PACIFIC GAS AND ELECTRIC COMPANY
Wildfire Mitigations Plans Discovery 2026-2028
Data Response

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PG&E File Name:	WMP-Discovery2026-2028_DR_SPD_007-Q001
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Requester DR No.:	SPD-PGE-WMP2026-007
Requesting Party:	Safety Policy Division
Requester:	Edwin Schmitt
Date Sent:	June 12, 2025

SUBJECT: FOLLOW-UP ON MITIGATION EFFECTIVENESS IN 2026-2028 BASE WMP (SPD- PGE-WMP2026-007)

Provide responses to the items listed below.

QUESTION 001

The following questions are all related to PG&E's estimated Mitigation Effectiveness.

a. Table PG&E-8.2.1-3 shows the blended average effectiveness for system hardening scenarios. The table is titled "Ignition Mitigation Effectiveness" but SPD understands from footnote (a) and review of "WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx" that the blended average effectiveness reported are based off outage data instead of ignition data. SPD also understands that PG&E does not use the mitigation effectiveness values from Table PG&E-8.2.1-3 when calculating the risk mitigated for each circuit segment from various mitigation programs and instead uses the mitigation effectiveness estimate for each specific ignition driver multiplied by the calculated risk for each circuit segment for each driver from the WDRM v4 model.[1]

   SPD used the driver mitigation effectiveness from ACI 25U and applied those values to the circuit segment ignition driver risk from WDRM v4 to establish the three cases presented in the table below: (1) all circuits segments in the WDRM v4, (2) all circuits segments in the HFTD in the WDRM v4, (3) the top 5% riskiest circuit segments.[2] SPD found the values in Table PG&E-8.2.1-3 appears to overestimate the risk reduced compared to the calculated risk reduction which PG&E uses in its risk calculations for covered conductor and underground primary.

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[1] SPD understands that the mitigation effectiveness for many wildfire programs for each ignition driver in WDRM v4 are calculated in "WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx" and presented in ACI 25U-03.

[2] The mitigation effectiveness for each driver was based on the mitigation effectiveness ratios in ACI 25U-03. The WDRM v4 risk calculations were based off "WMP-Discovery2023-2025_DR_CalAdvocates_041-Q005Atch01".

MITIGATION EFFECTIVENESS SUMMARY

Area where Mit. Effect. Is Calculated	WDRM SH Risk (natural units)	Residual Risk (natural units)			Residual Risk (%)			Mitigation Effectiveness (%)		
		CC	UG Primary	UG All	CC	UG Primary	UG All	CC	UG Primary	UG All
Total	1097	374	45	16	34.1%	4.1%	1.4%	65.9%	95.9%	98.6%
HFTD Only	964	329	38	13	34.1%	4.0%	1.3%	65.9%	96.0%	98.7%
Top 5%	503	172	20	7	34.3%	4.0%	1.4%	65.7%	96.0%	98.6%

i. Why does PG&E use the mitigation effectiveness estimated based on outages in Table PG&E-8.2.1-3?

ii. Why does PG&E not estimate the mitigation effectiveness based on the calculated risk in WDRM v4 when completing Table PG&E-8.2.1-3?

a) Would using the mitigation effectiveness based on the calculated risk in WDRM v4 align the values in Table PG&E 8.2.1-3 with the risk reduction values PG&E uses in decision making? Explain why or why not.

iii. SPD understands that PG&E does not use the values in Table PG&E-8.2.1-3 for risk calculations but often sees these values in television advertisements and other high-level presentations of PG&E's wildfire mitigation program. To this end, will PG&E revise Table PG&E-8.2.1-3 to reflect the mitigation effectiveness based on the calculated risk in WDRM v4, which is used when PG&E is making decisions about mitigation selection. Explain why or why not.

a) Will PG&E update its television advertisements and other high-level presentations to reflect the mitigation effectiveness based on the calculated risk in WDRM v4? Explain why or why not.

b. SPD also calculated a mitigation effectiveness based on the PG&E's estimated driver mitigation effectiveness[3] and the WDRM v4 event model wildfire risk classification for ignitions "WMP-Discovery2026-2028_DR_SPD_001-Q006Supp01Atch01CONF.xlsx." SPD found the values in Table PG&E-8.2.1-3 for both covered conductor and underground primary exceeded the estimated mitigation effectiveness from this second study. To this end, if PG&E does not plan to update the values in Table PG&E-8.2.1-3 explain why PG&E uses the outages rather than ignitions for understanding the mitigation effectiveness of various wildfire mitigations?

