

Wildfire 2020 RAMP Post-Filing Workshop

Electric Operations
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July 30, 2020



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Objective

Provide overview of PG&E's Wildfire Risk Assessment and Mitigation Program Portfolio going into 2023 General Rate Case

- I. Introduction
 - a. *Definition & RAMP Risk Scores*
 - b. *Regulatory Proceedings & Risk Modeling Summary*
- II. Risk Assessment
 - a. *Risk Bowtie Overview*
 - b. *Exposure/Tranches*
 - c. *Drivers and Sub-drivers*
 - d. *Consequences*
 - e. *Cross Cutting Factors*
- III. Mitigations and Controls
 - a. *Enhanced Vegetation Management*
 - b. *System Hardening and Non-Exempt Equipment Replacement*
 - c. *Public Safety Power Shutoff*
 - d. *Inspections*
- IV. Appendix

Definition

PG&E assets or activities that may initiate a fire that is not easily contained, endangering the public, private property, sensitive lands or environment.

Scope

- **In Scope:** PG&E assets or activities that may initiate a fire that is not easily contained, endangers the public, private property, sensitive lands or environment
- **Out of Scope:** Fire ignitions and associated impacts not related to PG&E electric system assets

Background

Changes in weather and vegetation growth and tree mortality patterns brought on by climate change, coupled with increased development in formerly wildland areas have led to increased consequences related to wildfire ignitions in recent years. As discussed in PG&E's 2020 GRC testimony on the Wildfire risk, 15 of the 20 most destructive wildfires in California's history have occurred since 2000, including 10 since 2015. PG&E's overhead electrical transmission and distribution assets are potential sources of wildfire ignition. PG&E faces significant wildfire challenges because of the size and geography of its service area. PG&E serves approximately 5.5 million electric customers across a service territory of approximately 70,000 square miles, more than half of which is included in HFTD areas.

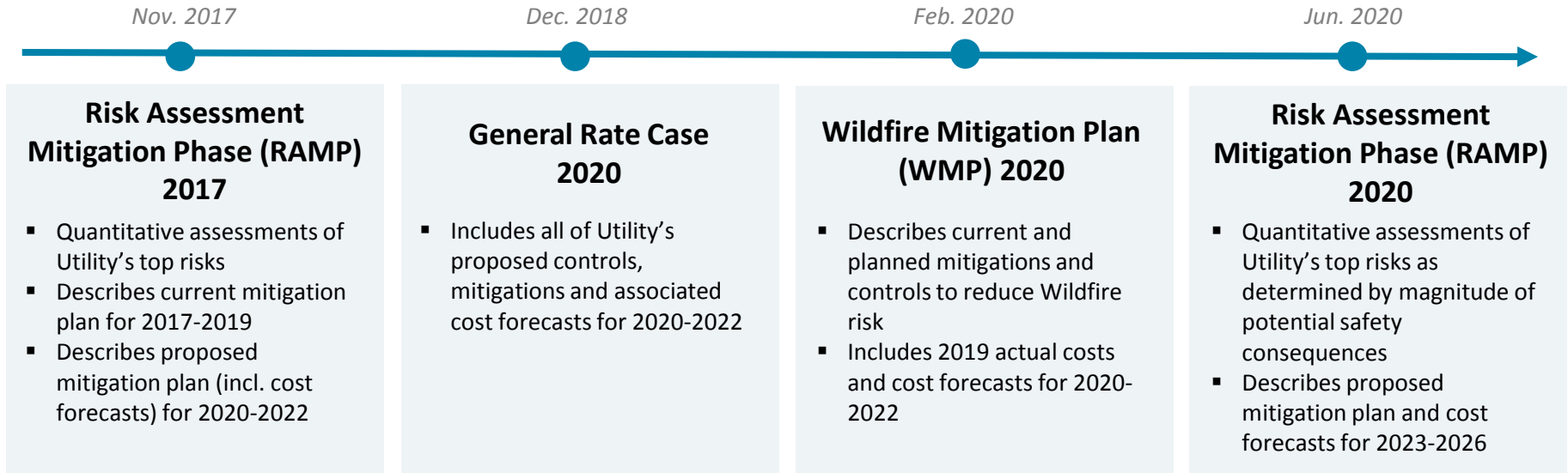


PG&E RAMP Risk Scores

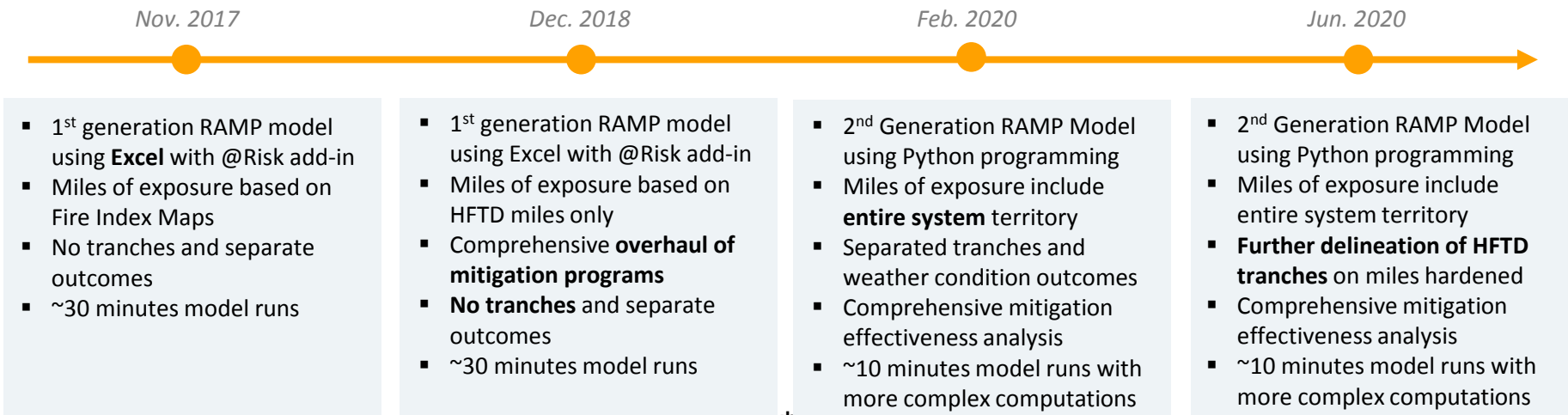
Rank	LOB	Safety Risks	2023 Baseline Score	
			Safety Risk Score	Multi-Attribute Risk Score
1	EO	Wildfire	9,856	25,127
2	SHED	Third Party Safety Incident	887	944
3	GO	Loss of Containment on Gas Transmission Pipeline	128	281
4	SHED	Contractor Safety Incident	94	94
5	SHED	Employee Safety Incident	86	90
6	GO	Loss of Containment on Gas Distribution Main or Service	72	99
7	SS	Real Estate and Facilities Failure	69	97
8	PGEN	Large Uncontrolled Water Release (Dam Failure)	41	70
9	EO	Failure of Electric Distribution Overhead Assets	18	525
10	SHED	Motor Vehicle Safety Incident	16	17
11	EO	Failure of Electric Distribution Network Assets	6	7
12	GO	Large Overpressure Event Downstream of Gas M&C Facility	5	13

The Wildfire risk modeling has evolved since the RAMP 2017 filing, across various regulatory proceedings

