind and its relationship to the project boundaries can be illustrated. These same compass headings will be used to reference the wind direction, aspect, and fire spread direction during the fire behavior discussion.

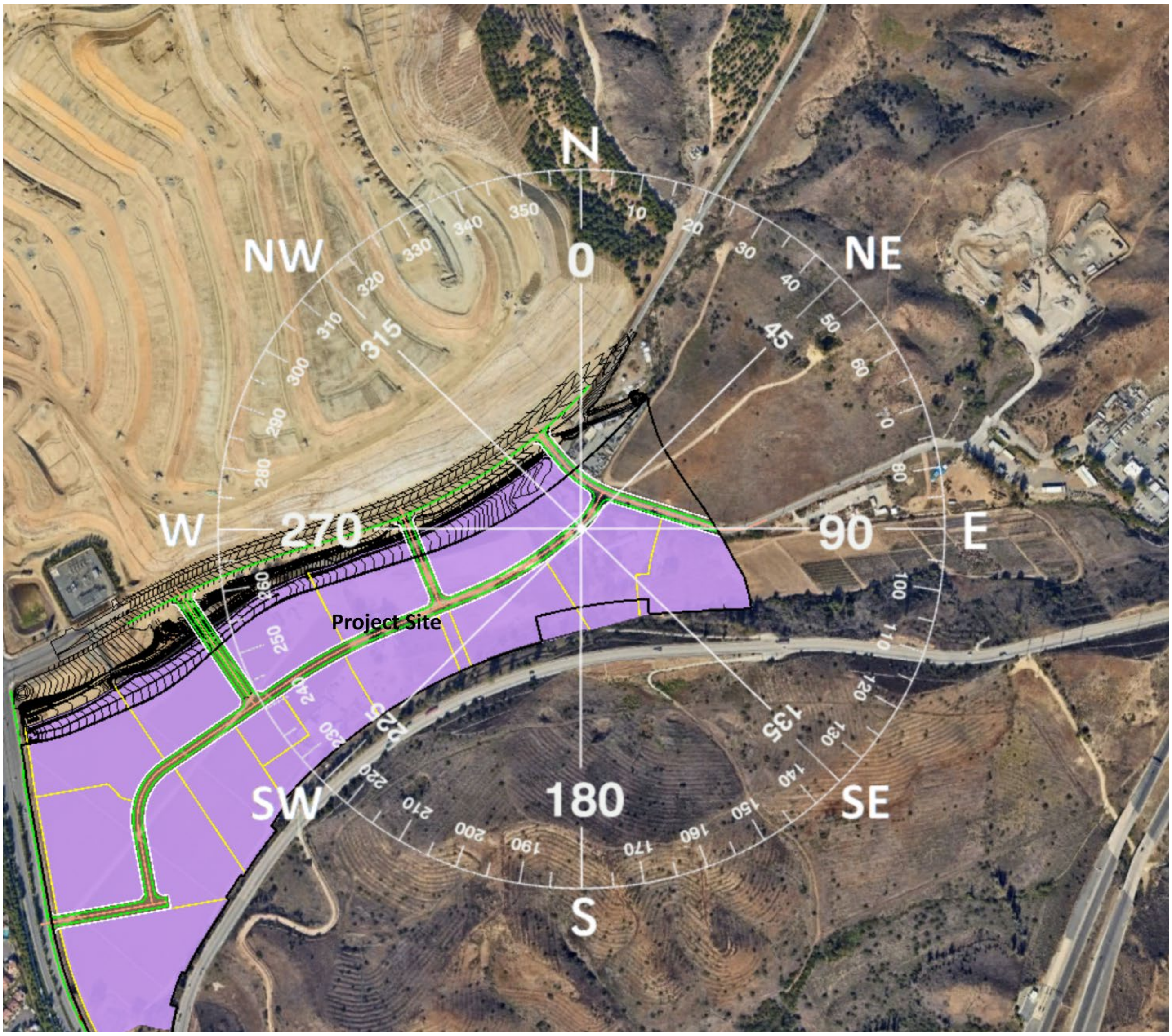


Figure 9 – Compass Directions

The results of the RWS data are shown on the wind rose graph in Figure 10 on the next page. This graph clearly shows the prevailing wind direction from the southwest/west for the onshore winds and from the northeast for the offshore flow. Occasionally, Santa Ana Wind events bring a stronger offshore flow, but the direction is not affected.

In Figure 11, next page, the wind rose has been superimposed onto the project site and the predominant winds depicted. It is easy to see that the wind aligns with the topography to produce up and down canyon winds for most of the wind directions on most days. The typical diurnal wind flow (onshore during the day and offshore at night) is caused by temperature differences between the land mass and the adjacent ocean. Santa Ana winds are cause by high pressure cells inland seeking equilibrium with the air over the ocean (offshore flow) but with greater intensity than the normal diurnal flow.

The data recaps on page 12 provide an overview of the 5 years of data. The shows a maximum wind speed of 37 mph and maximum wind gust of 59 mph. The lowest Relative Humidity (RH) was 4%.

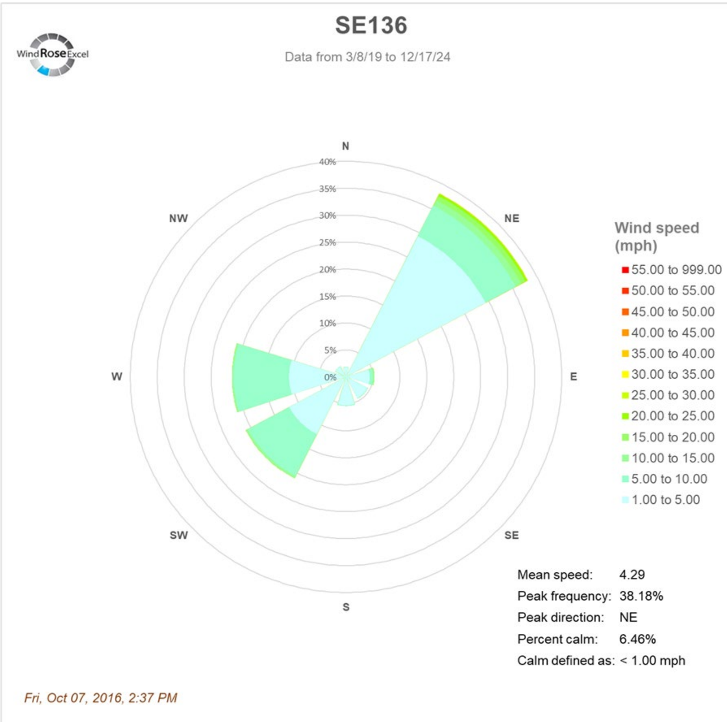


Figure 10 – Wind Rose

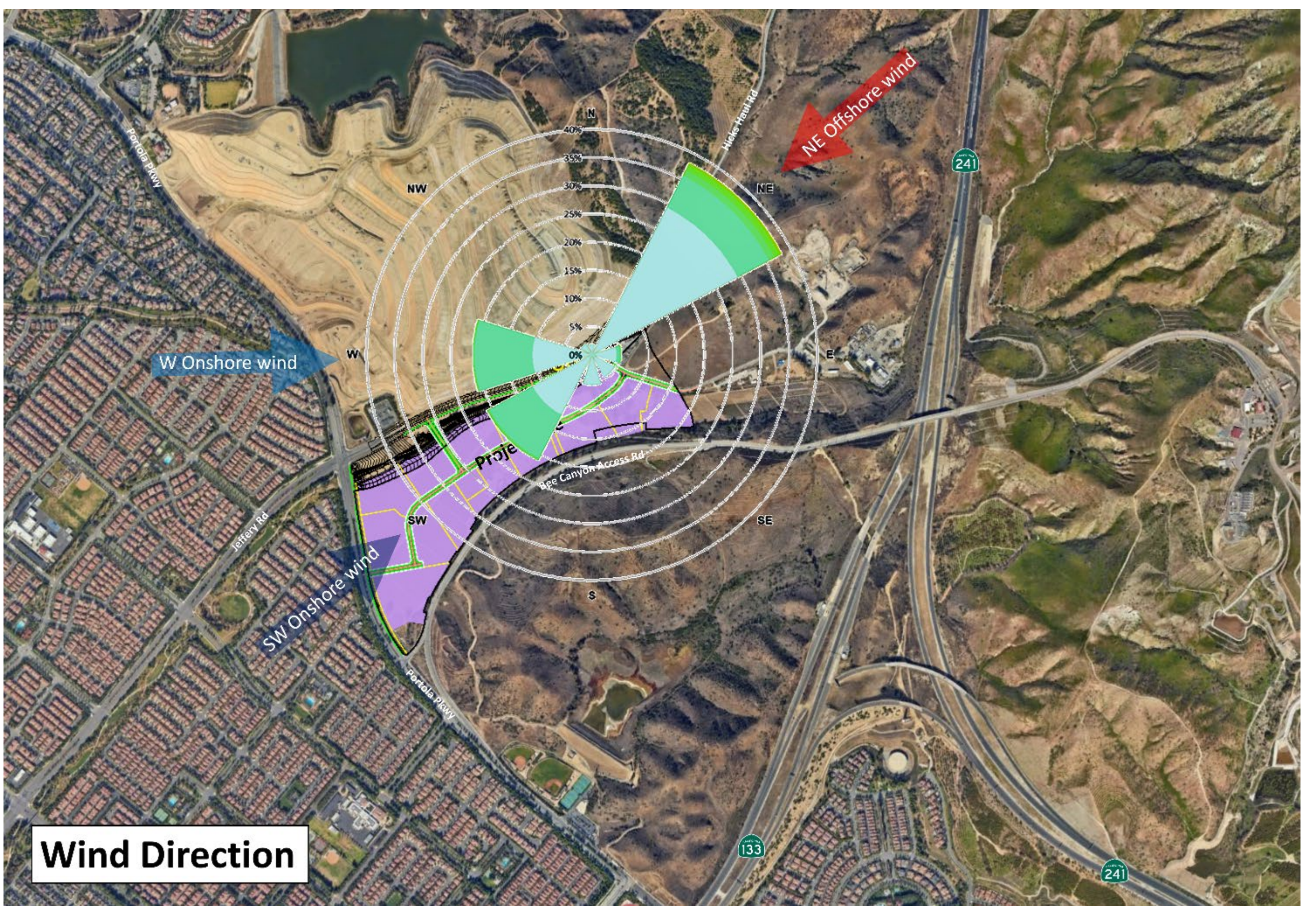


Figure 11 – Wind Rose Superimposed over the Project Site for Reference

SE136	Temp	RH	Wind	Direction	Gust
Min	35	4	0	0	0
Max	108	100	37	360	59
Average	63	68	4	154	7
99th	88	99	17		27
1st	44	10	0		1

SE136		Wind		Gust	
Greater than					
	60	-	0%	-	0%
	55	-	0%	4	0.001%
	50	-	0%	11	0.004%
	45	-	0%	72	0.02%
	40	-	0%	249	0.1%
	35	1	0.0003%	747	0.2%
	30	31	0.01%	1,793	1%
	25	323	0.1%	3,832	1%
	20	1,342	0.4%	7,256	2%
	15	4,104	1%	15,545	5%
	10	10,405	3%	63,781	21%
	5	90,240	30%	202,662	67%
	0	302,730	99.7%	303,093	99.9%
Blank		260	0.1%	-	0%
zero		524	0.2%	421	0.1%
Total		303,514		303,514	

SE136		Wind Gust (mph)								
Cardinal	Count	Percent	<5	>5	>10	>20	>30	>40	>50	>60
N	2,243	0.7%	1,662	581	152	7	-	0	0	0
NNE	7,530	2.5%	5,030	2,500	560	126	10	0	0	0
NE	89,599	29.5%	37,286	52,313	4,018	2,181	599	100	9	0
ENE	25,249	8.3%	10,288	14,961	6,415	3,959	1,147	148	2	0
E	7,139	2.4%	3,683	3,456	751	95	14	1	0	0
ESE	8,155	2.7%	3,411	4,744	1,237	72	-	0	0	0
SE	7,996	2.6%	3,646	4,350	819	59	1	0	0	0
SSE	6,817	2.2%	3,588	3,229	479	14	-	0	0	0
S	7,574	2.5%	3,944	3,630	611	4	-	0	0	0
SSW	13,809	4.5%	5,126	8,683	2,539	27	1	0	0	0
SW	26,582	8.8%	5,879	20,703	7,743	139	-	0	0	0
WSW	52,677	17.4%	5,645	47,032	23,933	423	16	0	0	0
W	34,906	11.5%	4,616	30,290	13,234	122	3	0	0	0
WNW	7,923	2.6%	3,267	4,656	1,053	25	2	0	0	0
NW	3,011	1.0%	1,975	1,036	132	1	-	0	0	0
NNW	1,780	0.6%	1,282	498	105	2	-	0	0	0
Blank	524	0.2%	-							
	303,514	100.0%	100,328	202,662	63,781	7,256	1,793	249	11	-
			33.1%	66.8%	21.0%	2.4%	0.6%	0.1%	0.004%	

Figure 12 – RWS data (5 years)

The strongest winds are from the NE and ENE but only consist of one-tenth of one percent of the total wind values. In fact, at the 99th percentile of the dataset, the wind gust speed is 27 mph.

