Appendix L

Fire Behavior Analysis Report

1 Fire Behavior Modeling History

Fire behavior modeling has been used by researchers for approximately 50+ years to predict how a fire will move through a given landscape (Linn 2003). The models have had varied complexities and applications throughout the years. One model has become the most widely used for predicting fire behavior on a given landscape. That model, known as "BEHAVE", was developed by the U. S. Government (USDA Forest Service, Rocky Mountain Research Station) and has been in use since 1984. Since that time, it has undergone continued research, improvements, and refinement. The version, BehavePlus, V6.0, includes updates incorporating years of research and testing. Numerous studies have been completed testing the validity of the fire behavior models' ability to predict fire behavior given site specific inputs. One of the most successful ways the model has been improved has been through post-wildfire modeling (Brown 1972, Lawson 1972, Sneeuwjagt and Frandsen 1977, Andrews 1980, Brown 1982, Rothermel and Rinehart 1983, Bushey 1985, McAlpine and Xanthopoulos 1989, Grabner, et. al. 1994, Marsden-Smedley and Catchpole 1995, Grabner 1996, Alexander 1998, Grabner et al. 2001, Arca et al. 2005). In this type of study, BehavePlus is used to model fire behavior based on pre-fire conditions in an area that recently burned. Real-world fire behavior, documented during the wildfire, can then be compared to the prediction results of BehavePlus and refinements to the fuel models incorporated, retested, and so on.

Fire behavior modeling includes a high level of analysis and information detail to arrive at reasonably accurate representations of how wildfire would move through available fuels on a given site. Fire behavior calculations are based on site specific fuel characteristics supported by fire science research that analyzes heat transfer related to specific fire behavior. To objectively predict flame lengths, spread rates, and fireline intensities, this analysis incorporated predominant fuel characteristics, slope percentages, and representative fuel models observed on site. The BehavePlus fire behavior modeling system was used to analyze anticipated fire behavior within and adjacent to key areas just outside of the proposed development.

Predicting wildland fire behavior is not an exact science. As such, the minute-by-minute movement of a fire will probably never be predictable, especially when considering the variable state of weather and the fact that weather conditions are typically estimated from forecasts made many hours before a fire. Nevertheless, field-tested and experienced judgment in assessing the fire environment, coupled with a systematic method of calculating fire behavior yields surprisingly accurate results. To be used effectively, the basic assumptions and limitations of fire behavior modeling applications must be understood.

1. First, it must be realized that the fire model describes fire behavior only in the flaming front. The primary driving force in the predictive calculations is the dead fuels less than 0.25 inches in diameter. These are the fine fuels that carry fire. Fuels greater than 1 inch have little effect, while fuels greater than 3 inches have no effect on fire behavior.
2. Second, the model bases calculations and descriptions on a wildfire spreading through surface fuels that are within 6 feet of the ground and contiguous to the ground. Surface fuels are often classified as grass, brush, litter, or slash.
3. Third, the software assumes that weather and topography are uniform. However, because wildfires almost always burn under non-uniform conditions, creating their own weather, length of projection period and choice of fuel model must be carefully considered to obtain useful predictions.
4. Fourth, fire behavior computer modeling systems are not intended for determining sufficient fuel modification zone/defensible space widths. However, it does provide the average length of the flames, which is a key element for determining defensible space distances for minimizing structure ignition.

Although BehavePlus has limitations, it can still provide valuable fire behavior predictions, which can be used as a tool in the decision-making process. In order to make reliable estimates of fire behavior, one must understand the relationship of fuels to the fire environment and be able to recognize the variations in these fuels. Natural fuels are made up of the various components of vegetation, both live and dead, that occur in a particular landscape. The type and quantity will depend upon soil, climate, geographic features, and fire history. The major fuel groups of grass, shrub, trees, and slash are defined by their constituent types and quantities of litter and duff layers, dead woody material, grasses and forbs, shrubs, regeneration, and trees. Fire behavior can be predicted largely by analyzing the characteristics of these fuels. Fire behavior is affected by seven principal fuel characteristics: fuel loading, size and shape, compactness, horizontal continuity, vertical arrangement, moisture content, and chemical properties.