PG&E Regulatory Filings addressing Risks



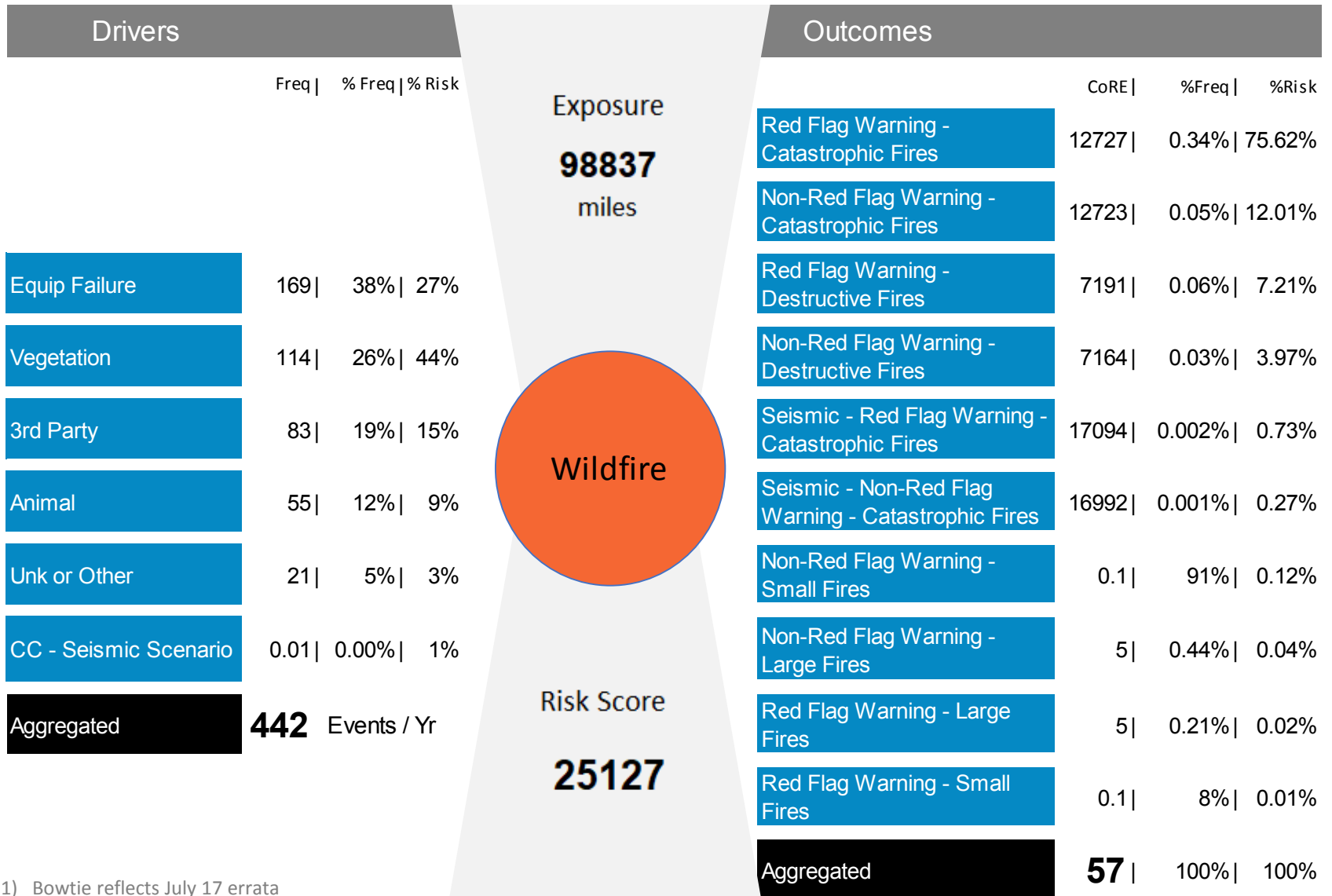
Evolution of Wildfire risk modeling



Risk Assessment – Bowtie Development

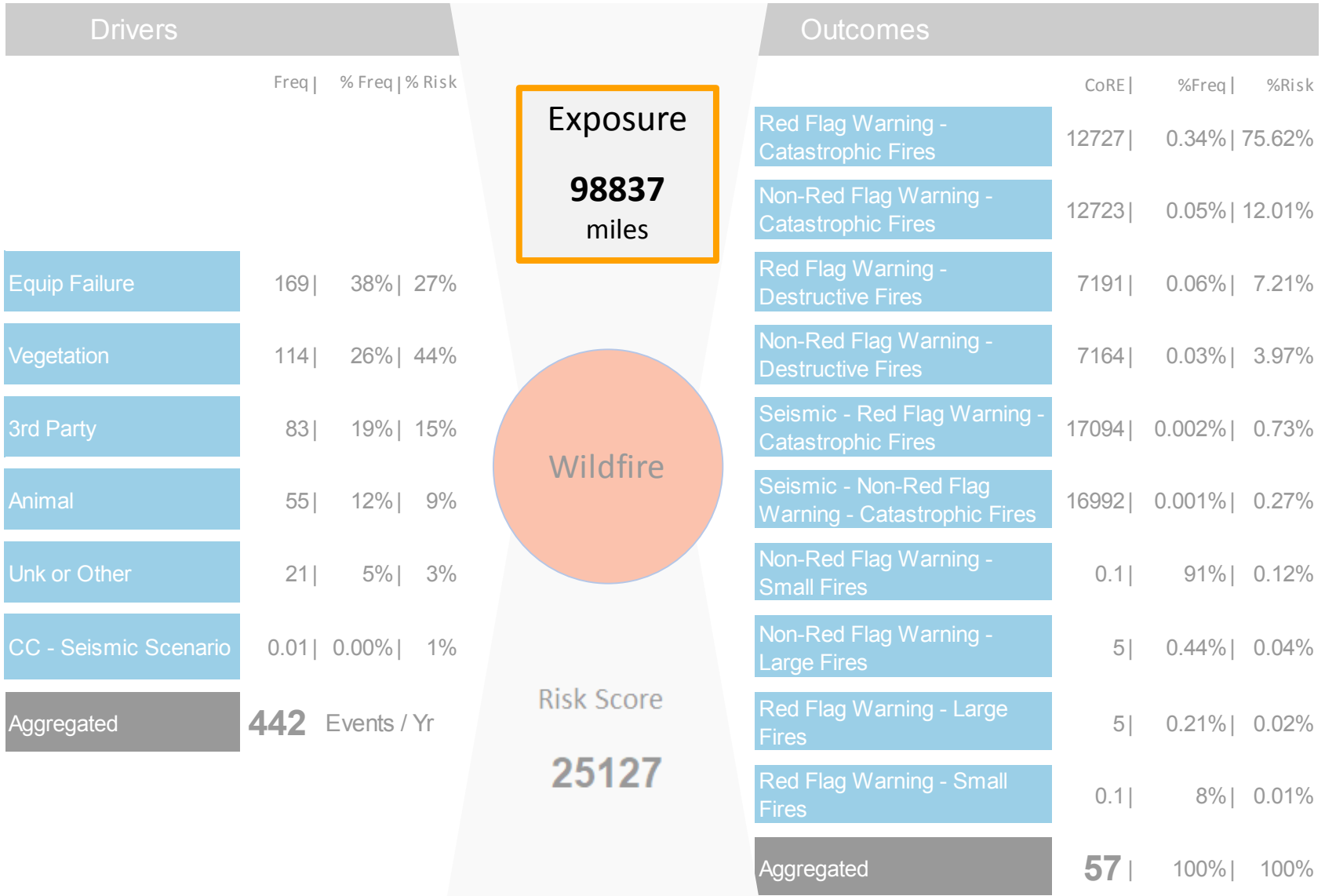


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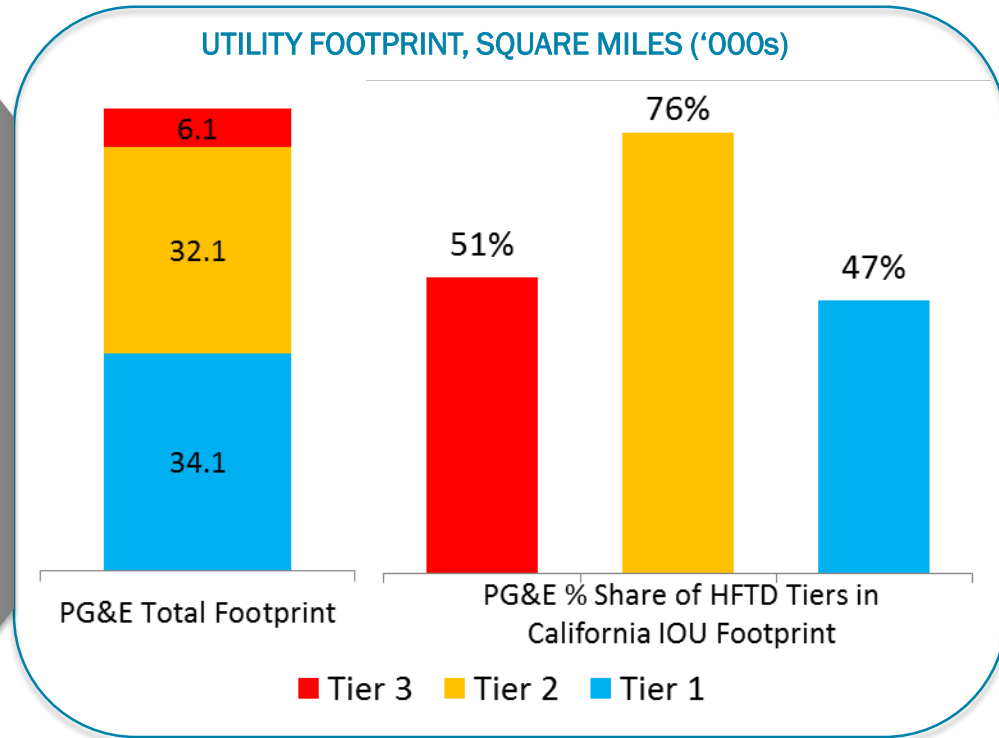
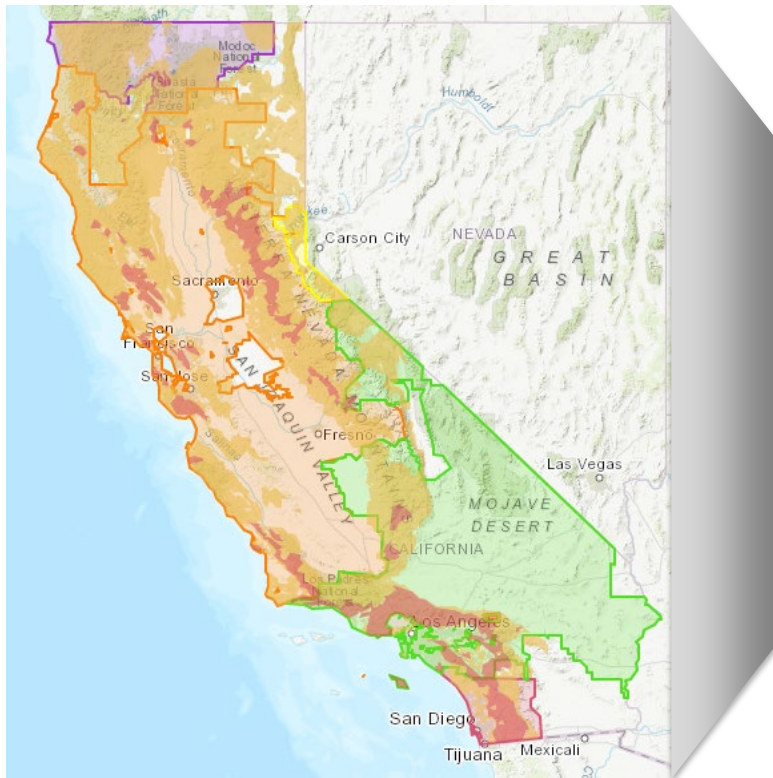
(1) Bowtie reflects July 17 errata

(2) Risk score represents Test Year Baseline Risk Score for 2023 (i.e. pre-mitigation risk score for 2023, post 2020-2022 mitigations, post all controls)



Wildfire Risks in PG&E's Service Area

Fire Threat Tiers by California IOUs

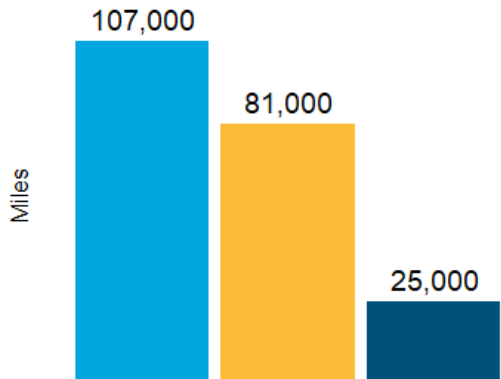


- Pacific Gas & Electric
- Southern California Edison
- San Diego Gas and Electric
- CPUC Tier 2
- CPUC Tier 3

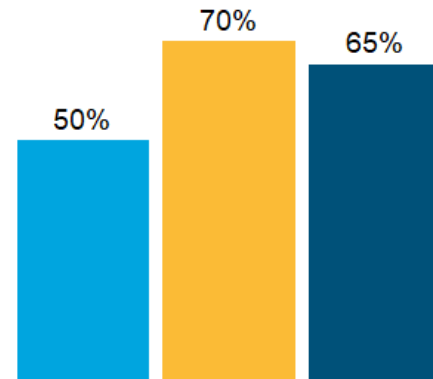
Sources: PG&E – Company data, SCE – Grid Safety and Resiliency Program Application; SDG&E – PG&E analysis

Distribution Circuit Miles

PG&E SERVICE TERRITORY



PG&E % SHARE OF CALIFORNIA IOU DISTRIBUTION CIRCUIT MILES



KEY

- Primary distribution circuit miles
- Overhead distribution circuit miles
- Overhead distribution circuit miles in High Fire Threat Areas

OBSERVATIONS

- PG&E has the largest population of the overhead conductors in the fire threat areas of the California IOUs.