BehavePlus Calculation wind inputs for computer fire runs - worst-case scenarios are:

- 60 mph NE offshore wind
- 30 mph SW onshore wind

After establishing the wind direction and speeds to be used in the modeling, it is essential to also understand how the wind travels across the landscape (topography). This is accomplished by using the software program from the Missoula Fire Sciences Laboratory called Wind Ninja. The site states, "*Wind is one of the most important environmental factors affecting wildland fire behavior. Complex terrain in fire-prone landscapes induces local changes in the near-surface wind that are not predicted well by either operational weather models or expert judgment. WindNinja was developed to help fire managers predict these winds.*" For this analysis, version 3.11.2 has been used.

The offshore flow (NE) was modeled at 60 mph to simulate the stronger wind gust recorded at the site over the past 5.8 years. Wind is shadowed or sheltered in the interface with the project at the Seed Farm and along the Hicks Canyon Wash access road. With the domain average wind speed set at 60 mph, the site boundary does not experience winds over that level. Most of the interface is below 146 mph.

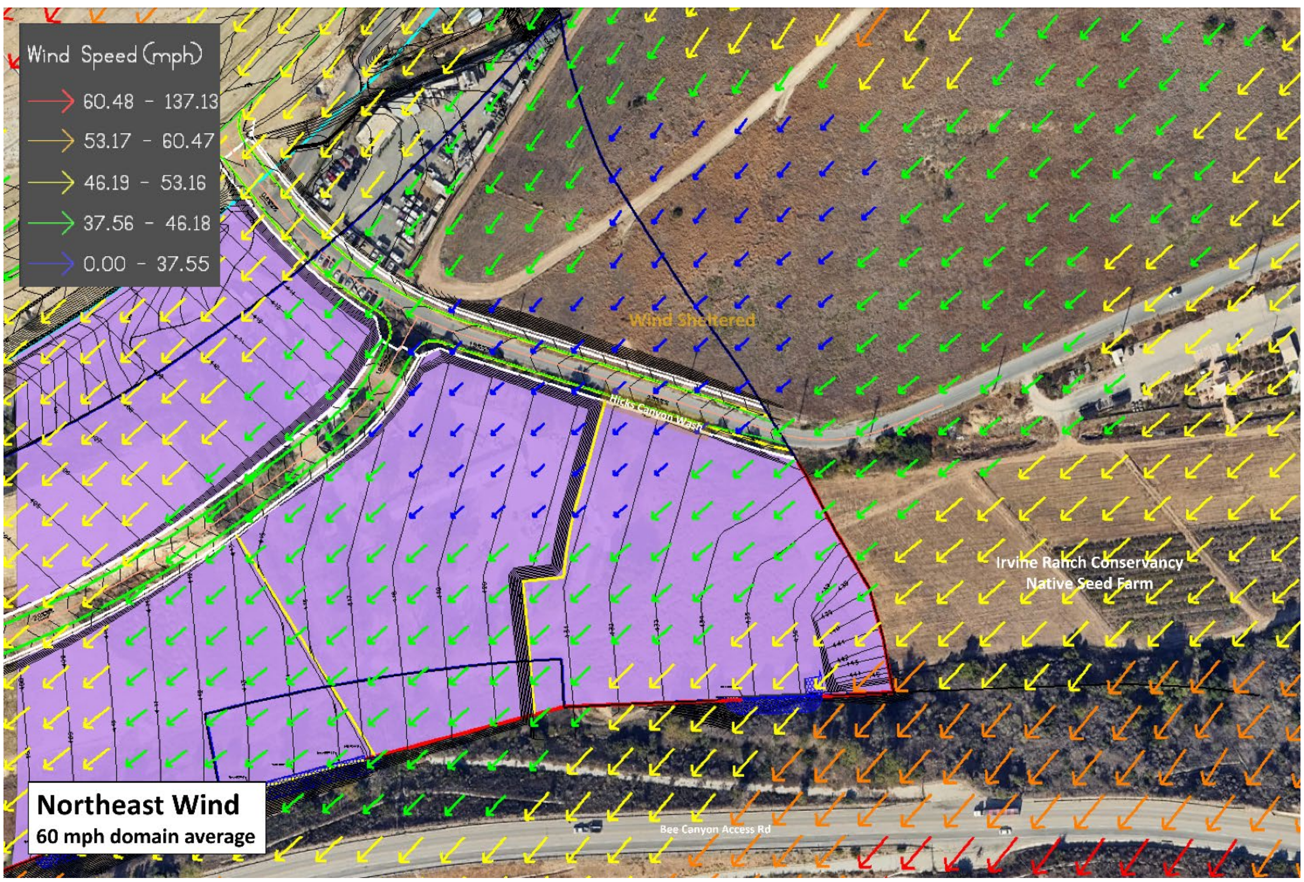


Figure 13 -Wind Ninja Output over the Project Site - NE Wind

For this eastern interface (Seed Farm and Hick Canyon Wash) the SW wind would take fire away from the project site along the entire interface. Along the Bee Canyon Access Road (bottom of Figure 14) the wind is sheltered by the roadway being above the project site.

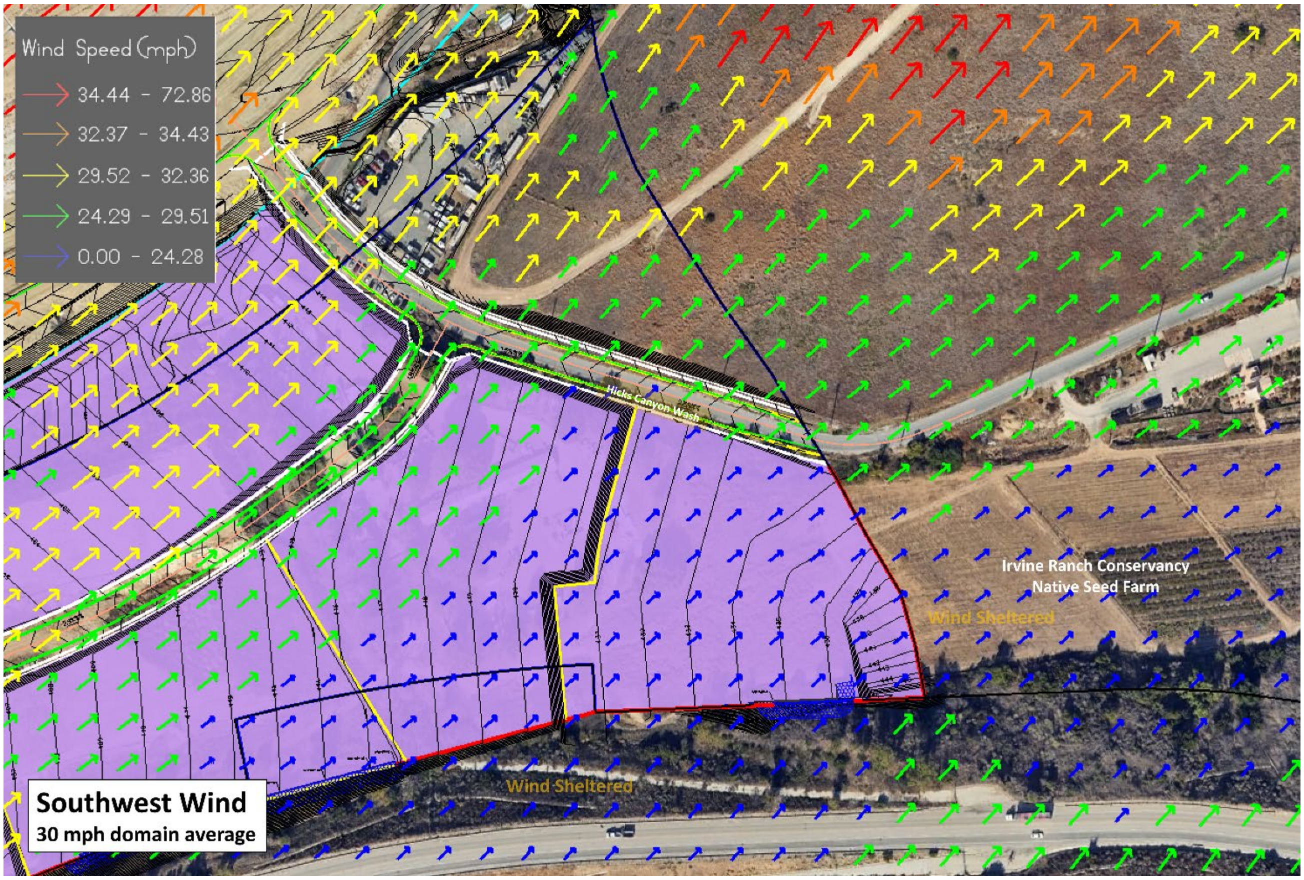


Figure 14 - Wind Ninja Output over the Project Site - SW Wind

The project site does not have areas of wind acceleration, nor does it have increased winds due to other topographical features on or near the site.

Wildland Interface Fuel Types

For the purposes of the BehavePlus modeling by the standardized fuel models were used as provided by the National LANDFIRE Database maintained by U.S. Department of the Interior U.S. Geological Survey. Figure 16, on the next page, provides an illustration of the wildland fuels adjacent to the Gateway Village Project site. The large majority of the wildland interface area around the project site is GR1 (101), GR2 (102), GS1 (121), with some GS2 (122), and TL6 (186).
Fuel Parameters are as follows:

Fuel **Model GR1** (101) Dry Climate Grass is short, patchy, and possibly heavily grazed. Spread rate moderate, flame length low. Dynamic. Moisture of extinction is 15%. Fuel bed depth is 0.4 feet.

Fuel **Model GR2** (102) Dry Climate - Moderately coarse continuous grass, average depth about 1 foot. Spread rate high, flame length moderate. Dynamic. Moisture of extinction is 15%. Fuel bed depth is 1.0 feet.

Fuel **Model GS1** (121) Dry Climate - Shrubs are about 1-foot high, low grass load. Spread rate moderate, flame length low. Dynamic. Moisture of extinction is 15%. Fuel bed depth is 0.9 feet.

Fuel **Model GS2** (122) Dry Climate - Shrubs are 1 to 3 feet high, moderate grass load. Spread rate high, flame length moderate. Dynamic. Moisture of extinction is 15%. Fuel bed depth is 1.5 feet.

Fuel **Model TL6** (186) Fuelbed not recently burned. Fuelbed composed of broadleaf (hardwood) litter. Moderate load, less compact. Spread rate moderate; flame length low. Moisture of extinction is 25%. Fuel bed depth is 0.3 feet.