3 The mitigation effectiveness for each driver was based on the mitigation effectiveness ratios in ACI 25U-03. The ignitions classifications were based off of WMP-Discovery2026-2028_DR_SPD_001-Q006Supp01Atch01CONF.xslx"

Ignition-Based Mitigation Effectiveness for HFTD		
OH	UG Pri*	UG All*
65%	96%	99%

* does not account for ignitions related to UG system

c. It does not appear that the distribution drivers of ignitions and outages match - which PG&E acknowledges in its response to ACI PG&E-25U-01 where PG&E explains that WDRM v4 has a p(i Jo) model to account for this issue. Despite noting the mismatch in ignitions and outages, PG&E does not appear to account for this issue in its mitigation effectiveness estimations. This may have several impacts on mitigation effectiveness calculations.[4] For instance, when the distribution of drivers of ignitions and outages do not match, this could manifest itself in misrepresenting the actual mitigation effectiveness of the ignition drivers. If there was a large percentage of outages that were unlikely to cause ignitions - a mitigation effectiveness based on outages could overstate the mitigation effectiveness of a particular ignition driver. This mismatch in mitigation effectiveness could propagate to misrepresent the risk reduced based off the calculated risk associated with the ignition drivers in WDRM v4. To determine the mitigation effectiveness of a mitigation for each ignition driver, SPD understands that PG&E's SMEs estimate mitigation effectiveness for a multitude of outage drivers as seen in sheet "Grid Hardening SME Input" of WMP- Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx. SPD understands the SME inputs are used to develop a mitigation effectiveness for each of the ignition drivers in WDRM v4 based on the outage data in "WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx." For the ignition driver "vegetation_branch," "WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx" indicates there are 8075 outages (excluding those labeled "N/A"). Within the 8075 "vegetation_branch" outages, 296 outages (3.6%) are identified as not being 100% mitigated by Underground Primary Only.[5] Based on the SME Mitigation effectiveness estimates for the various outages PG&E associates with the ignition driver "vegetation_branch," PG&E estimates that Underground Primary Only is 98% effective for the ignition driver "vegetation_branch." This differs substantially when compared to a study of historical ignitions. Of the 2804 CPUC-reportable ignitions classified as part of the WDRM v4 event model wildfire risk classification (see "WMP-Discovery2026- 2028_DR_SPD_001-Q006Supp01Atch01CONF.xlsx."),

4 For instance, the outage mitigation effectiveness estimates in Table PG&E-8.2.1-3 appears less conservative when compared to mitigation effectiveness estimates based on ignitions and separately based on the calculated risk mitigated in PG&E's WDRM v4 as discussed in other sub-questions.

5 Note that all of the 296 outages are associated with the secondary voltage levels or customer equipment.

332 ignitions are classified as "vegetation_branch."[6] Of those 332 ignitions, PG&E reported 75 "vegetation_branch" ignitions related to the secondary system (22%).[7] For simplicity when calculating the effectiveness based on historical ignitions, SPD used the “high” effectiveness assigned by PG&E to the 75 secondary ignitions for the outage driver “Vegetation|Treebranchfellonline|Secondary|Normal” and assumed all other ignitions would be 100 percent mitigated to match PG&E’s assessment. SPD finds the “vegetation_branch” driver mitigation effectiveness based on the historical ignition data to be 94.3% effective.[8] Using a mitigation effective of ~52% (which is the average of the PG&E SME-estimated mitigation effectiveness for service and secondary conductor ignitions related to the vegetation_branch driver in “WMP-Discovery2026- 2028_DR_SPD_001-Q010Atch02.xlsx.”), the mitigation effectiveness computed for the “vegetation_branch” driver is 89%. A similar analysis can be done with ignitions classified as “vegetation_branch” related to HFTD ignitions to compute an effectiveness of 96% and 92% for former and later assumed mitigation effectiveness.[9] These differing mitigation effectiveness estimates (the various ignition-based effectiveness and the outage-based effectiveness of 98 percent) imply that the individual mitigation effectiveness computed for each ignition driver that is used to compute the risk reduced for each driver in WDRM v4 may be incorrectly estimating the risk reduced because the distribution of outage drivers does not appear to match the distribution of ignition drivers. For the case of “vegetation_branch,” it appears that the Underground Primary mitigation effectiveness with PG&E’s current outage-based methodology may be overestimating the risk reduced.[10] Given this information, explain how PG&E can adjust its outage-based mitigation effectiveness to more directly compute the estimated risk reduction from mitigations.