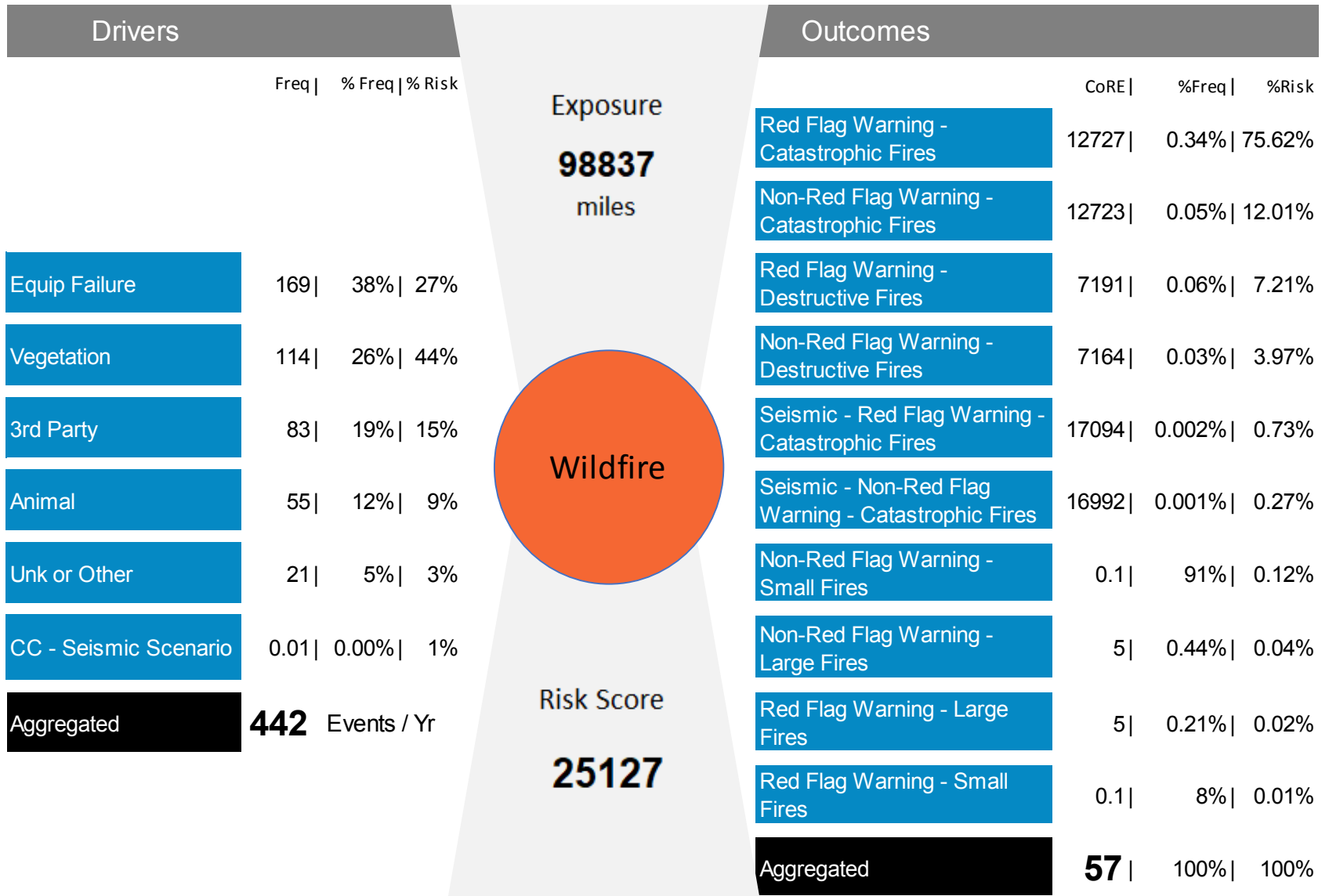
Note: (1) California IOUs is comprised of PG&E, SCE, and SDG&E. PG&E Fire Threat Area mileage is defined as HFTD Tier 3, 2, and Zone 1. SCE Fire Threat Area is defined as High Fire Risk Area (HFRA), which contains Tier 3 and Tier 2 areas and additional areas selected by SCE. SDG&E Fire Threat Area is defined as Fire Threat Zone as established in its 2016 RAMP Filing. Sources: PG&E: RAMP Filing 2017, company data; SCE: Grid Safety and Resiliency Program, September 2018; SDG&E: RAMP Filing 2016

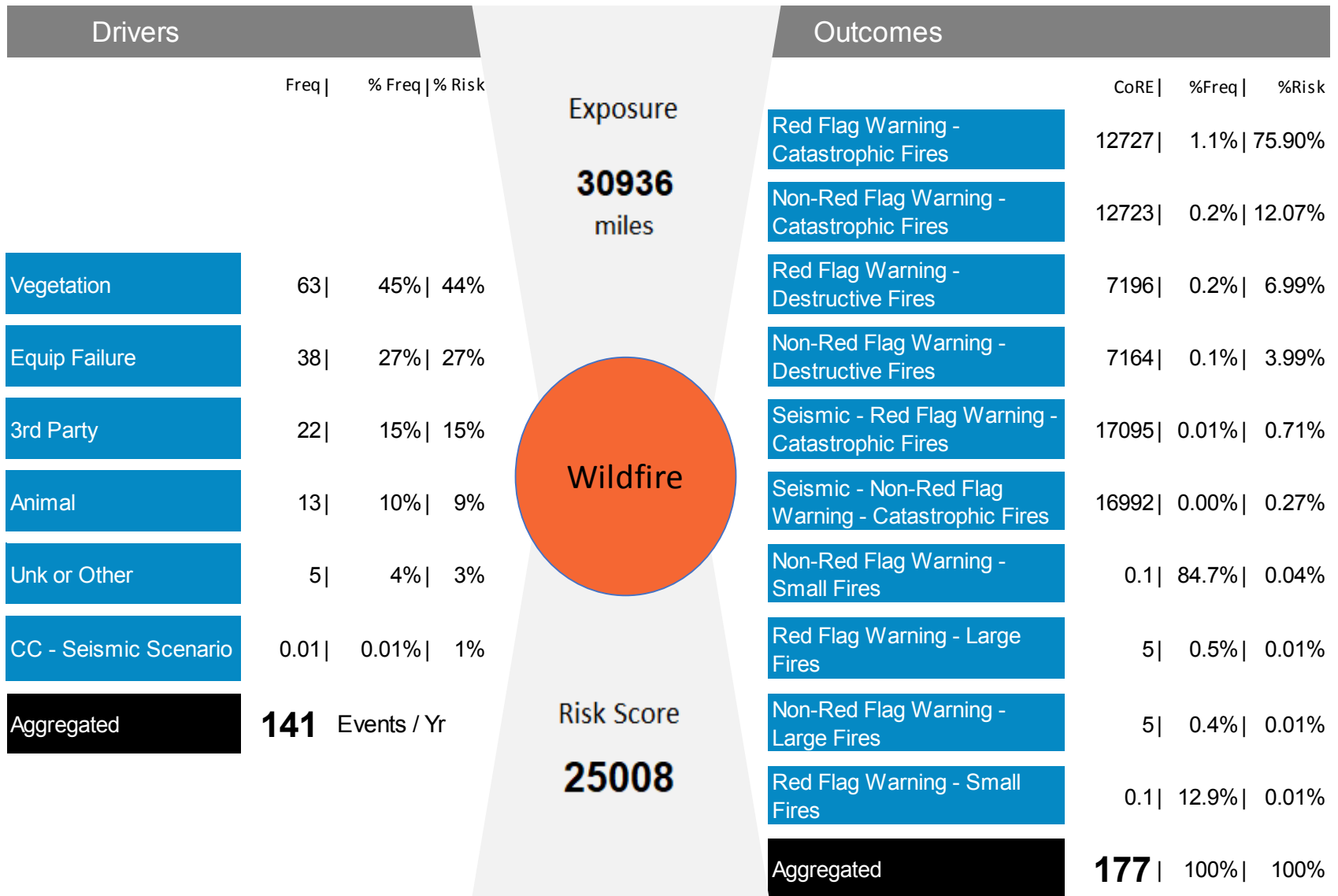
Exposure area of risk consists of 99,000 miles of overhead primary circuit miles.
Exposure is divided into eight tranches.