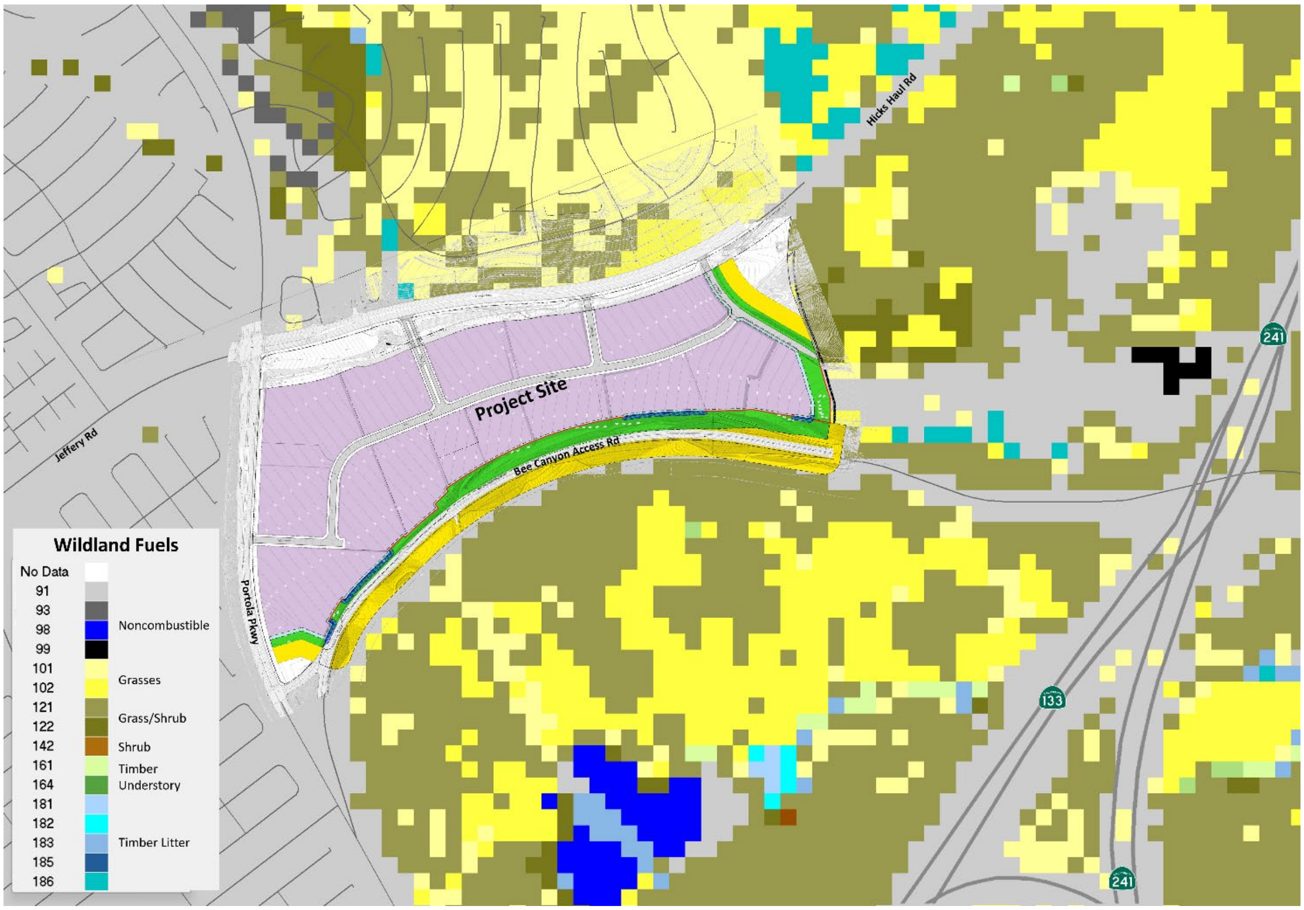


Figure 15 – Wildland Fuels (Landfire Database – Scott and Burgan 40)

In addition to the standard fuel models (Scott and Burgan 40), one specific Southern California fuel model is applicable to this site, and that is the Sage/Buckwheat model (SCAL18). This is the predominant fuel type in the GS fuels on the site. The parametersare shown below:

Fuel **Model SCAL18** is a southern California-specific model for coastal sage scrub and Buckwheat OR dominated by coastal sage scrub AND greater than 15 years maturity OR dominated by northern mixed chaparral AND greater than or equal to 3 years maturity AND less than or equal to 12 years maturity. The vegetation has an average fuel depth of 3 feet and a moisture of extinction of 25%.

Fuels Discussion

The predominant fuels near the project site are grasses, grass/scrub mixtures, and tree understory as shown above and in a series of photos in Appendix B of this report. Each of the grids is 30 meters square (just under ¼ acre). Fuels parameters for each grid are determined by the predominant fuel types. This does mean that other fuels can and may be present in each grid. All six of the fuel models above are represented within the interface area.

When completing the field validation of the Landfire data, it was determined that the areas adjacent to the project site had some Sage and Buckwheat on and in the Seed Farm. While not currently covered, it could be covered entirely with Sage and Buckwheat. While this is not the predominant fuel at present, a case could be made for the entire slope being overrun by this fuel type. Since this fuel type (SCAL18) has a higher flame length and energy component, it was used as the worst-case fuel for this site.

Photo 1, below, shows the grass/shrub fuel arrangement which covers the majority of the project site interface. It qualifies as a GS2 in terms of composition, fuel loading, and fuel height but does contain both buckwheat (Eriogonum fasciculatum) and sagebrush (Artemisia californica) in quantities large enough to be concerned about how the fuel bed will evolve. The few large shrubs are mostly Toyon (generally fire-resistant). There are many areas of invasive species, such as the black mustard (Brassica nigra) shown here in Photo 1. These are not as much of a concern as the sage/buckwheat combination (SCAL18) fuels, which burn with a much higher intensity.

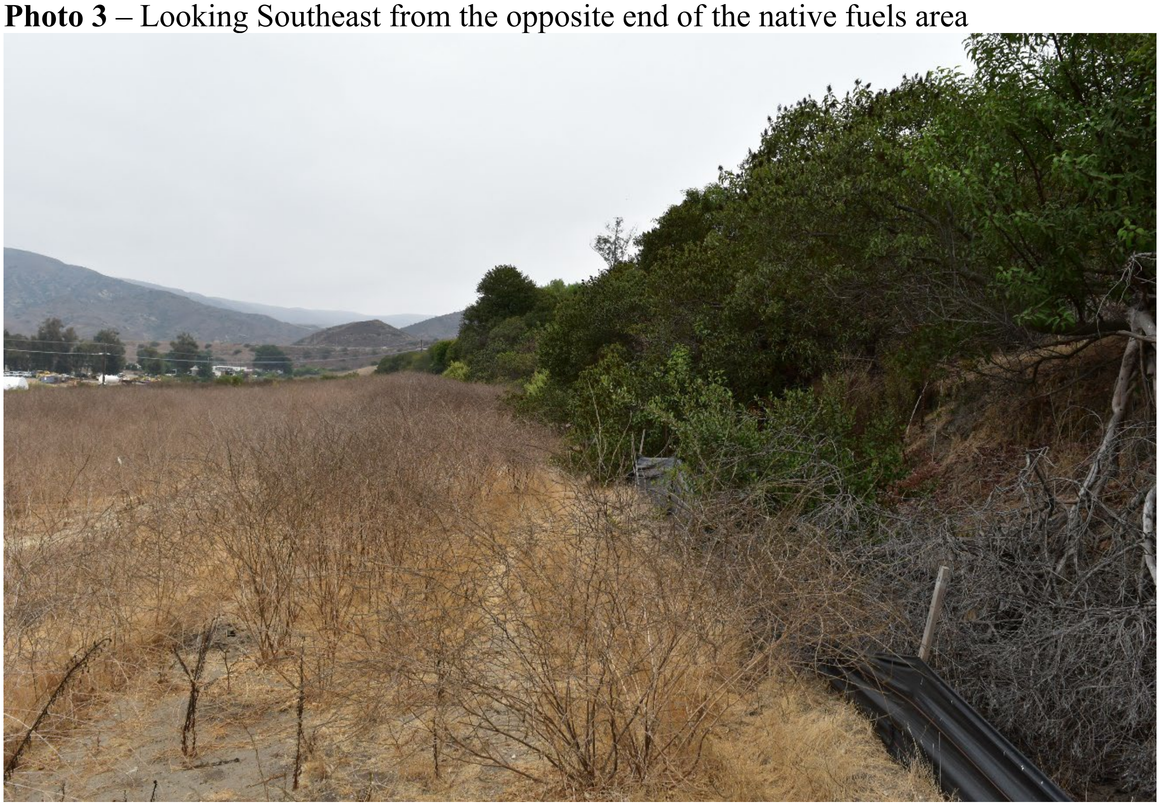
Photo 1 - Grass and Shrub Fuels on the Southwest side of the project site

Photo 2, on the next page, provides a view of the Hicks Canyon Wash area as it parallels the access roadway between the roadway and the project site. This riparian area has a mix of shrubs, shrubform trees and trees with an intermix of grasses. This is a ribbon of fuels as opposed to a fuelbed in the more traditional sense.

Photo 3, on the next page, provides a view from the opposite side of the Hicks Canyon Wash interface. The vegetation mixes that are present on the slope here are similar to other side, but the area of the Seed Farm is more consistent and uniform from the past cultivation activities. This area is currently fallow. It could be any native plant deemed in need of seed production and has been treated as such.

Photo 2 – Same location as above, looking to the NW.

Photo 3 – Looking Southeast from the opposite end of the native fuels area



Finally, Photo 4, provides a look across the Seed Farm from the project site looking to the east/northeast. Due to the nature of the Seed Farm, it is expected that whatever plants are utilized here, they will be allowed to seed, making them receptive to wildland fires in the adjacent open space areas.

Photo 4 – Fuels viewed from the road below.

Fire modeling has been accomplished using the SCAL18 fuel as the worst-case scenario.

Elevation/Slope/Terrain

The project site is relatively flat, having been used for row crops prior to the current development efforts. The general nature of the topography in the area is flat to the west, rising up to the east in the transition from valley floor to the foothills. The area is a series of smaller drainages which generally run NE/SW.

To the northeast, east, and south are ridgelines that parallel the project site. These generally rise up to the northeast to a larger ridgeline which runs southeast/northwest or perpendicular to the project site. This arrangement is shown in Figure 17, on the next page in an oblique view of the project over a three-dimensional aerial graphic. Elevation is not a major factor in site's fire behavior for this site. The changes in elevation produce slope (amount of change in a specific distance) and aspect (orientation of the face of the slope to the compass/sun) which must be examined.

The slope is an important input to the BehavePlus modeling software. For this reason, a slope analysis was completed using the Landfire database for this area. Figure 18, on page 20, is a graphic representation of the average slope within each of the 30-meter grids in the dataset.