i. If, in the above explanation, PG&E intends to state that ignitions from equipment/lines at secondary voltages (like service conductors and secondary lines) are less risky than ignitions from primary lines, provide computations

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6 SPD understands that PG&E used the classification for ignitions of the "WDRM v4 event model wildfire risk classification" to compute the risk associated with the "animal bird" ignition risk driver from WDRM v4.

7 To find the 75 ignitions associated with the secondary system, SPD used a filter on the voltage classification to single out ignitions that PG&E reported occurred at the 750 V, 480 V, 240 V and 120 V levels with a filter for the HFTD.

8 The calculation is ((332-75)*100%+75*75%)/332 = 94.%. SPD is using these mitigation effectiveness values solely to demonstrate how the outage mitigation effectiveness and the ignition mitigation effectiveness for each driver give different results.

9 There are 229 ignitions classified to the “vegetation-branch” driver in PG&E’s HFTD and 20 including the voltage filter described in footnote 7.

10 This effect is similar but less impactful for covered conductor – at least for the “vegetation_branch” driver. PG&E’s outage-based mitigation effectiveness assesses covered conductor as 76% effective for the “vegetation_branch” driver. PG&E’s average mitigation effectiveness for the “vegetation_branch” driver for covered conductor is ~51% for secondary/service conductor outages and 77% for other outages. Using these numbers in the same manner as the previous example computes a 71% effective for the vegetation_branch driver based on historical ignitions across the service territory and 73% effective based on HFTD ignitions.

which show how this impacts the mitigation effectiveness, taking into account that Service Conductors and Secondary lines may remain energized in PSPS/RFW conditions when connected to undergrounded primary lines.

d. PG&E submitted “WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx” which includes the number of outages in each year (see table below). The number of outages varies extensively on a yearly basis with a low of 6758 outages in 2015 and a high of 26751 outages in 2024. Confirm the correct subset of outages was included in WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx

   i. If the correct subset of outages was included in WMP-Discovery2026-2028_DR_SPD_001-Q010Atch02.xlsx, provide an explanation for why 2024 exhibits neatly double the number of outages of any other year on record.

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Number of Outages	6758	8434	13677	7806	13804	9348	12840	8919	8727	26751

e. The mitigation effectiveness calculation on undergrounding mitigations appears to neglect the impact from undergrounding ignitions - in fact Table PG&E-8.2.1-3 states underground outages are not included in the study. Based on "WMP-Discovery2023_DR_SPD_003- Q004.pdf," SPD understands that ignitions on undergrounded lines occur at a much lower rate per mile than overhead lines - but also understands that the rate of ignitions on undergrounded lines is not zero. Explain how PG&E accounts for the ignition risk from undergrounded lines in its mitigation effectiveness, especially accounting for unique drivers for undergrounded systems.

f. In "WMP-Discovery2026-2028_DR_SPD_003-Q00S.pdf," PG&E states that it estimates 1.25 miles of undergrounding is needed to mitigate 1 mile of overhead. A simplistic per mile ignition-based effectiveness based on "WMP-Discovery2023_DR_SPD_003-Q004.pdf' would imply that undergrounding an overhead line would reduce the ignition rate by 95% on a per mile basis. However, this analysis neglects the twenty five percent increase in underground miles and thus exposure from converting from overhead to underground mileage. How does PG&E account for the increased exposure from undergrounding overhead miles in its analysis of mitigation effectiveness?