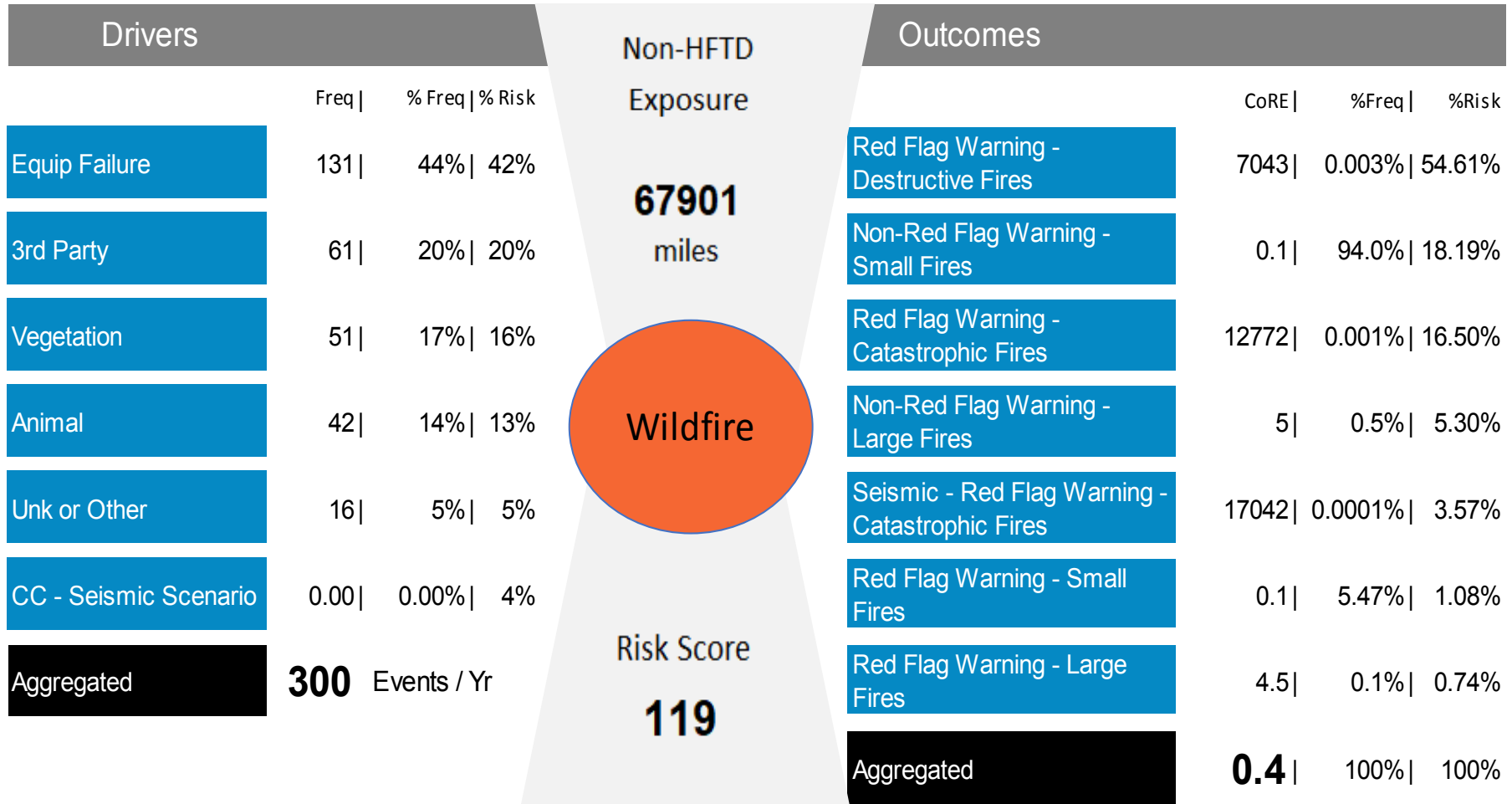
- This total consists of approximately 81,000 distribution overhead circuit miles and 18,000 transmission overhead circuit miles
- Prior models only included approximately 52,000 circuit miles identified as Fire Index Areas prior to adoption of HFTD
- Current model includes all circuit miles in PG&E territory, separating between HFTD and non-HFTD territories
- Allows PG&E to understand the magnitude of the risk between parts of the system, and better differentiate risk spend efficiency analysis

	Distribution	Transmission	Substation ¹
HFTD	25,400	5,525	203
Non-HFTD	55,300	12,600	739
Total	80,710	18,125	942

(1) Substations includes switching stations and other facilities; assigned 1 circuit mile of lines for modeling purposes.