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2 Modeling Inputs

2.1 Fuels

The seven fuel characteristics help define the 13 standard fire behavior fuel models (Anderson 1982) and the more recent custom fuel models developed for Southern California (Weise and Regelbrugge 1997). According to the model classifications, fuel models used for fire behavior modeling (BehavePlus) have been classified into four groups, based upon fuel loading (tons/acre), fuel height, and surface-to-volume ratio. Observation of the fuels in the field (on site) determines which fuel models should be applied in modeling efforts. The following describes the distribution of fuel models among general vegetation types for the standard 13 fuel models and the custom Southern California fuel models:

- Grasses — Fuel Models 1 through 3
- Brush — Fuel Models 4 through 7, SCAL 14 through 18
- Timber — Fuel Models 8 through 10
- Logging slash — Fuel Models 11 through 13.

In addition, the aforementioned fuel characteristics were utilized in the recent development of 40 new fire behavior fuel models (Scott and Burgan 2005) developed for use in the BehavePlus modeling system. These new models attempt to improve the accuracy of the 13 standard fuel models outside of severe fire season conditions, and to allow for the simulation of fuel treatment prescriptions. The following describes the distribution of fuel models among general vegetation types for the 40 new fuel models:

- Grass — Models GR1 through GR9
- Grass shrub — Models GS1 through GS4
- Shrub — Models SH1 through SH9
- Timber understory — Models TU1 through TU5
- Timber litter — Models TL1 through TL9
- Slash blowdown — Models SB1 through SB4.

For the Elephant Hill Project site BehavePlus analyses, fuel model assignments were based on observed field conditions. As is customary for this type of analysis, the terrain and fuels directly adjacent to the proposed development and fuel modification zones (FMZ) are used for determining flame lengths and fire spread. It is these fuels that would have the potential to affect the project's structures from a radiant and convective heat perspective as well as from direct flame impingement. Fuel beds, including non-native grasslands intermixed with sparse amounts of coastal sage scrub and chaparral habitats were observed adjacent to the proposed single-family and multi-family residential developments. These fuel types can produce flying embers that may affect the project, but defenses have been built into the structures to prevent ember penetration. Table 1 provides a description of the two fuel models observed in the vicinity of the site that were subsequently used in the analysis for this project. Modeled areas include the native and non-native grasslands (Fuel Model Gr4) found at the base of the hillsides and an intermix of grasslands and coastal sage scrub and chaparral (Fuel Model Gs2), which were found on the steeper hillsides north, south, and east of the proposed developments. Dudek also conducted modeling of the site for post-Fuel Modification Zones' (FMZ) recommendations for this project (Refer to Table 2 for post-FMZ fuel model descriptions). Fuel modification includes establishment of 30-foot irrigated setback zone

(Zone A) and an irrigated/transition zone (Zone B) on the periphery of the development site. For modeling the post-FMZ treatment condition, the fuel model assignments for grasslands and the intermix of grasslands and scrublands were re-classified according to the specific fuels management (e.g., irrigated vs cut grasses to 6 inches in height) treatment as identified in the Project's Fuel Modification Plan. Attachment 1, BehavePlus Analysis Map, identifies the fire behavior analysis locations.

Table 1. Existing Fuel Model Characteristics

Fuel Model Assignment	Vegetation Description	Location	Fuel Bed Depth (Feet)
Gr4	Non-native Grasslands	Represents grasses surrounding the project development.	<2.0 ft.
Gs2	Grass-shrub vegetation	Represents grass-shrub hillsides surrounding the project development	< 3.0 ft

Table 2. Post-development Fuel Model Characteristics

Fuel Model Assignment	Vegetation Description	Location	Fuel Bed Depth (Feet)
8	Zone A and B: irrigated landscapes	Perimeter Fuel Modification Zone A and B	<3.0 ft.
Gr1	Roadside Zone and Zone B: Grasses cut to 6 inches in height	Perimeter Fuel Modification Zone B and Roadside Zone	< 0.5 ft.