g. From "WMP-Discovery2023_DR_SPD_003-Q004.pdf," SPD understands that PG&E's SMEs assessed that the relative risk of an underground ignition was less than an overhead ignition based on PG&E's assessment that no underground ignitions between 2015 and 2021 were larger than 10 acres. How has PG&E's views changed on the relative risk of underground ignitions to overhead ignitions since that response and has PG&E found additional justification for the assessment?

   i. Explain if this justification includes that the exposure of the lines may be different - for instance - the relative risk of ignition of lines undergrounded as part of wildfire mitigation may be higher than lines that were undergrounded for other reasons.

h. Has PG&E experienced any ignitions on lines (including both the primary and hardened overhead secondary portions of the line) which have been undergrounded as part of a wildfire mitigation?

i. If so, provide the PIIR.

i. In "WMP-Discovery2026-2028_DR_SPD_001-Q007.pdf' PG&E explained that "Support Structure: Electrical" and "Transformer: Leaking" the drivers from WDRM v4 are not included in the system hardening composite. Explain why.

   i. For "Support Structure: Electrical" in particular - the WDRM v4 event model wildfire risk classification classified 1 ignition related to this driver as larger than 300 acres (out of 31 total) and 5 of these ignitions as greater than 10 acres (out of 136 total). These numbers are both greater than other drivers which are included in the system hardening score. Why is this model not included in the system hardening composite?

   ii. Per WDRM v4, the Transformer: Leaking driver has a very small amount of risk which may make sense to neglect - but "Support Structure: Electrical" appears to comprise 9% of the total computed risk from WDRM v4 (6% of the HFTD only risk), which is the fourth highest driver. How does PG&E account for the residual risk from non-system hardening composite drivers after performing hardening?

   iii. If drivers discussed in Question 1.i.ii are not being mitigated by system hardening programs – this would imply that an average system hardening project with 99% effectiveness would leave ~9% of wildfire risk on the system (6% in the HFTD). Is PG&E discounting the mitigation effectiveness calculations for system hardening so that a system hardening project that is estimated to be 99% effective for the system hardening composite is not over-estimating the risk reduced since it is not addressing some of the calculated drivers of wildfire risk in WDRM v4?

      a) If so, explain how and provide a dataset to demonstrate how it is incorporating this into the mitigation effectiveness calculation.

      b) If not, explain why PG&E is not discounting the mitigation effectiveness calculations for system hardening.

   iv. PG&E's response to "TURN_004_Q10" states that covered conductor is estimated to be 52% effective against EPSS risk, but in Table PG&E-8.2.1-3 PG&E's mitigation effectiveness for wildfire ignition expects it to be 67% effective, which is based on the number of outages expected to be mitigated. Why are these numbers not more similar given both are related to the number of expected outages?

ANSWER 001

a. The values provided in Table 8.2.1-3 are blended average effectiveness values using outages as a proxy for ignitions. Limited ignition data is available for hardened assets and therefore we do not have sufficient data to use ignition data as the basis for our mitigation effectiveness analyses. Because we do not have sufficient ignition data, PG&E uses outage data as a reasonable proxy because it is abundantly available and allows for a statistically significant analysis. The unique percentage of risk reduced by these mitigations when applied to a specific circuit segment, or group of segments, will vary above or below the nominal values in the table.

- PG&E interprets SPD's calculations to represent mitigation effectiveness as a function of risk reduction based on the risk drivers at the circuit segment level, then calculating an average of those results.
- In WMP Table 8.2.1-3, PG&E reports the Blended Average Effectiveness values to portray an average effectiveness of each mitigation in preventing ignitions, using abundant historic outages as a proxy to support a more statistically significant study than can be performed using historic ignitions. PG&E stands by our analysis results as accurate average effectiveness values.
- The difference between the approaches above are:
    - We plan on employing a mitigation method that is calculated to be, on average, 98% effective at reducing the potential of an ignition at the undergrounded location.
    - The estimated risk reduction to be achieved in any given location is based on the risk drivers at that specific location, and the amount of risk that exists at that location (independent of the Blended Average Effectiveness).