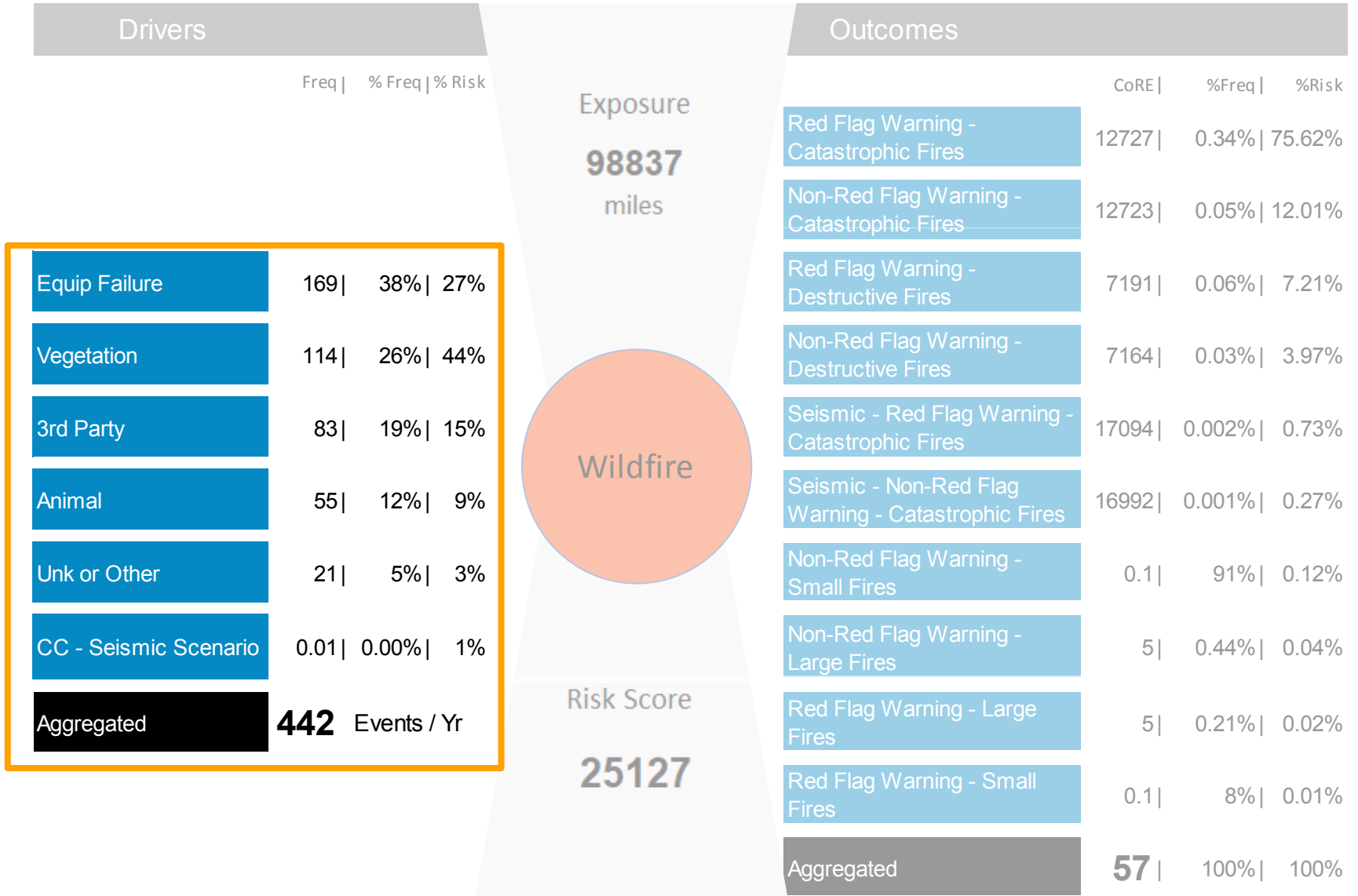


Eight tranches were developed that segment the PG&E asset system, thus better understanding and modeling the causes and consequences of ignitions

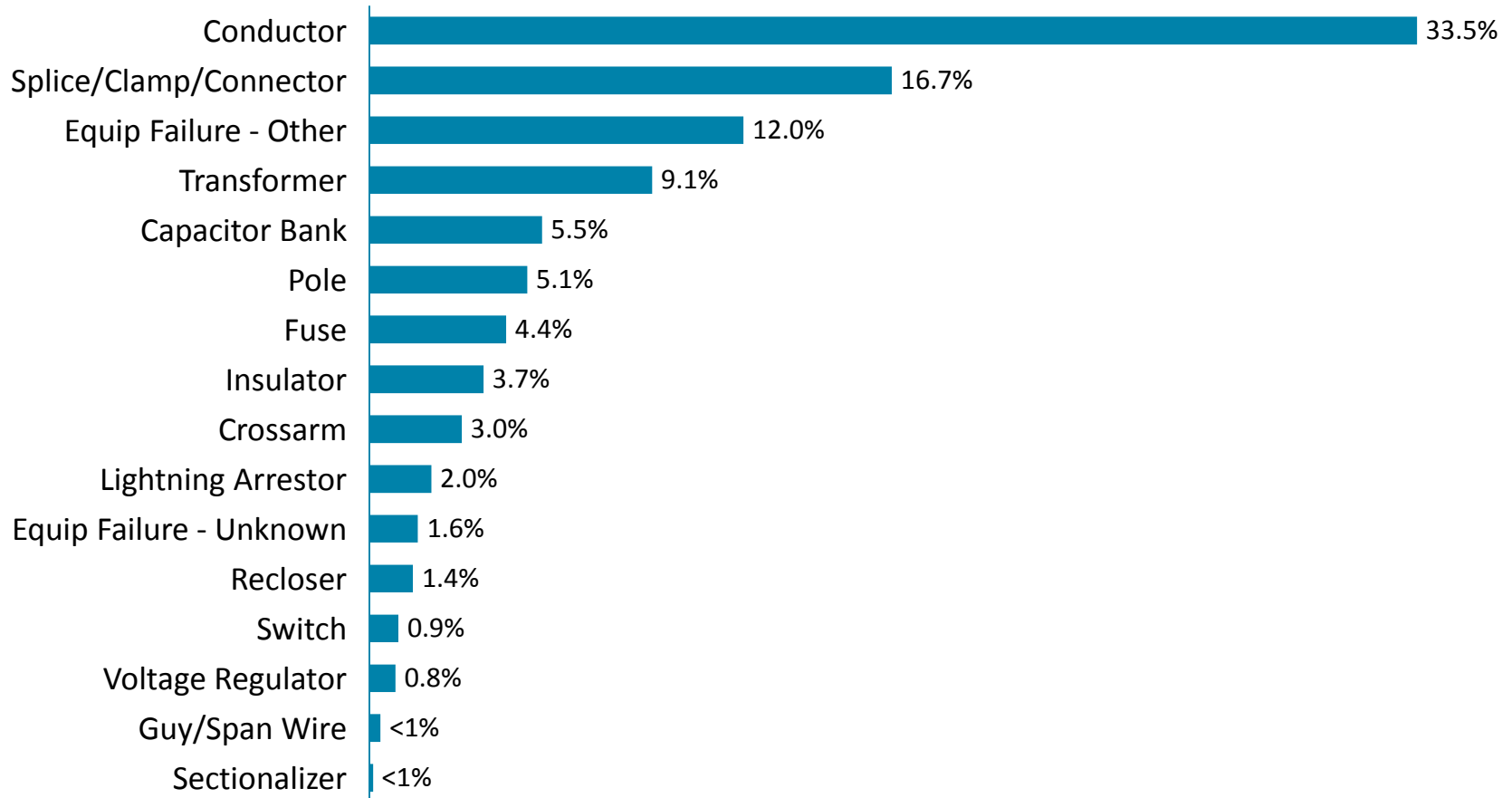
Wildfire Tranche Categories	Description	Mile Exposure	% of Mile Exposure	% of Risk Score
HFTD-Distribution – Hardened	Distribution lines in HFTD areas already hardened as of 2019	171	0.17%	0.60%
HFTD-Distribution – To be Hardened	Distribution lines in HFTD areas that will be in scope of System Hardening program	6,929	7.01%	45.41%
HFTD-Distribution – Remainder	Distribution lines in HFTD areas that are outside scope of System Hardening program	18,310	18.53%	47.01%
HFTD – Transmission	Transmission lines in HFTD areas	5,525	5.59%	6.51%
HFTD – Substation¹	Substations located in HFTD areas	1	0.00%	0.00%
Non-HFTD Distribution	Distribution lines in non-HFTD areas	55,300	55.95%	0.46%
Non-HFTD Transmission	Transmission lines in non-HFTD areas	12,600	12.75%	0.02%
Non-HFTD Substation¹	Substations located in non-HFTD areas	1	0.00%	0.00%
Total		98,837	100%	100%

(1) Substations assigned 1 circuit mile of lines for modeling purposes.