2.2 Weather

Historical weather data for the region was processed and utilized to determine appropriate fire behavior weather input variables for the Elephant Hill Project site fire behavior evaluations. To evaluate different scenarios, data for both the 50th percentile weather (on-shore winds) and the 97th percentile weather (off-shore winds) conditions were analyzed using the FireFamily Plus software[1] package. Remote Automated Weather Station (RAWS) data from the Santa Fe RAWS[2] was evaluated from June 1 through November 30 for all available data years. Available data years for the Santa Fe RAWS include 1994 to 2019. Following analysis in FireFamily Plus, fuel moisture and wind speed information data was incorporated into the BehavePlus modeling runs. Initial wind direction and wind speed values for the BehavePlus modeling runs were manually entered during the data input phase. The input wind speed and direction is roughly an average surface wind at 20 feet above the vegetation over the analysis area. Table 3 summarizes the weather and wind input variables used in the BehavePlus modeling efforts.

1 https://www.firelab.org/project/firefamilyplus

2 RAWS ID # 045437; Latitude: 34.121168 Longitude: 117.945459; Elevation: 498 ft. Santa Fee Station is approximately 9.8 miles northwest of the Elephant Hill Project site.

Table 3. Fuel Moisture and Wind Inputs

Variable	50th Percentile Weather Condition (Onshore Winds)	97th Percentile Weather Condition (Offshore Winds)
1h Moisture	5%	2%
10h Moisture	7%	3%
100h Moisture	12%	7%
Live Herbaceous Moisture	42%	30%
Live Woody Moisture	85%	60%
20-foot Wind Speed	19 mph[1] (sustained winds)	19 mph[1](sustained winds) and wind gusts of 50 mph
Wind Direction	270°	0°, 60°, and 165°
BehavePlus Wind Adjustment Factor	0.4	0.4

Note:
1 mph = miles per hour

2.3 Slope

Slope is a measure of angle in degrees from horizontal and can be presented in units of degrees or percent. Slope is important in fire behavior analysis as it affects the exposure of fuel beds. Additionally, fire burning uphill spreads faster than those burning on flat terrain or downhill as uphill vegetation is pre-heated and dried in advance of the flaming front, resulting in faster ignition rates. For the BehavePlus analysis, slope values were measured from google earth maps at the locations of each modeling scenario, and ranged in value between flat (<5%) to 42 percent.

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3 BehavePlus Analysis

To objectively predict flame lengths, intensities, and spread rates, the BehavePlus V6.0 fire behavior modeling system (Andrews, Bevins, and Seli 2004) was used in four modeling scenarios for the Elephant Hill Project and incorporated observed fuel types representing the dominant on-site and off-site vegetation, measured slope gradients, and wind and fuel moisture values derived from RAWS data sets. Modeling scenario locations were selected to better understand different fire behavior that may be experienced on or adjacent the site. The results of fire behavior modeling analysis are presented in Table 4 for pre-project conditions and Table 5 for post-project conditions.

Table 4: Fire Behavior Model Results - Existing Conditions for Elephant Hill

Fire Scenarios	Flame Length (feet)	Fireline Intensity (Btu[1]/feet/second)	Spread Rate (mph[2])	Spotting Distance[3] (miles)
Scenario 1: Summer on-shore weather from the west, 2% slope; 19 mph sustained winds (50th percentile)				
Grasslands (Gr4)	13.2	1,549	2.2	0.5
Grass-Shrub (Gs2)	7.2	413	0.6	0.4
Scenario 2: Fall off-shore extreme weather from N, 34% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Grasslands (Gr4)	18.3 (33.6)[4]	3,141 (11,833)	3.8 (14.3)	0.7 (2.0)
Grass-scrub (Gs2)	10.4 (19.1)	916 (3,438)	1.0 (3.9)	0.5 (1.3)
Scenario 3: Fall off-shore extreme weather from NE, 42% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Grasslands (Gr4)	18.5 (33.8)	3,234 (11,922)	3.9 (14.4)	0.7 (2.0)
Grass-scrub (Gs2)	10.5 (19.1)	945 (3,465)	1.1 (3.9)	0.5 (1.3)
Scenario 4: Fall off-shore extreme weather from South, 40% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Grasslands (Gr4)	18.5 (33.8)	3,233 (11,924)	3.9 (14.4)	0.7 (2.0)
Grass-scrub (Gs2)	10.5 (19.1)	944 (3,466)	1.1 (3.9)	0.5 (1.3)