i. PG&E uses outages as a proxy for ignitions since there is abundant data available from thousands of different types of failure events, each with the potential to cause an ignition, to support a statistically significant analysis.

ii. The primary objective of the WDRM v4 is to predict wildfire risk associated with the distribution system. The WDRM does not calculate mitigation effectiveness. Further, the WDRM v4 is a set of machine learning (ML) models, and it is not appropriate to extract causal information from the predictive models. The models predict future values based on historical event data.

   a) We began an analysis with outages as a proxy for ignitions to define driver-level effectiveness values and apply these to estimate risk reduction based on the WDRM predicted risk values.

iii. The values in Table 8.2.1-3 are simply averages that are used to present a high-level summary of the more detailed data PG&E uses for location-specific risk reduction analysis.

   a) PG&E is not planning to update its television commercials. PG&E regularly assesses public messaging as additional data becomes available.

b. As described in response to Question (1)(a)(i) above, outage data is more abundantly available than ignition data and supports a more statistically significant analysis. Therefore, outage data is a suitable proxy for ignition data to inform effectiveness calculations. The values in table 8.2.1-3 are reference points that can be used broadly. The driver-level effectiveness values are then applied against their respective WDRM risk drivers to calculate a more precise risk reduction estimate. Please see section 8.2.1 of our WMP for a detailed explanation of the approach applied.

c. PG&E interprets the question to be about appropriateness of PG&E's use of outage data at estimating mitigation effectiveness vs. ignition data. Generally, PG&E uses outage data and expert engineering mitigation analysis to model effectiveness, due to the lack of ignition data available to accurately calculate effectiveness across specific circuit segments, lack of observed data on relatively new mitigation methods (e.g. covered conductor), and complexity of calculating effectiveness on overlapping mitigation methods, as PG&E has detailed in *"RAMP-2024_DR_TURN_006-Q004.pdf"*, *"WMP-Discovery2026-2028_DR_TURN_003-Q008.pdf"*, and *"WMP-Discovery2026-2028_DR_TURN_004-Q007.pdf"*.

   Concerning, SPD's analysis of vegetation_branch failures on secondary and service lines, there are several complications with this assessment and the conclusion drawn that undergrounding primary's effectiveness would be reduced:

   - The bulk of those ignitions, if not all, have occurred on bare secondary conductor or aged grey service lines without breakaway connectors.
   - A vegetation_branch failure on a service line which is overhead hardened using breakaway connectors, in the "UG Primary" scenario, is almost guaranteed to disconnect in the case of the failure event, prohibiting any ignition.
   - This same feature is not available on primary distribution voltage covered conductor lines, therefore it is reasonable to assume that the effectiveness of overhead hardening secondary and service lines is more effective than the effectiveness of overhead hardening primary voltage lines.

     i. Additionally, PG&E applies conservative assumptions when estimating mitigation effectiveness for secondary and service lines. In the "Underground Primary" (UG Primary) scenario, due to limited granularity in geospatial data for these secondary and service assets, mitigation effectiveness for the "secondary conductor" driver is discounted by approximately 50%, even in areas with minimal or no secondary infrastructure. In practice, many secondary lines are co-located with primary lines and are typically undergrounded together, suggesting that actual effectiveness may be closer to the "UG All" scenario, which assumes ~99% effectiveness.

d. The correct subset of outages was included.

   i. The imported outage dataset for 2024 included a large number of planned maintenance outages which were pre-filtered out from earlier years in the analysis. The additional approximately 19,000 planned maintenance outages in 2024 were assessed consistently with other types of company-initiated events as "N/A" effectiveness and do not impact the results of the analysis.

e. PG&E's analysis already considers the potential for ignitions on underground assets. PG&E does not assume that converting overhead assets to underground assets equates to absolute elimination of ignition risk (which would result in effectiveness outputs of 100% for the underground scenario). PG&E accounts for the fact that underground assets are still an energy source and, although significantly less likely, retain the potential to cause ignitions.