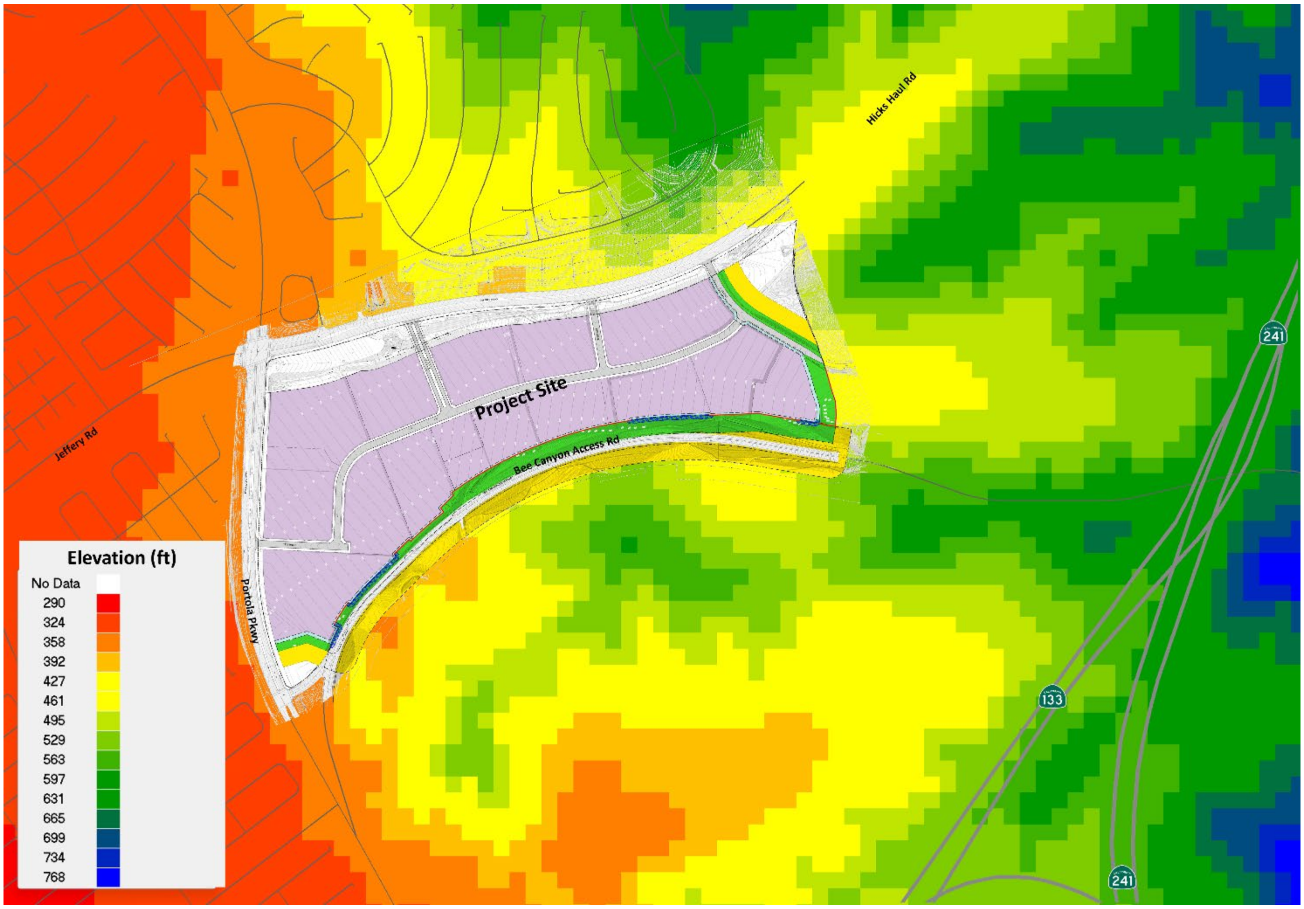


Figure 16 – Elevation Map

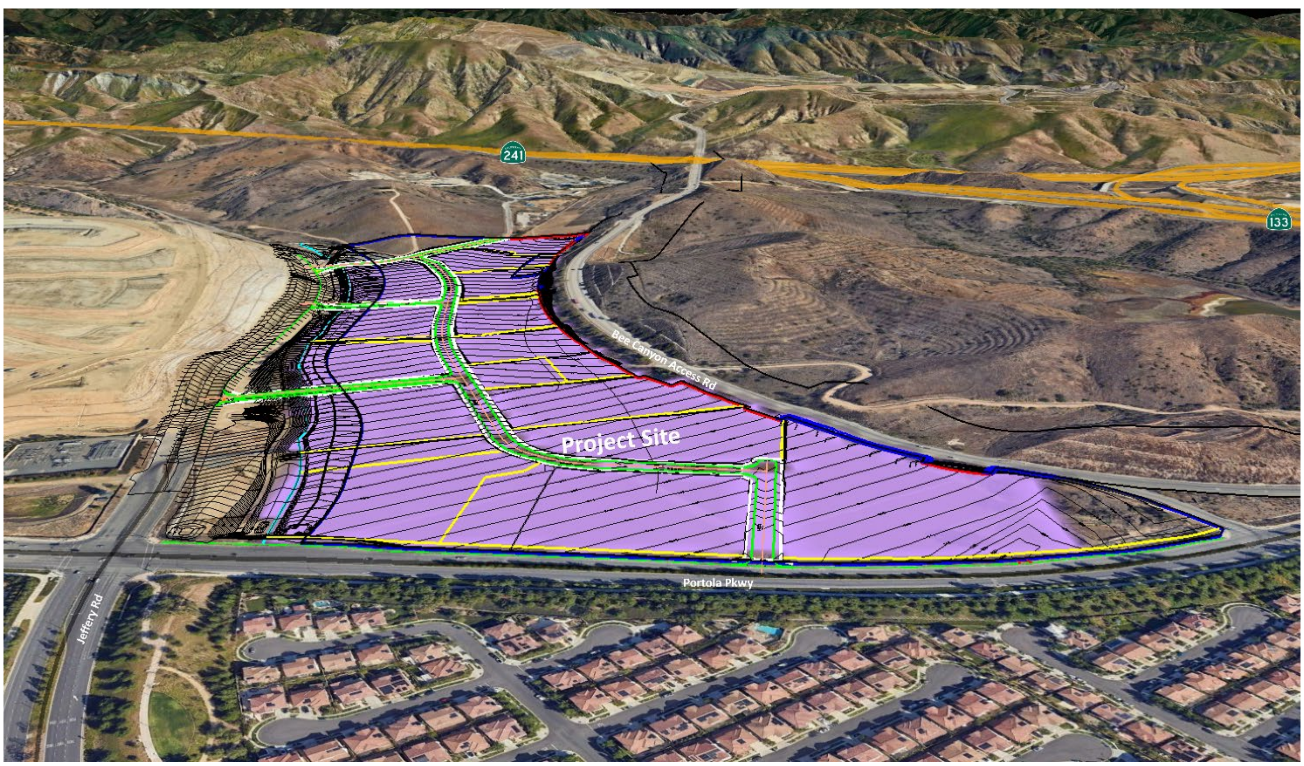


Figure 17 – Site Topography

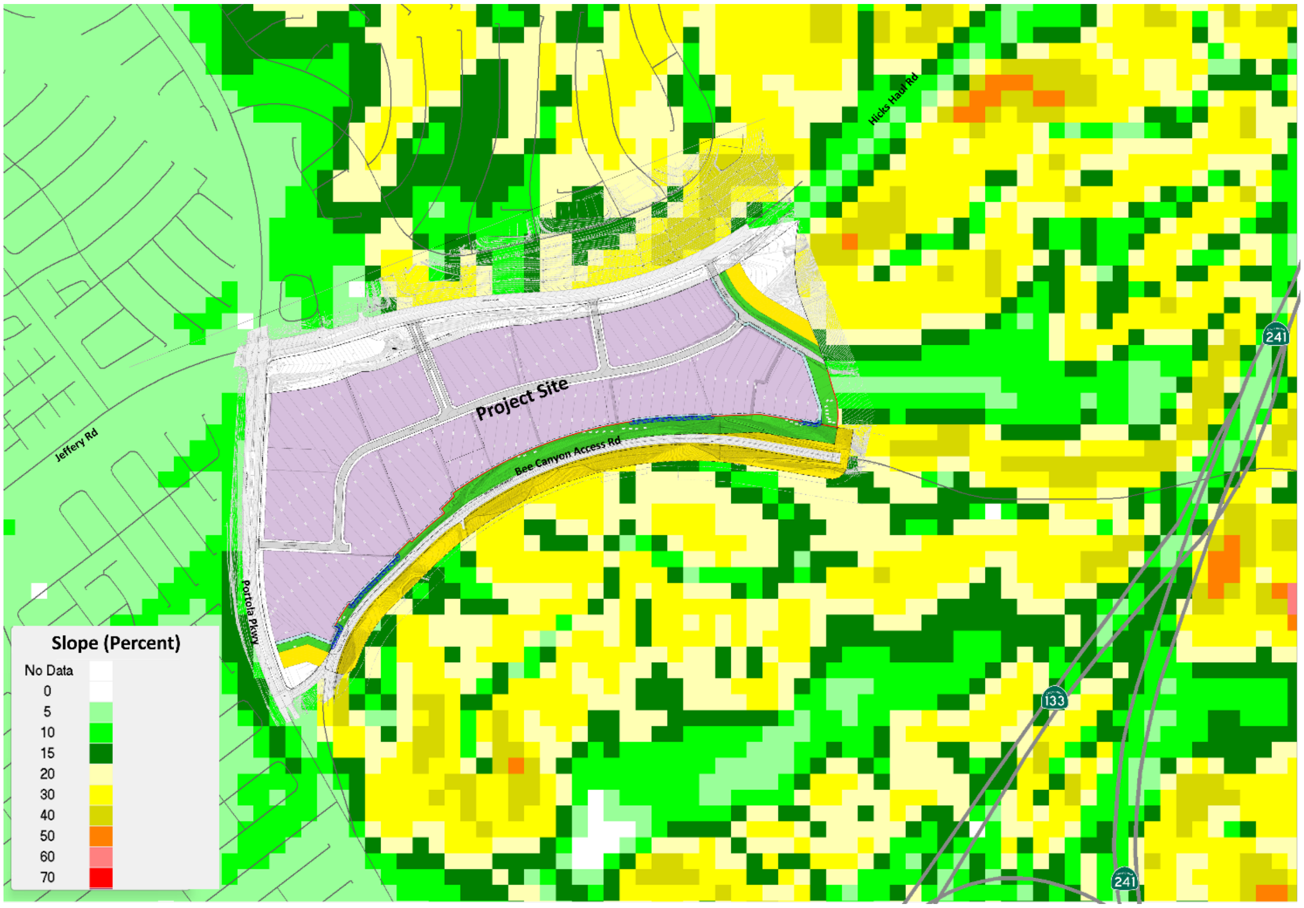


Figure 18 Slope Analysis from Landfire Database

The maximum slope in any grid within the immediate areas is 14 degrees (25%) due to the averaging over the grid area. The majority of the project site is essentially flat (less than 2% slope). The edges of the property are manufactured slopes (2:1 or less) which have revegetated under natural conditions on the east and south interfaces. To the north, the site was mass graded and is currently being developed. It is void of any wildland fuels. The modeling will use the 10%as its worst-case scenario in the Seed Farm interface. All other interfaces will have the prescriptive 170' fuel modification zones and do not require modeling.

Aspect is important in the relationship that it plays in fuel moisture and fuel loading. South aspects, in most of Southern California, tend to be drier and have less growth because of the amount of direct sunlight that they receive compared to the north aspects if the slope is steep enough. On this site, the slopes are not great enough to influence fuel moisture by aspect. The only relationship aspect will have on fire behavior for this site is when they align with the winds.

The Landfire data averages the aspects within the 30-meter grids and, therefore, can be misleading. For example, if a ridgeline runs directly down a grid, the algorithm will add up the compass directions and average them. This is normally not an issue but in the case of the ridgeline it is. If the ridge runs west to east, the two sides are north and south. The algorithm would average the (0 degrees for north and 180 degrees for south = 90 degrees or east) and come up with an east facing slope. This has not been a factor on this site. Flat areas of the database have a zero value and show up at the north aspects in the graphic.

The worst-case fire conditions exist when topography, fuels, and wind are in alignment. Full alignment (lots are upslope from the native fuels and are in alignment with the extreme winds–Santa Ana) of all three factors does not occur in the project site. The site has no underslung (downslope) fuels and all interfaces are generally upslope from the project site in the few areas where slope/aspect exists on the interface (Northeast across the Hicks Canyon Wash and south along the Bee Canyon Access Road). The project site has been turned into a black and white image for this graphic to keep from confusing the areas of aspect with the project fuel modification zones (yellow and green on previous images).