Notes:
1 Btu = British thermal unit(s)
2 mph = miles per hour
3 Spotting distance from a wind driven surface fire.
4 Parenthesis represent 50 mph gusts

Table 5: Fire Behavior Model Results - Post-Project Conditions for Elephant Hill

Scenario	Flame Length (feet)	Fireline Intensity (BTU/feet/second)	Spread Rate (mph)	Spotting Distance (miles)
Scenario 1: Summer on-shore weather from the west, 2% slope; 19 mph sustained winds (50th percentile)				
Fuel modification Zone A and B (FM8)	3.0	63	0.2	0.4
Fuel modification zone B and Roadside (Gr1)	10.6	959	1.5	0.9
Scenario 2: Fall off-shore extreme weather from N, 34% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Fuel modification Zone A and B (FM8)	2.6	46	0.1	0.3
Fuel modification zone B and Roadside (Gr1)	3.1	67	0.5	0.4
Scenario 3: Fall off-shore extreme weather from NE, 42% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Fuel modification Zone A and B (FM8)	2.6	46	0.1	0.3
Fuel modification zone B and Roadside (Gr1)	3.1	67	0.5	0.4
Scenario 4: Fall off-shore extreme weather from South, 40% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
Fuel modification Zone A and B (FM8)	2.6	46	0.1	0.3
Fuel modification zone B and Roadside (Gr1)	3.1	67	0.5	0.4

It should be noted that the results presented in Tables 4 and 5 depict values based on inputs to the BehavePlus software. The fuels models used in this analysis are dynamic models that were designed by the U.S. Forest Service to more accurately represent southern California fuel beds. Changes in slope, weather, or pockets of different fuel types are not accounted for in this analysis. Model results should be used as a basis for planning only, as actual fire behavior for a given location will be affected by many factors, including unique weather patterns, small-scale topographic variations, or changing vegetation patterns.

Interpretation of Fire Behavior Modeling Results

Fire type is one of the following four types: surface (e.g., understory fire), torching (e.g., passive crown fire; surface fire with occasional torching trees), conditional crown (e.g., active crown fire possible if the fire transitions to the overstory), and crowning (e.g., active crown fire; fire spreading through the overstory crowns). Dependent on the variables: transition to crown fire and active crown fire.

The following describes the fire behavior results (Heisch and Andrews 2010) as presented in Tables 4 and 5:

Surface Fire:

- Flame Length (feet): The flame length of a spreading surface fire within the flaming front is measured from midway in the active flaming combustion zone to the average tip of the flames.
- Fireline Intensity (Btu/ft/s): Fireline intensity is the heat energy release per unit time from a one-foot wide section of the fuel bed extending from the front to the rear of the flaming zone. Fireline intensity is a function of rate of spread and heat per unit area, and is directly related to flame length. Fireline intensity and the flame length are related to the heat felt by a person standing next to the flames.

- Surface Rate of Spread (mph): Surface rate of spread is the "speed" the fire travels through the surface fuels. Surface fuels include the litter, grass, brush and other dead and live vegetation within about 6 feet of the ground.

The information in Table 6 pertains to interpretation of flame length and fireline intensity as it relates to fire suppression efforts for surface fires (Andrews and Rothermel 1982). Based on the post-development calculated flame lengths of under 3.0 feet tall, fire fighters should be able to conduct a direct attack on the fire within the FMZ Zone A, but they would need retardant aircraft or dozers beyond Zone A.

Table 6. Fire Suppression Interpretation

Flame Length (ft)	Fireline Intensity (Btu/ft/s)	Interpretations
Under 4 feet	Under 100 BTU/ft/s	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
4 to 8 feet	100-500 BTU/ft/s	Fires are too intense for direct attack on the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and retardant aircraft can be effective.
8 to 11 feet	500-1000 BTU/ft/s	Fires may present serious control problems – torching out, crowning, and spotting. Control efforts at the fire head will probably be ineffective.