f. While it is often necessary to reroute underground lines from the exact route of pre-existing overhead lines, approximately 1.25 miles of undergrounding may be installed to replace 1 mile of overhead lines. However, the wildfire risk exposure of underground lines is directly attributable to the exposed equipment such as riser poles or transformers which are not installed completely subsurface, rather than the cable itself. The supplemental rerouted primary conductor is not expected to impact wildfire risk exposure by any quantifiable measure. Since the additional mileage is underground and protected from environmental exposure, risk factors like wind and vegetation are nearly eliminated compared to overhead lines. Additionally, these lines are often relocated to areas of lower wildfire consequence, including roadways with reduced vegetation and improved access for maintenance; therefore, accounting for additional risk exposure is not applicable.

g. PG&E's view has not changed.

   i. Not applicable, as our view has not changed.

h. PG&E is not aware of any ignitions on lines which have been undergrounded as part of Wildfire Mitigation system hardening.

   i. Not applicable.

i. The "Support Structure: Electrical" model was not included in the System Hardening composite because the model is intended to predict tracking related events. The pole tracking ignitions primarily occur during wet or foggy conditions in urban areas and are typically contained to the pole top. The primary mitigation for the contamination that leads to tracking events is insulator washing. Heavy rainfall can also wash away contamination. To focus the System Hardening composite on the drivers of concern in High Fire areas during dry conditions, the "Support Structure: Electrical" model was excluded from the System Hardening composite.

   The "Transformer: Leaking" model only included one ignition in the historical ignition data. It was concluded that this failure driver does not present a significant ignition risk and lacked historical data to train the p(i|o) model. To focus the System Hardening composite on the primary drivers of concern in High Fire areas during dry conditions, the "Transformer: Leaking" model was excluded from the System Hardening composite.

   i. Please see the starting paragraph for (i) above for why the "Support Structure: Electrical" model was excluded from the System Hardening composite.

   ii. PG&E addresses wildfire risk on the distribution system through a comprehensive mitigation strategy as described in the WMP. The WDRM was designed to provide each mitigation program with a custom composite of wildfire risk based on the addressable risk drivers. For example, vegetation management composite is composed of three WDRM v4 vegetation models. This ensures that the vegetation mitigation programs are focused on locations with vegetation-related risk.

   iii. It's important to understand that mitigation effectiveness represents an average across the system within HFTD at reducing ignitions. Risk reduction is a location specific risk benefit estimated by combining the location specific wildfire risk with the HFTD-wide driver-level mitigation effectiveness values.

      PG&E only considers the risks defined in the system hardening composite WDRM v4 dataset when analyzing system hardening mitigations. As such, it would not be appropriate to discount effectiveness assumptions based on non-wildfire risk drivers.

a. N/A

b. PG&E is not discounting the mitigation effectiveness calculations for System Hardening. Since covered conductor and undergrounding are considered to be highly effective mitigations at preventing contamination and arcing during wet weather, including those risks drivers in the System Hardening composite would increase the risk reduced and shift the resiliency mitigations to locations where ignitions occur during wet weather. This would be an undesired impact due to the WDRM v4 model's inability to isolate wet weather ignitions occurring during the wildfire season months (Jun – Nov).

iv. The method of analyzing the effectiveness of covered conductor in preventing ignitions versus preventing outages is quite similar in that both methods use expert engineering assessments of the cause of historic outages. However, the delta lies within the expert engineering assessment of each individual outage combination, otherwise referred to as "failure mode" and the degree to which the mitigation would be effective at preventing an outage from that failure mode and how effective it would be at preventing an ignition from that failure mode. The study referenced in Table PG&E-8.2.1-3 considers how effective the mitigation would be in preventing an *ignition* from the failure event. The study referenced in PG&E's response to TURN_004_Q10 instead assesses how effective the mitigation would be in preventing an outage from the failure event. It was assessed that certain failure modes are more apt to result in an outage than an ignition as shown in the table below:

Basic Cause	**Supplemental Cause**	**Failed/ Involved Equipment**	**Equipment Condition**	**Qualitative Ignition Effectiveness Assumption**	**Qualitative Outage Effectiveness Assumption**
Vegetation	Tree - branch fell on line	Conductor, Overhead	Bent or Twisted	**Very High**	**Medium**