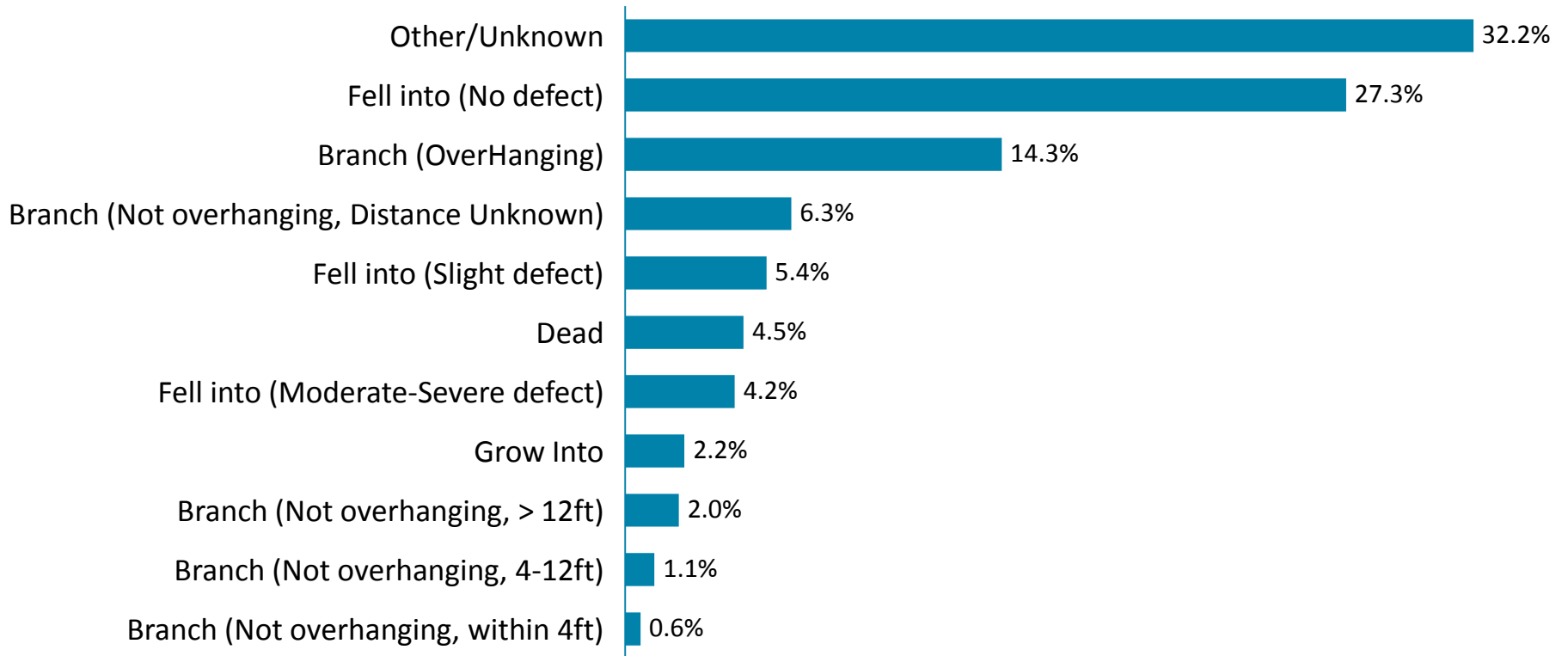
(2) % of Exposure and % of Risk Score as of July 17th errata