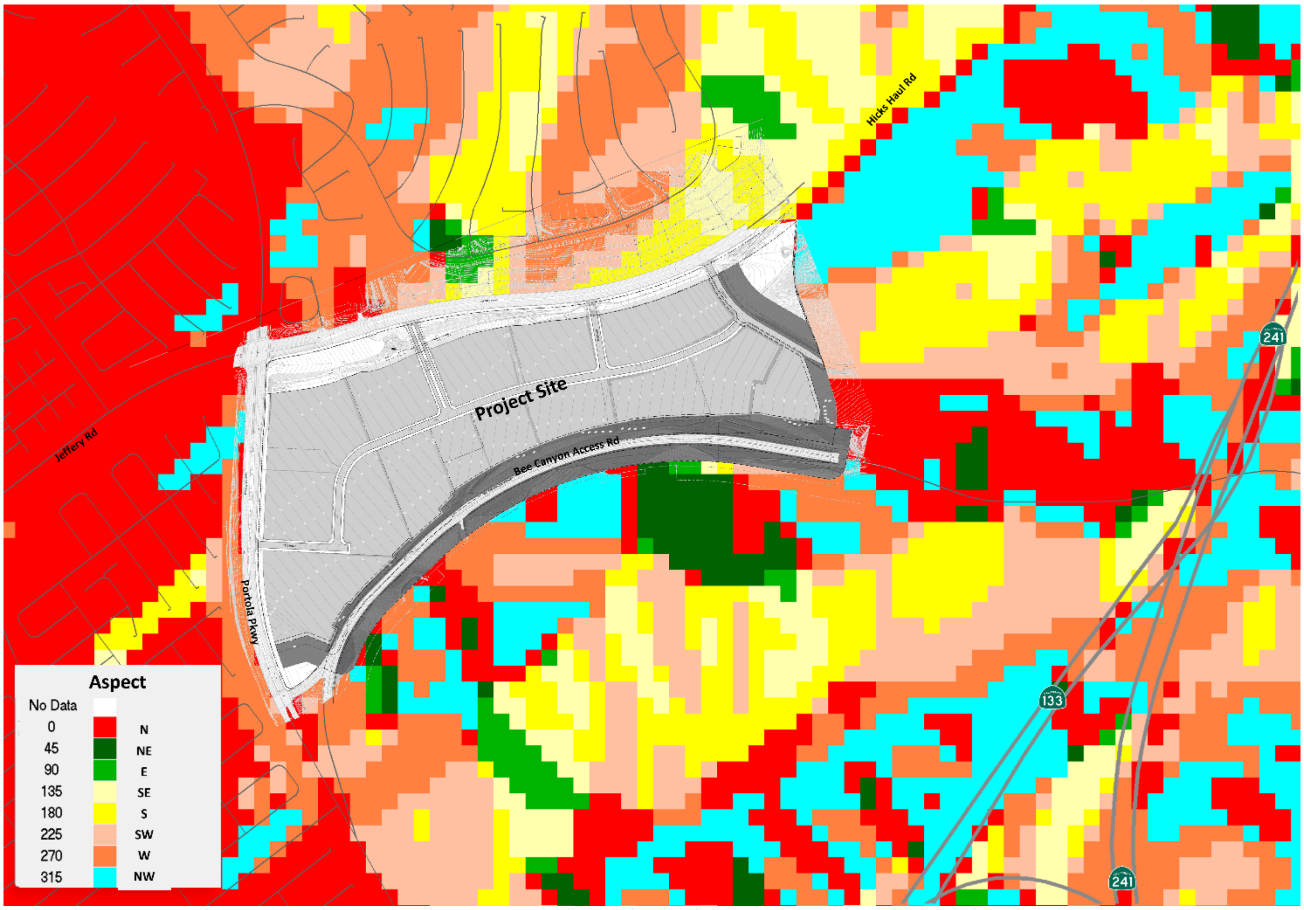


Figure 19 Aspect Analysis from Landfire Database

BehavePlus Plus Fire Behavior Inputs and Results

Worst case National Wildfire Coordinating Group Fireline Handbook models have been used for analysis ; specifically, fuel model SCAL18 coastal sage scrub models. Worst-case fire weather was used as well. Inputs for the BehavePlus Fire Behavior Model are as follows:

- One-hour dead fuel moistures were calculated at 3%; ten hour at 4% and 100 hour at 5%.
- Live Herbaceous fuels were calculated at 30% in the wildland.
- Live Woody fuels were calculated at 50% in the wildland.
- Temperatures were assumed to be over 100 degrees.

- Worst-case scenarios assumed a 10% slope (5.7 degrees) in the Seed Farm interface.
- Winds are calculated out of the SW at 30 mph and out of the NE at 60 mph (20-foot wind speed).
- Aspect of the slope is indicated as directly upslope as worst-case scenario.
- Spread direction is shown in the(direction of greatest spread per Behave outputs.
- Wind adjustment factor of 0.5 was used under the worst-case scenario.

The inputs to the NE fire modeling are shown in Figure 20 (Fuel Descriptions from the outputs have been added for readability).

Full details for each model run are available in the appendixes. Version 6.0.0 of the BehavePlus modeling program was used for this analysis.

<u>BehavePlus Plus Related References:</u>

1. <u>Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model</u>. Scott, Joe H.; Burgan, Robert E. 2005. General Technical Report RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station p. 72.
2. <u>BehavePlus Plus fire modeling system, version 5.0: Variables</u>. Andrews, P. L. 2009. General Technical Report RMRS-GTR-213WWW Revised. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

The modeling inputs/outputs are attached in the appendixes but have been summarized here in the next few figures for discussion purposes.

BehavePlus 6.0.0 Mon, Dec 23, 2024 at 10:50:20 Page 1

Inputs: SURFACE		
Description		Gateway Village
Fuel/Vegetation, Surface/Understory		
Fuel Model		gr2, gs2, sh5, SCAL18, tl6
Fuel Moisture		
1-h Fuel Moisture	%	3
10-h Fuel Moisture	%	4
100-h Fuel Moisture	%	5
Live Herbaceous Fuel Moisture	%	30
Live Woody Fuel Moisture	%	50
Weather		
20-ft Wind Speed	mi/h	0, 5, 10, 15, 20, 25, 30, 35, 40, 45
Wind Adjustment Factor		0.5
Wind Direction (from north)	deg	45
Terrain		
Slope Steepness	%	10
Site Aspect	deg	45

Figure 20 – BehavePlus Inputs

The NE wind modeled at 60 mph could produce a flame length of 51.6 feet under maximum conditions with the worst-case fuels if the fire were to be burning in a continuous fuel bed and had reached equilibrium (sustained maximum rate of spread for the conditions). Figure 21, below, provides the flame lengths at various wind speeds. It should be noted that even at 80 mph, the flame lengths are only 60.3 feet. While the wind speed increases by 33%, the sh5 flame length increases by only 16.9% as a result. The SCAL18 flame length by 12.9%. The impact of the wind at this point is not linear. The weather data does not show winds of any kind (sustained or gust) above 60 mph at the project site location over the past 5.8 years. This time period includes the Silverado Fire in 2020 which burned over this area.

Gateway Village

Head Fire

Surface Fire Flame Length (ft)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	1.7	2.1	5.0	5.8	1.3
5	4.2	5.0	13.9	16.4	2.3
10	6.4	7.6	19.8	21.5	3.4
15	8.3	9.9	24.5	25.3	4.4
20	10.0	11.9	28.5	28.5	5.3
25	11.5	13.8	32.1	31.3	6.1
30	11.6	15.5	35.4	33.7	6.9
35	11.6	17.2	38.5	36.0	7.7
40	11.6	18.8	41.4	38.0	8.4
45	11.6	20.3	44.1	40.0	9.1
50	11.6	21.8	46.7	41.8	9.8
55	11.6	23.2	49.2	43.5	10.5
60	11.6	23.4	51.6	45.1	10.5
65	11.6	23.4	53.9	46.6	10.5
70	11.6	23.4	56.1	48.1	10.5
75	11.6	23.4	58.2	49.5	10.5
80	11.6	23.4	60.3	50.9	10.5

Figure 21 – Behave Outputs for NE wind

The project site is bounded by roadways on all sides except the Seed Farm (Portola, Bee Canyon Access, Jeffery, and the Hick Canyon Wash access road). Because of this, a fire cannot burn onto the project site as a line of fire but rather must "spot over" the roadways by embers or brands in most locations (direct flame contact over the Hicks Canyon Wash access is possible without the fuel modification zones). Fires resulting from embers or bands do not have the same behavior as an established fire in the early minutes of the fire start. The fire must accelerate to a point of free burning equilibrium (the state modeled in Behave) before the maximum results shown above are achieved.

Fire Acceleration

Fire acceleration is defined as the rate of increase in spread rate/fire line intensity from a given source. It is also defined as the rate of increase in spread rate from the current rate to an equilibrium spread rate under constant environmental conditions. Fire acceleration measures the amount of time required for a fire spread rate to achieve the theoretical steady state spread rate given: 1) its existing spread rate and 2) constant environmental conditions. Fire acceleration is fuel-dependent but independent of fire behavior. The incorporation of acceleration means that fire spread rates will not immediately adjust to the equilibrium spread rates when conditions change.

The amount of fire acceleration is dependent on the rate factor. The default rate for acceleration to 90% of equilibrium rates is 20 minutes from a point source fire. Line source fires are known to accelerate much faster (Johansen 1987) than point source fires. Although the equilibrium spread rate is dependent on fuel conditions, the buildup or acceleration rate has been found to be fuel independent for a variety of fuel types (excelsior, pine needles, and conifer understories).

A single acceleration rate may not be accurate for all fuel types (McAlpine and Wakimoto 1991), especially between very different fuel types. Fire in grass fuels is expected to accelerate more rapidly than in slash fuels, but there is little data to guide these settings. Acceleration is presumed to be independent of fire behavior or eventual spread rate.

Fire acceleration is important because the flame lengths that are being discussed from the modeling in the Behave program assume that the fire has reached a self-sustaining equilibrium state. In the smaller areas of the project site, and, where fire could establish itself within an area that is perpendicular to the wind, the fire will not reach this point before it runs out of fuel. This is the rationale for diminished distances for some of the defensible spaces from interior fuel beds, which are not directly connected to exterior fuel beds. In these instances, the fire must spot into the fuel bed, build to a steady burning state, and then continue to a state of equilibrium. When the amount of fuel is simply not available within the interface area, to complete this process, mitigations have been adjusted to the actual risk on hand for these areas.

If we assume that a fire doubles in size every two minutes during the acceleration phase (wind driven fire), it is possible to see how far the fire might travel as it accelerated. Since the early acceleration does not use much fuel, we will begin to examine the fire when it reaches a five-foot flame length. At this point, it will be moving forward at about 3 feet per minute; two minutes later, it will be a ten-foot flame length and will be traveling at 14 feet per minute; two minutes more (six total), the flame length is now 20 feet, and the fire is moving at 53 feet per minute. Somewhere around the seven-minute mark, this fire will have consumed over 100 feet of fuel and will only have a 25 foot +/- flame length. It would not be possible to exceed the 30-foot flame length maximum used in this report for an onshore wind event. The calculations are provided in Figure 22.

This is important for smaller strips of vegetation which are along the roadways (riparian areas) that might burn but will not produce the level of fire behavior that is shown in the modeling due to the configuration (amount, location, and continuity) of the wildland fuels. Smaller strips of riparian vegetation within fuel modification zones are not an issue where physical barriers (radiant heat walls) or distance can provide the needed safety margins. The fuel modification plan will address these types of interfaces where they might occur and will provide the appropriate solutions.

	Flame Length			
	5	**10**	**20**	feet
	2.7	13	48	chains
	66	66	66	
	178	858	3,168	feet
	60	60	60	
	3	14	53	ft/min
	60	60	60	
	0.05	0.24	0.88	ft/sec
2 min	5.94			feet
4 min		28.6		feet
6 min			105.6	feet
Running total (distance)	5.94	34.54	140.14	feet

Figure 22 – Acceleration Distance Calculation

Much of the interface for the project site has 100 feet or less of native vegetation adjacent to the project site. In all cases, the native vegetation is bounded by a wide roadway beyond the interface. None of the adjacent fuels connects to a wildland area directly. This means that fire cannot burn into the interface as a “line of fire”. All fires in this interface must start as a point source fire and grow into equilibrium if there is enough fuel to do so. In the majority of the interface, this is unlikely, if not impossible, given the amount of fuel that is available to burn. This study has, however, used the maximum rates in the design of this fire protection system (fuel modification)

The onshore flow will take fire away from the project site at the Seed Farm interface. All of the wildland safety features provided to protect against the NE wind scenario are present and will provide more than adequate levels of protection for winds from any direction, including the SW onshore flow that is predominate at this site.

The final analysis is to examine the potential for a fire within the adjacent native fuels to damage or ignite a structure within the project site. This can happen in one of four ways. First is direct contact with the fire. The maximum flame length is 60.3 feet under any wind scenario, regardless of the direction or the wind up to 80 mph. Any distance greater than 60.3 feet will keep the flames off of the structures. While the offshore (NE) scenario indicated a flame length of 51.6, a flame length of 60 feet will be used for the radiant heat calculations.

The second is radiant heat. The laws of physics indicate that the decay of radiant heat is calculated by dividing the energy produced by the square of the distance from the heat source (Figure 23).