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4 SUMMARY

The results as presented in Table 4, wildfire behavior in non-treated grasslands, presented as a Fuel Model Gr4, represents the most extreme conditions, varying with different wind speeds. In this case, flame lengths can be expected to reach up to approximately 34 feet with 50 mph gusts (Off-shore wind conditions) and approximately 13 feet with 19 mph wind speeds (On-shore winds). The fuel modification zones proposed for this Project are approximately three-times as wide as the worst-case scenario flame lengths. Spread rates for non-treated grasslands range from 2.2 mph (On-shore winds) to 14.4 mph (Off-shore winds). The Elephant Hill Project site is positioned in a way where the terrain slopes up and away from the project development. A fire will usually travel much faster uphill than downhill and the slope steepness will ultimately contribute to the fire's rate of spread. Spotting distances, where airborne embers can ignite new fires downwind of the initial fire, range from 0.5 miles to 2 miles. In comparison, a grass-shrub fuel type could generate flame lengths up to approximately 19 feet high with a rapid spread rate of 3.9 mph. The fire could potentially be spotting for a distance of 1.3 miles.

As presented in Table 5, Dudek conducted modeling of the Elephant Hill Project site for post-FMZ fuel recommendations. Fuel modification includes establishment of a 30-foot irrigated setback zone and an irrigated/transition zone on the periphery of the project development. For modeling the post-FMZ treatment condition, fuel model assignments were re-classified for the FMZ A and B (Fuel Model 8) and FMZ B and Roadside Fuels (Grasses cut to 6-inches in height - Fuel Model Gr1). Fuel model assignments for all other areas remained the same as those classified for the existing condition. As such, the FMZ areas experience a significant reduction in flame length and intensity. The 34-foot (non-native grassland fuel bed) tall flames predicted during pre-treatment modeling during extreme weather conditions are reduced to approximately 3.1 feet tall at the outer edges and less than 3.0 feet in the FMZ A near the structures of the development due to the higher live and dead fuel moisture contents. Additionally, surface spread rates decrease to approximately 1.5 mph with spotting distance decreasing to 0.9 miles.

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5 References

Alexander, M.E. 1998. Crown fire thresholds in exotic pine plantations of Australasia. Australian National University, Canberra, Australian Capital Territory. Ph.D. Thesis. 228p.

Anderson, Hal E. 1982. *Aids to Determining Fuel Models for Estimating Fire Behavior*. USDA Forest Service Gen. Tech. Report INT-122. Intermountain Forest and Range Experiment Station, Ogden, UT. http://www.fs.fed.us/rm/pubs_int/int_gtr122.pdf

Andrews, P.L. 1980. Testing the fire behavior model. In Proceedings 6th conference on fire and forest meteorology. April 22–24, 1980. Seattle, WA: Society of American Foresters. Pp. 70–77.

Andrews, Patricia L., Collin D. Bevins, and Robert C. Seli. 2008. BehavePlus fire modeling system, version 4.0: User's Guide. Gen. Tech. Rep. RMRS-GTR-106WWW Revised. Ogden, UT: Department of Agriculture, Forest Service, Rocky Mountain Research Station. 132p.

Andrews, Patricia L., and Richard C. Rothermel. 1982. Charts for Interpreting Wildland Fire Behavior Characteristics. USDA Forest Service Gen. Tech. Report INT-131. Intermountain Forest and Range Experiment Station, Ogden, UT. September 1982. 21 p.

Brown, J.K. 1972. Field test of a rate-of-fire-spread model in slash fuels. USDA Forest Service Res. Pap. Int-116. 24 p.

Brown, J.K. 1982. Fuel and fire behavior prediction in big sagebrush. USDA Forest Service Res. Pap. INT-290. 10p.

Bushey, C.L. 1985. Comparison of observed and predicted fire behavior in the sagebrush/ bunchgrass vegetation-type. In J.N. Long (ed.), Fire management: The challenge of protection and use: Proceedings of a symposium. Society of American Foresters. Logan, UT. April 17–19, 1985. Pp. 187–201.