While this is simplified, it is overall accurate at a conceptual level. Several models exist for the calculation of the Radiant Heat Flux on a structure from various fire sources. Most are complicated and have a set of complex assumptions that must be made. The Inverse Square Law does not specify a unit of measure. The formula is relational between the distance and the source. The drop in heat from the source to distance r is relational to distant 2r and 3r. Firesafe uses a simple formula as a “yardstick“ for generalized assumptions about radiant heat from fire. This formula is the FI (Fireline Intensity) from the Behave outputs over the distance in feet squared. Because Newton’s Law is relational, it does not specify a unit of measure. Firesafe has derived its “rule of thumb” from the, using the formula shown below.

radiant heat flux < 20kw/m² at distance of 2x maximum flame length

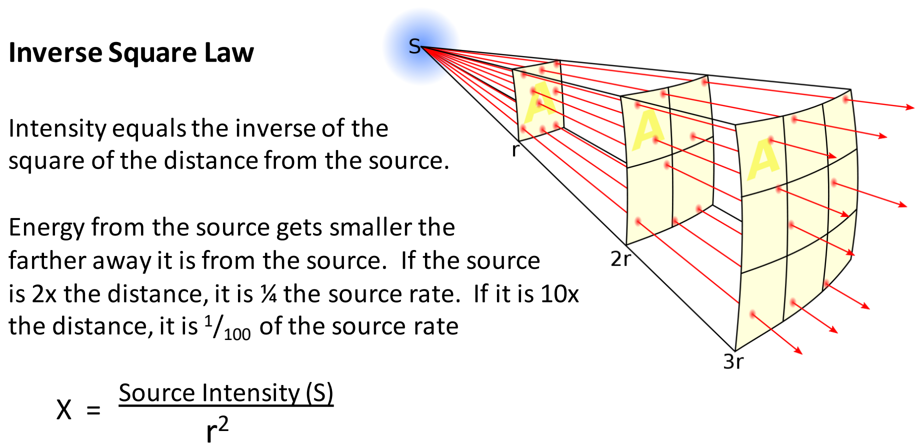


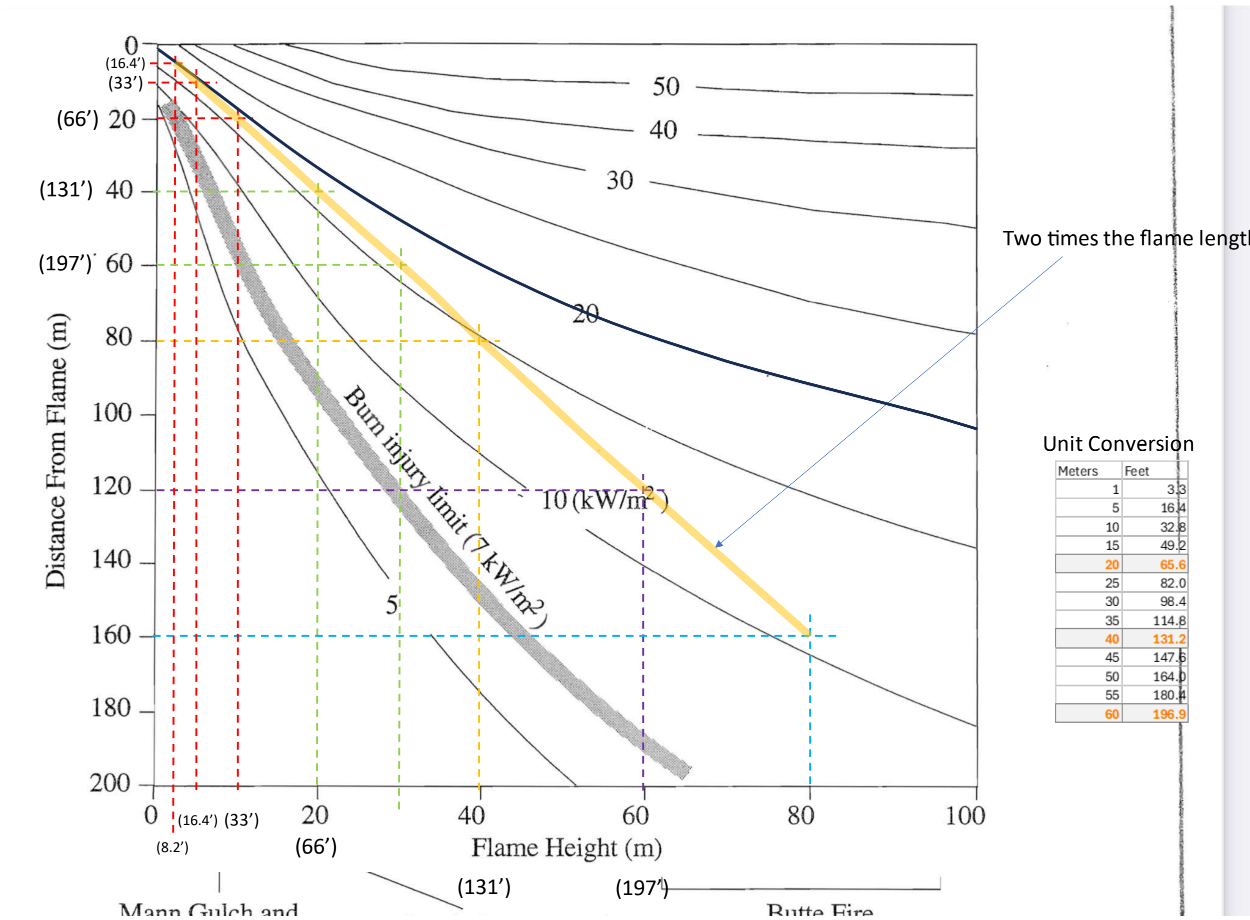
Figure 23 – Inverse Square Law

Jack D. Cohen and Bret W. Butler completed research, and published, “Modeling Potential Structure Ignitions from Flame Radiation Exposure with Implications for Wildland/Urban Interface Fire Management”, for the 13th Fire and Forest Meteorology Conference in Lorne, Australia in 1996, which was the starting point for the entire “structure ignition zone” body of work that followed. They concluded the 40 meter was a sufficient distance to protect a structure from a 20-meter flame length. This distance would not exceed the amount of heat flux needed to have piloted ignition of a wood surface due to the radiant heat decay and the lack of exposure duration (residence time).

Several studies have found this relationship. In this study, a mathematical model was developed to predict the radiant energy incident on a firefighter as a function of flame height and the distance between the firefighter and the flame (Butler and Cohan, 1996). The results are shown in “Figure 24. The chart has an additional overlay (no change to underlying values), which highlights the at two times the flame length in distance from the fire (orange line).

In nearly all cases, two times the maximum flame length will provide a radiant heat flux value under 20 kW/m^2. This stands to reason as flame length (LF) is a function of fireline intensity (*I*) in Byram’s formula $LF=0.0775*I^{0.46,}$ which most closely approximates the interchanges between these two values (fireline intensity and flame length) in the Behave program.

We should be very clear here; this is not the only factor in the amount of heat that might be subject to a specific structure. The real world is much more complicated than a simple formula. Most literature indicates that a hardened structure should be able to withstand 20 to 30 kW/m^2 for a period of 5 minutes or less and not ignite. Using the two times the maximum flame length on the worst-case fire should place the actual value much less than the ones calculated here when a fire actually burns in the interface.



Meters	Feet
1	3.3
5	16.4
10	32.8
15	49.2
20	**65.6**
25	82.0
30	98.4
35	114.8
40	**131.2**
45	147.6
50	164.0
55	180.4
60	**196.9**

Figure 24 – Source of Radiant Heat Formula

Jack Cohen's SIAM (Structural Ignition Assessment Model) uses a radiant heat flux threshold of 20 kW/m^2 for 5.5 minutes as the baseline for structure ignition (Cohen, J.D., 1995. Structure Ignition Assessment Model (SIAM), USDA Forest Service Gen. Tech. Rep. PSW-GTR- 158). The residence time for a fire within the adjacent drainage would have a residence time of less than one minute under the worst-case scenario; far below the 5.5 minutes needed, and would not have sufficient heat beyond the fuel medication zone to ignite any structures. The adjacent wildland areas simply lack the quantity of fuel necessary to burn at a high rate for a time period long enough to create a radiant heat issue at the distances provided at two times the maximum flame length.

Radiant heat flux (energy/time/area reaching a surface) is the amount of radiant heat energy a wall could receive from flames, depending on its distance from the fire. Figure 25, on the next page, is from live fire experiments conducted by Jack Cohen, showing the relationship between radiant heat energy and distance to a structure. The test-fire is 20 meters in height and 50 meters wide. The graphic shows how energy dissipates over distance. At 40 meters (2x the flame height), the ignition time is over ten minutes, whereas at 30 meters, it is 90 seconds. The ignition time is inverse to the heat flux in terms of energy vs distance. The heat energy drops exponentially, and the ignition time increases exponentially as well.

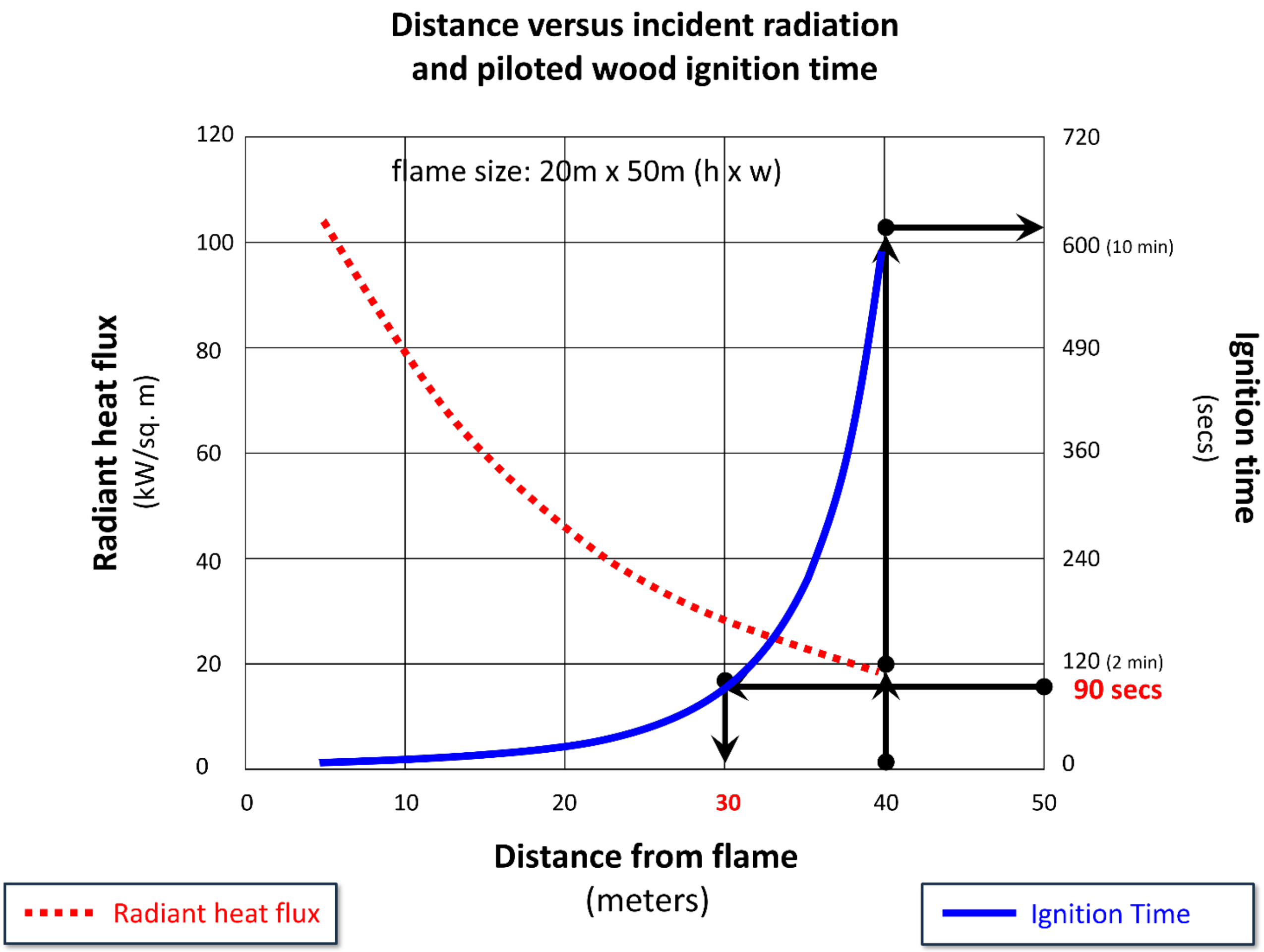


Figure 25 - Radiant Heat Exposure *(Jack D. Cohen, What is the Wildland Fire Threat to Homes?, April 10, 2000, School of Forestry, Northern Arizona University, Flagstaff, AZ)*

The design of the fuel modification zones will ensure that the structures within the project site will not have heat energy exposures of 20 kW/m^2 (this level will kill half of the victims exposed to it in 30 seconds but requires 5.5 minutes of exposure to ignite a wood wall). Figure 26, on the next page, provides a guide to radiant heat levels and their effect on structures and the human body.

Per the Behave outputs, the 60.3-foot flame lengths will produce 145,796 kW/m Fireline Intensity. At 100 feet, the maximum energy generated has fallen to under 20 kW/m^2 using the simplified formula. (145,796/(100*100) = 14.58 kW/m)

This is not a level of safety for residents or firefighters (exposed skin would burn in eight seconds) but is low enough to protect the hardened structures (5.5 minutes to piloted ignition on wood structures).

The third method of fire encroachment is convected heat. This impact area is generally about 75% of the radiant heat impact zone. While small pulses of convected heat may exceed the radiant heat zone and be a danger to the respiratory tracts of firefighters, these pulses are not sufficient enough in duration to cause ignition of structural materials.

Btu/s/ft² Rate	kW/m² Rate	Time to Ignition seconds	Time to Ignition minutes	
17.3	60	10	0.17	
14.4	50	16	0.27	
11.6	40	28	0.47	
10.7	37			Damage to process equipment and collapse of mechanical structures
9.0	31	60	1.00	
8.7	30	66	1.10	
6.4	22	210	3.50	
5.8	20	337	5.50	Piloted wood ignition after 5.5 minutes
5.2	18			Death in 50% of victims after 30 seconds
4.6	16			Blistering of exposed skin after 5 seconds
3.6	12.5	1,200	20.00	20 minutes to ignition/2nd degree burn in 8 seconds
2.9	10			Pain on exposed skin after 3 sec/ death in 1% of victims after 40 seconds
2.0	7			Max exposure in PPE for 90 sec
1.8	6.4			Pain on exposed skin after 8 sec
1.4	5.0			2nd degree burns on exposed skin in 40 seconds
1.2	4.3	18,000	300.00	5 hours to ignition
1.2	4.0			First degree burns after 20 seconds
0.7	2.3			Pain on exposed skin after 2 minutes
0.6	2.1			Minimum to cause pain after 60 second
0.5	1.7			Minimum to cause pain
0.3	1.0			Equal to the maximum radiant heat transfer on a clear sunny day

Figure 26 – Calculation of Radiant Heat Exposure

Convection exposure is a more difficult issue as the science of this factor is limited with current studies underway to further expand our knowledge of this area of wildland fire science. Some facts are known:

> Radiative heat fluxes peak between 20 and 300 kW/m^2. The convective heat flux is characterized by rapid fluctuation between positive and negative convective values owing to alternating packets of cool air intermingled with hot combustion products. The convective heat flux peaks between 22 and 140 kW/m^2. *Frankman 2013, Measurements of convective and radiative heating in wildland fires, CSIRO Publishing, International Journal of Wildland Fire http://dx.doi.org/10.1071/WF11097, page K.*

> In a time-resolved heat flux data study from two different locations and times in the same prescribed fire event, data was collected. They were grouped into a low intensity set (hereafter labeled Burn 1), and a moderate intensity set (hereafter labelled Burn 2). Both sets were evaluated to determine the effect of sampling rate on the interpretation of convective and radiative heat fluxes. Findings from the analyses have direct application to measurement methods and interpretation of energy transport measurements in wildland fires. *Frankman 2013b, The effect of sampling rate on interpretation of the temporal characteristics of radiative and convective heating in wildland flames, CSIRO Publishing, International Journal of Wildland Fire 2013, 22, 168–173 http://dx.doi.org/10.1071/WF12034*

> Overall, fire convective energy is lower than fire radiative energy, but the peak energy pulses of the convective heat flux are greater in the convective heat than in the radiant heat (Figure 27). Convective heat has pulses of cooler air, which lower the overall energy average, as shown in Figure 38 on the next page.

The point here is not to discuss how convective heat energy vs. radiant heat energy contributes to fuel ignition but rather to show on the macro level that convective energy is not as likely to be a factor in structure ignition if the distance provided between the fire and structure is great enough to stop radiant heat from igniting it.

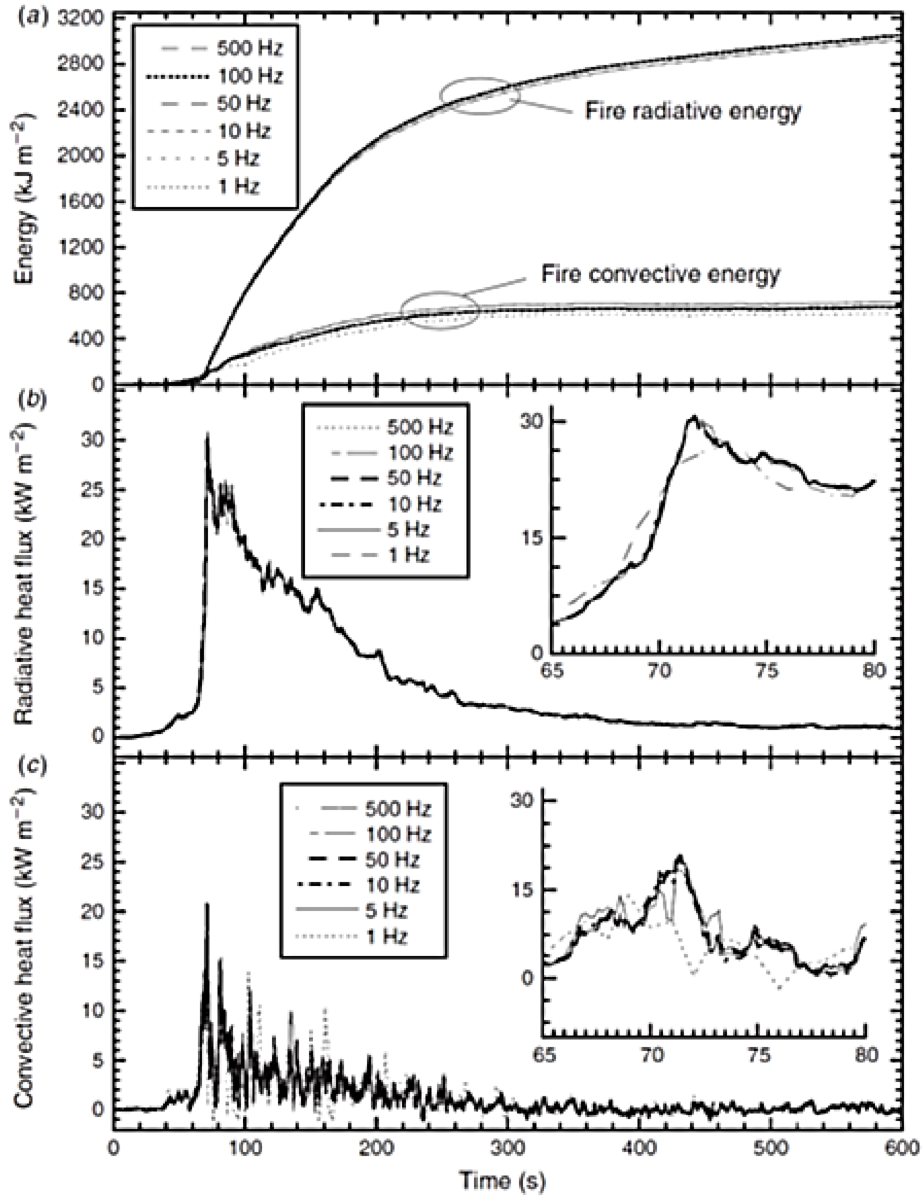


Fig. 2. Integrated energy and 2-s moving averages for Burn 2. (*a*) Fire radiative energy and convective energy calculated from integral of measured fluxes, (*b*) fluxes calculated using a 2-s moving average of the 500-, 100-, 50-, 10-, 5- and 1-Hz radiative flux signals, (*c*) fluxes calculated using a 2-s moving average the 500-, 100-, 50-, 10-, 5- and 1-Hz convective flux signals. Inset figures in (*b*) and (*c*) are included to further illustrate the difference in signal between the moving averages of the various sample rates over a short time frame.

Figure 27 – Convective Heat vs Radiant Heat

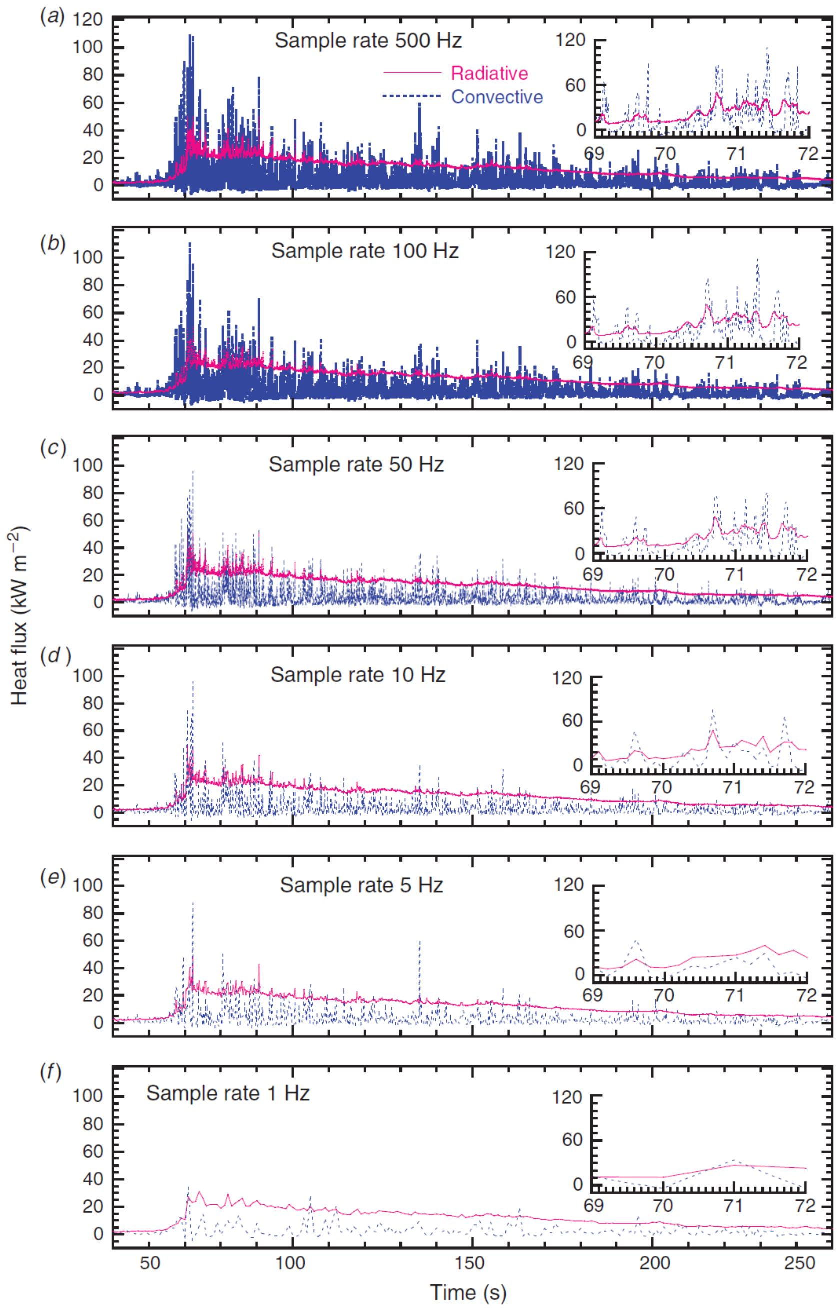


Fig. 1. The effect of sample rate on measured heat flux in Burn 2. (*a*) presents the initial signal captured at 500 Hz, (*b*) presents the 500-Hz signal down-sampled to 100 Hz and so on to 1 Hz for (*f*). The inset figures depict the signal over a 4-s time period centred at or near ignition.

Figure 28 – Convective Heat Rate

In Figure 28, above, notice how the blue lines (convective heat) exceed the red lines (radiant heat), but the overall average is less for the blue line, AND the blue lines have negative (cooling) values, whereas the red lines do not. It is not that convective heating by superheated gases does not play a role in fire propagation or in fire phenomena such as "area ignitions". They do, but the fuels and topography around the Project Site do not lend themselves to these issues without a large continuous fuel bed to create the environment necessary to have this effect make an impact on the Project Site.

The final method of fire encroachment would be embers and brands. The Institute for Business and Home Safety (IBHS) makes the following statement:

> Buildings are ignited by embers and flames during wildfires. Flying embers and wind-blown, ground-traveling burning debris are by far the most prevalent attack mechanisms threatening structures during a wildfire. CAL FIRE identified embers as the major cause of home loss (Mell et al., 2010). Potter and Leonard (2011) reported that "well over 90% of houses were ignited in the absence of direct flame attack or radiant heat (exceeding 12 kW/m2) from the main fire front." Hence, embers cause a great deal of damage, whether directly or indirectly. *WILDLAND FIRE EMBERS AND FLAMES: Home Mitigations That Matter,Faraz Hedayati, PhD, Stephen L. Quarles, PhD, Steven Hawks, IBHS Research, April 2023, page 6.*

Embers can and will travel great distances. The Project Site will be protected from this threat by compliance with California Building Code Chapter 7A and California Residential Code Section R337 throughout.