FireFamily Plus 2008. http://www.firelab.org/project/firefamilyplus.

Grabner, K., J. Dwyer, and B. Cutter. 1994. "Validation of Behave Fire Behavior Predictions in Oak Savannas Using Five Fuel Models." Proceedings from 11th Central Hardwood Forest Conference. 14 p.

Grabner, K.W. 1996. "Validation of BEHAVE fire behavior predictions in established oak savannas." M.S. thesis. University of Missouri, Columbia.

Grabner, K.W., J.P. Dwyer, and B.E. Cutter. 2001. "Fuel model selection for BEHAVE in midwestern oak savannas." *Northern Journal of Applied Forestry*. 18: 74–80.

Heinsch, Faith Ann; Andrews, Patricia L. 2010. BehavePlus fire modeling system, version 5.0: Design and Features. General Technical Report RMRS-GTR-249. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 111 p.

Lawson, B.D. 1972. Fire spread in lodgepole pine stands. Missoula, MT: University of Montana. 110 p. thesis.

Linn, R. 2003. "Using Computer Simulations to Study Complex Fire Behavior." Los Alamos National Laboratory, MS D401. Los Alamos, NM.

Marsden-Smedley, J.B. and W.R. Catchpole. 1995. Fire behaviour modelling in Tasmanian buttongrass moorlands. II. Fire behaviour. *International Journal of Wildland Fire*. Volume 5(4), pp. 215–228.

McAlpine, R.S. and G. Xanthopoulos. 1989. Predicted vs. observed fire spread rates in Ponderosa pine fuel beds: a test of American and Canadian systems. In Proceedings 10th conference on fire and forest meteorology, April 17–21, 1989. Ottawa, Ontario. pp. 287–294.

Rothermel, Richard C. 1983. How to predict the spread and intensity of forest and range fires. GTR INT-143. Ogden, Utah: USDA Forest Service Intermountain Research Station.161 Rothermel, R.C., and G.C. Rinehart. 1983. "Field procedures for verification and adjustment of fire behavior predictions." Res. Pap. INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 25 p.

Rothermel, R.C., and G.C. Rinehart. 1983. "Field procedures for verification and adjustment of fire behavior predictions." Res. Pap. INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 25 p.

Scott, Joe H. and Robert E. Burgan. 2005. *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model*. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

Sneeuwjagt, R.J., and W.H. Frandsen. 1977. "Behavior of experimental grass fires vs. predictions based on Rothermel's fire model." *Canadian Journal of Forest Resources*. 7:357–367.

Weise, D.R. and J. Regelbrugge. 1997. Recent chaparral fuel modeling efforts. Prescribed Fire and Effects Research Unit, Riverside Fire Laboratory, Pacific Southwest Research Station. 5p.

Attachment 1

BehavePlus Analysis Map

Table 1. Existing Fuel Model Characteristics

Fuel Model Assignment	Vegetation Description	Location	Fuel Bed Depth (Feet)
Gr4	Non-native Grasslands	Represents grasses surrounding the project development.	<2.0 ft.
Gs2	Grass-shrub vegetation	Represents grass-shrub hillsides surrounding the project development	< 3.0 ft

Table 2. Post-development Fuel Model Characteristics

Fuel Model Assignment	Vegetation Description	Location	Fuel Bed Depth (Feet)
8	Zone A and B: irrigated landscapes	Perimeter Fuel Modification Zone A and B	<3.0 ft.
Gr1	Roadside Zone and Zone B: Grasses cut to 6 inches in height	Perimeter Fuel Modification Zone B and Roadside Zone	< 0.5 ft.

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Notes:
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4 Parenthesis represent 50 mph gusts

Table 5: Fire Behavior Model Results - Post-Project Conditions for Elephant Hill

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Scenario 2: Fall off-shore extreme weather from N, 34% slope; 19 mph sustained, 52 mph gusts (97th percentile)				
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SOURCE: AERIAL-BING MAPPING SERVICE

DUDEK

0 400 800 1,600 Feet

ATTACHMENT 1

BehavePlus Analysis Map

Elephant Hill Fire Protection Plan