Fire Behavior Summary

The modeling indicates that flame lengths of just over 60 feet are possible under perfect conditions, in the worst case scenario that does currently exist at or near the project site. The design criteria for the project site must properly protect the structures from wildland fire under these conditions. Most of the fuels are not aligned with the slope, and wind and fuels are not continuous enough to drive fire behavior to the level of the equilibrium spread rates used in the modeling in most of the areas adjacent to the project site; however, the entire defense system will be designed to protect all of the structures regardless of specific location adjacent to the native fuels on the Gateway Village Project site.

The fire protection system for this project has assumed a lack of maintenance within the boundary area. Parts of the interface have a native habitat area immediately adjacent to the project site boundary (Seed Farm). Due to its nature as a seed farm, options for vegetation modification are not possible in this area. As currently configured, a fire in the Seed Farm interface could produce a flame length of 51.6 feet with the wind speeds recorded in the adjacent area. A fuel bed that is not currently present and a wind speed 33% higher than has been recorded have been used to produce a 60 foot fleam length and the need for a minimum 120 buffer. The radiant heat from the maximum fire is mitigated at a distance of 120 feet for the structures with an extreme high level of confidence.

In accordance with the fuel modification design, a landscape plan that utilizes a plant palette consisting of fire-resistant plants and native and/or appropriate non-native drought tolerant species in accordance with Orange County Fire Authority guidelines has been completed.

The technical results provided as part of the Fire Behavior Analysis within this report were obtained using BehavePlus Plus version 6.0.0. and Wind Ninja version 3.11.2 software.

Gene F. Begnell
Fire Protection Analyst

Fire Behavior Analysis and Report Summary

Based on the scientific fire behavior analysis, exterior portions of structures within the Gateway Village Project site will not ignite from the exterior fire exposure from a wildland vegetation fire with a fuel modification zone arrangement. This is primarily because the greatest fire energy is too far away from the structures due to a lack of wildland fuels and fire intensity as it approaches the project site from any direction; in addition, the northwest/southwest interfaces past the vegetation margins adjacent to the project site are developed.

Modeling has shown that the performance-based design on the project site provides the necessary protection to keep the structures safe during a wildland fire incident. Additional protection within the adjacent native fuels and that additional distance will not increase the safety of these structures beyond the point that is already provided. The majority of the interface will be the prescriptive 170-foot fuel modification zone configuration.

The codes enforced by the Orange County Fire Authority for Fuel Modification were developed to handle the exact type of fuels interfacing with development areas. The proposed fuel modification zones meet the accepted design criteria (performance-based) for new development within other areas of Orange County.

We recommend approval of this Fire Behavior Report as an accurate and acceptable assessment of the hazard and risk factors for the Gateway Village Project site as they relate to wildland fire protection and the Special Maintenance Area design.

Respectfully;

Gene F. Begnell
Fire Protection Analyst

Concurrence;

David Oatis
Principal, Firesafe Planning Solutions

Appendix A- Gateway

Site Photos Locations

Photo locations are shown on the map above as reference points. Several photos were taken from each general location and are within a few feet of each other. For simplicity, these photo sites have been grouped in the locations shown above.

Photo Site 1 – Looking North

Looking West

Photo Site 2 – Looking East

Looking West

Photo Site 3 – Looking South

Looking North

Photo Site 4 – Looking West

Looking South across the Seed Farm

Photo Site 5 – Looking West to Project Site perimeter from Seed Farm

Looking South across the Seed Farm

Photo Site 6 – Looking West from south edge of Seed Farm

Looking North across the Seed Farm

Photo Site 7 –Looking Northeast

Looking West

Photo Site 8 –Looking West

Looking East

Photo Site 9 –Looking Southeast

Looking South

Photo Site 10 – Looking South

Looking North

Photo Site 11 –Looking West

Looking Southwest

Appendix B

Behave Outputs

Inputs: SURFACE

Description		Gateway Village Offshore

Fuel/Vegetation, Surface/Understory

Fuel Model		gr2, gs2, sh5, SCAL18, tl6

Fuel Moisture

1-h Fuel Moisture	%	3
10-h Fuel Moisture	%	4
100-h Fuel Moisture	%	5
Live Herbaceous Fuel Moisture	%	30
Live Woody Fuel Moisture	%	50

Weather

20-ft Wind Speed	mi/h	0, 5, 10, 15, 20, 25, 30, 35, 40, 45
Wind Adjustment Factor		0.5
Wind Direction (from north)	deg	45

Terrain

Slope Steepness	%	10
Site Aspect	deg	45

Run Option Notes

Maximum effective wind speed limit IS imposed [SURFACE].

Fire spread is in the HEADING direction only [SURFACE].

Wind is in specified directions [SURFACE].

Wind and spread directions are degrees clockwise from north [SURFACE].

Wind direction is the direction from which the wind is blowing [SURFACE].

Output Variables

Surface Fire Rate of Spread (ft/min) [SURFACE]

Surface Fireline Intensity (Btu/ft/s) [SURFACE]

Surface Fire Flame Length (ft) [SURFACE]

Surface Fire Dir of Max Spread (from north) (deg) [SURFACE]

(continued on next page)

Input Worksheet (continued)

Notes

Gateway Village

Head Fire

Surface Fire Rate of Spread (ft/min)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	4.0	3.0	5.8	3.7	1.0
5	29.2	19.7	54.0	36.4	3.9
10	73.1	48.9	115.8	65.7	9.1
15	128.7	85.9	183.9	93.8	15.8
20	193.6	129.2	256.5	121.3	23.8
25	266.3	177.7	332.6	148.2	32.9
30	268.7	230.9	411.7	174.7	42.9
35	268.7	288.3	493.4	200.9	53.8
40	268.7	349.6	577.3	226.7	65.6
45	268.7	414.6	663.1	252.4	78.1
50	268.7	482.9	750.9	277.8	91.3
55	268.7	554.5	840.2	303.0	105.0
60	268.7	565.2	931.2	328.1	105.0
65	268.7	565.2	1023.5	353.0	105.0
70	268.7	565.2	1117.3	377.8	105.0
75	268.7	565.2	1212.3	402.4	105.0
80	268.7	565.2	1308.5	426.9	105.0

Gateway Village Offshore

Head Fire

Surface Fireline Intensity (kW/m)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	59	100	646	882	32
5	438	652	6022	8589	119
10	1099	1619	12900	15505	279
15	1934	2843	20489	22152	486
20	2908	4273	28580	28629	732
25	4001	5878	37065	34983	1012
30	4037	7638	45879	41240	1321
35	4037	9538	54976	47418	1657
40	4037	11567	64322	53530	2019
45	4037	13716	73892	59583	2404
50	4037	15977	83664	65586	2811
55	4037	18345	93624	71543	3234
60	4037	18700	103756	77459	3234
65	4037	18700	114048	83338	3234
70	4037	18700	124492	89182	3234
75	4037	18700	135077	94995	3234
80	4037	18700	145796	100778	3234

Gateway Village

Head Fire

Surface Fire Flame Length (ft)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	1.7	2.1	5.0	5.8	1.3
5	4.2	5.0	13.9	16.4	2.3
10	6.4	7.6	19.8	21.5	3.4
15	8.3	9.9	24.5	25.3	4.4
20	10.0	11.9	28.5	28.5	5.3
25	11.5	13.8	32.1	31.3	6.1
30	11.6	15.5	35.4	33.7	6.9
35	11.6	17.2	38.5	36.0	7.7
40	11.6	18.8	41.4	38.0	8.4
45	11.6	20.3	44.1	40.0	9.1
50	11.6	21.8	46.7	41.8	9.8
55	11.6	23.2	49.2	43.5	10.5
60	11.6	23.4	51.6	45.1	10.5
65	11.6	23.4	53.9	46.6	10.5
70	11.6	23.4	56.1	48.1	10.5
75	11.6	23.4	58.2	49.5	10.5
80	11.6	23.4	60.3	50.9	10.5

Gateway Village

Head Fire

Surface Fire Dir of Max Spread (from north) (deg)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	225	225	225	225	225
5	225	225	225	225	225
10	225	225	225	225	225
15	225	225	225	225	225
20	225	225	225	225	225
25	225	225	225	225	225
30	225	225	225	225	225
35	225	225	225	225	225
40	225	225	225	225	225
45	225	225	225	225	225
50	225	225	225	225	225
55	225	225	225	225	225
60	225	225	225	225	225
65	225	225	225	225	225
70	225	225	225	225	225
75	225	225	225	225	225
80	225	225	225	225	225

Discrete Variable Codes Used
Gateway Village

Fuel Model

102	gr2	Low load, dry climate grass (D)
122	gs2	Moderate load, dry climate grass-shrub (D)
145	sh5	High load, dry climate shrub (S)
18	SCAL18	Sage / Buckwheat
186	tl6	High load broadleaf litter (S)

Inputs: SURFACE

Description		Gateway Village Onshore

Fuel/Vegetation, Surface/Understory

Fuel Model		gr2, gs2, sh5, SCAL18, tl6

Fuel Moisture

1-h Fuel Moisture	%	3
10-h Fuel Moisture	%	4
100-h Fuel Moisture	%	5
Live Herbaceous Fuel Moisture	%	30
Live Woody Fuel Moisture	%	50

Weather

20-ft Wind Speed	mi/h	0, 5, 10, 15, 20, 25, 30
Wind Adjustment Factor		0.5
Wind Direction (from north)	deg	225

Terrain

Slope Steepness	%	50
Site Aspect	deg	225

Run Option Notes

Maximum effective wind speed limit IS imposed [SURFACE].

Fire spread is in the HEADING direction only [SURFACE].

Wind is in specified directions [SURFACE].

Wind and spread directions are degrees clockwise from north [SURFACE].

Wind direction is the direction from which the wind is blowing [SURFACE].

Output Variables

Surface Fire Rate of Spread (ft/min) [SURFACE]

Surface Fireline Intensity (Btu/ft/s) [SURFACE]

Surface Fire Flame Length (ft) [SURFACE]

Surface Fire Dir of Max Spread (from north) (deg) [SURFACE]

(continued on next page)

Input Worksheet (continued)

Notes

Gateway Village Onshore

Head Fire

Surface Fire Rate of Spread (ft/min)

20-ft Wind Speed	Fuel Model				
mi/h	gr2	gs2	sh5	SCAL18	tl6
0	29.4	20.5	40.9	22.5	4.6
5	54.6	37.2	89.1	55.2	7.4
10	98.6	66.4	150.9	84.4	12.6
15	154.2	103.4	219.0	112.6	19.3
20	219.0	146.6	291.6	140.0	27.3
25	268.7	195.1	367.7	166.9	36.4
30	268.7	248.3	446.8	193.5	46.4

Gateway Village Onshore

Head Fire

Surface Fireline Intensity (kW/m)

20-ft Wind Speed mi/h	Fuel Model				
	gr2	gs2	sh5	SCAL18	tl6
0	442	677	4557	5314	141
5	821	1230	9933	13021	228
10	1481	2196	16811	19937	387
15	2316	3421	24400	26584	595
20	3290	4851	32491	33061	841
25	4037	6456	40976	39415	1120
30	4037	8216	49790	45672	1429

Gateway Village Onshore

Head Fire

Surface Fire Flame Length (ft)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	4.2	5.1	12.2	13.1	2.5
5	5.6	6.7	17.5	19.8	3.1
10	7.3	8.8	22.3	24.1	3.9
15	9.0	10.7	26.5	27.6	4.8
20	10.5	12.6	30.2	30.5	5.6
25	11.6	14.4	33.6	33.0	6.4
30	11.6	16.1	36.8	35.4	7.2

Gateway Village Onshore

Head Fire

Surface Fire Dir of Max Spread (from north) (deg)

20-ft Wind Speed mi/h	Fuel Model gr2	gs2	sh5	SCAL18	tl6
0	45	45	45	45	45
5	45	45	45	45	45
10	45	45	45	45	45
15	45	45	45	45	45
20	45	45	45	45	45
25	45	45	45	45	45
30	45	45	45	45	45

Discrete Variable Codes Used
Gateway Village Onshore

Fuel Model

102	gr2	Low load, dry climate grass (D)
122	gs2	Moderate load, dry climate grass-shrub (D)
145	sh5	High load, dry climate shrub (S)
18	SCAL18	Sage / Buckwheat
186	tl6	High load broadleaf litter (S)