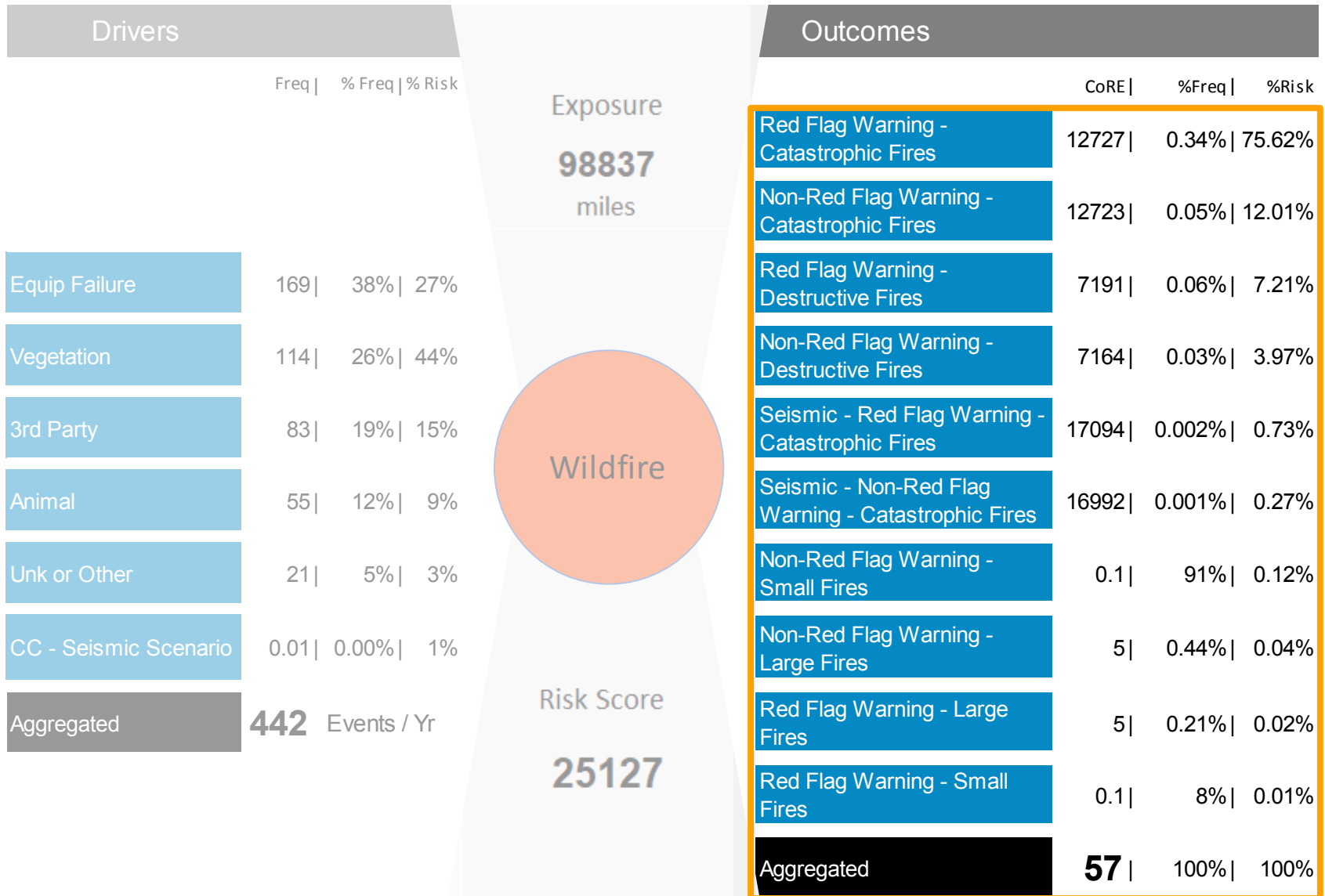


Equipment Failure Sub-drivers



Vegetation Sub-drivers



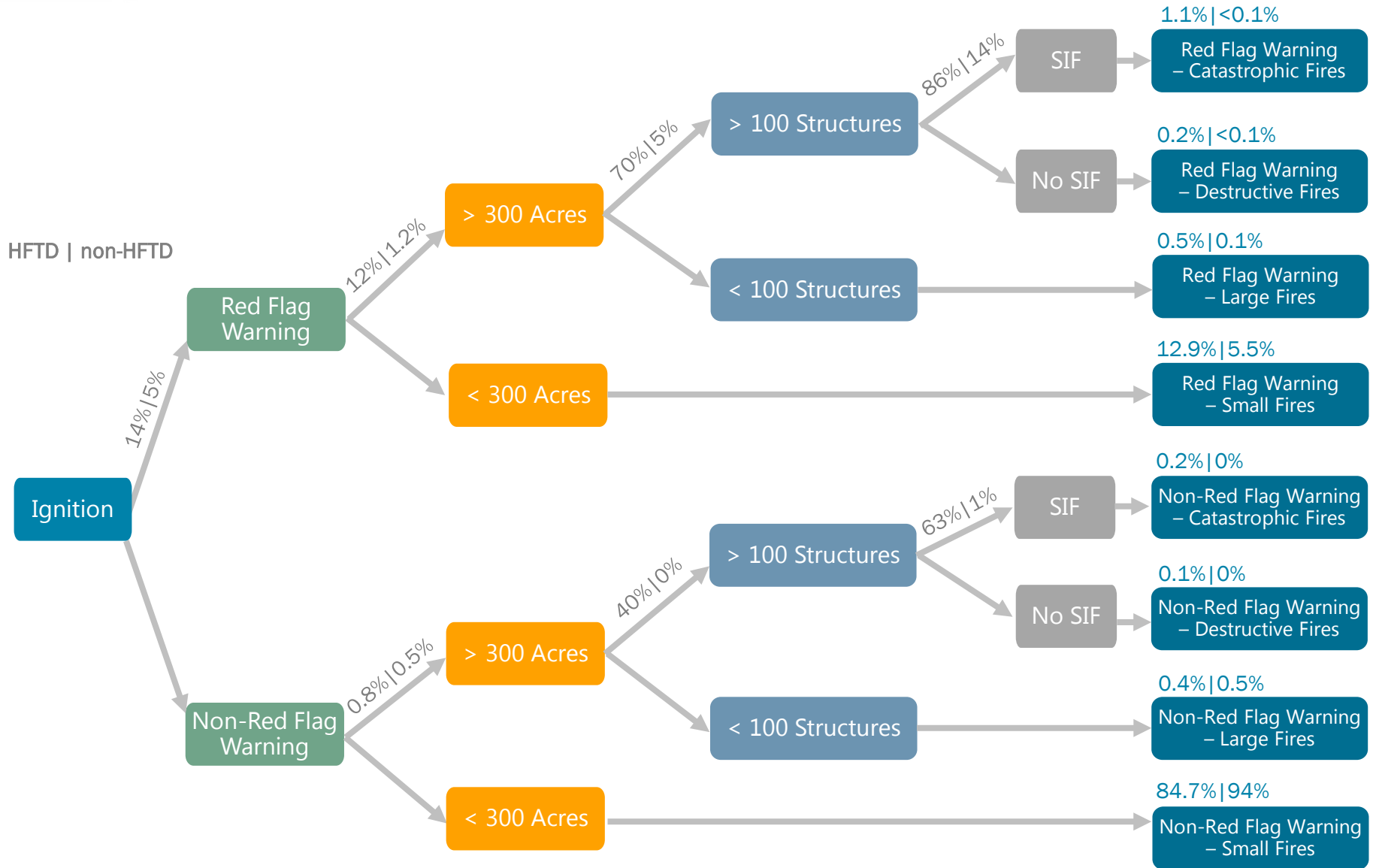


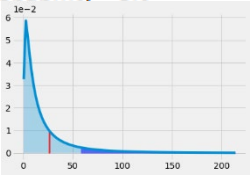
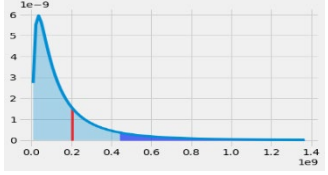
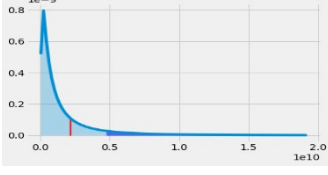
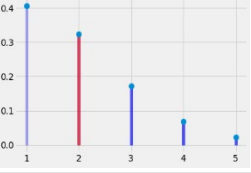
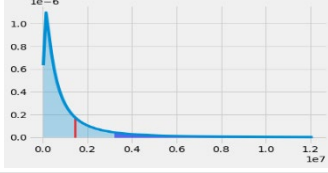
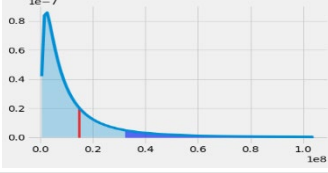
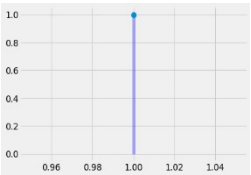
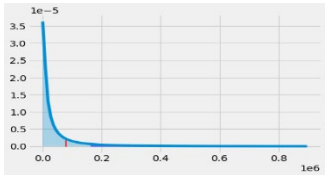
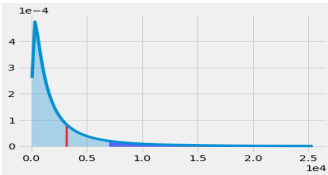
Unlike in the 2017 RAMP, where PG&E considered all ignitions as a single category, in the 2020 RAMP PG&E is providing a more granular view of ignitions in terms of three variables: (1) size/destructiveness, (2) whether the ignition took place during Red Flag Warning, (3) association with a seismic event

Fire Type	Red Flag Warning	Seismic Event	Frequency	% of Risk
Catastrophic	Yes	No	0.34%	75.81%
Catastrophic	No	No	<0.10%	12.05%
Catastrophic	Yes	Yes	<0.10%	0.72%
Catastrophic	No	Yes	<0.10%	0.27%
Destructive	Yes	N/A	<0.10%	7.06%
Destructive	No	N/A	<0.10%	3.90%
Large	Yes	N/A	0.21%	0.02%
Large	No	N/A	0.44%	0.05%
Small	Yes	N/A	7.8%	0.01%
Small	No	N/A	91%	0.12%

Additional Considerations:

- 83% of the total Wildfire risk is from ignitions on RFW days that lead to catastrophic or destructive fires
- PG&E’s decision to invest in PSPS, which is targeted at reducing ignitions when RFW conditions, aligns with mitigating highest percentage of risk
- This also supports PG&E’s investment in situational awareness mitigations, such as improvements in meteorology, that will improve PG&E’s ability to predict and respond to conditions that have the greatest potential for ignitions to turn into more dangerous fires



		Safety	Electric Reliability	Financial
Catastrophic / Destructive	Source	CAL FIRE & SME Input	PG&E Data	CAL FIRE
	Distribution	Catastrophic: Sampling Probability = 100% Destructive: Sampling Probability = 0% SIF [Lognormal] Mean = 26 STD = 49 Fatality/SIF = 50% 	Sampling Probability = 100% [Lognormal] Mean = 199 M STD = 295 M 	Sampling Probability = 100% [Lognormal] Mean = 2.1 B STD = 4.7 B 
CoRE		5,622	434	6,685
Large	Source	CAL FIRE & SME Input	PG&E Data	CAL FIRE
	Distribution	Sampling Probability = 2% SIF [Zero-trunc Poisson] Mean = 2 Prob(Fatality SIF) = 50% 	Sampling Probability = 100% [Lognormal] Mean = 1.4 M STD = 2.8 M 	Sampling Probability = 30% [Lognormal] Mean = 14 M STD = 23 M 
CoRE		1	1	2
Small	Source	CAL FIRE	PG&E Data	CAL FIRE
	Distribution	Sampling Probability = 0.1% SIF [Deterministic] Mean = 1 Prob(Fatality SIF) = 50% 	Sampling Probability = 96% [Lognormal] Mean = 76 K STD = 279 K 	Sampling Probability = 100% [Lognormal] Mean = 3 K STD = 6 K 
CoRE		0.040	0.035	0.002

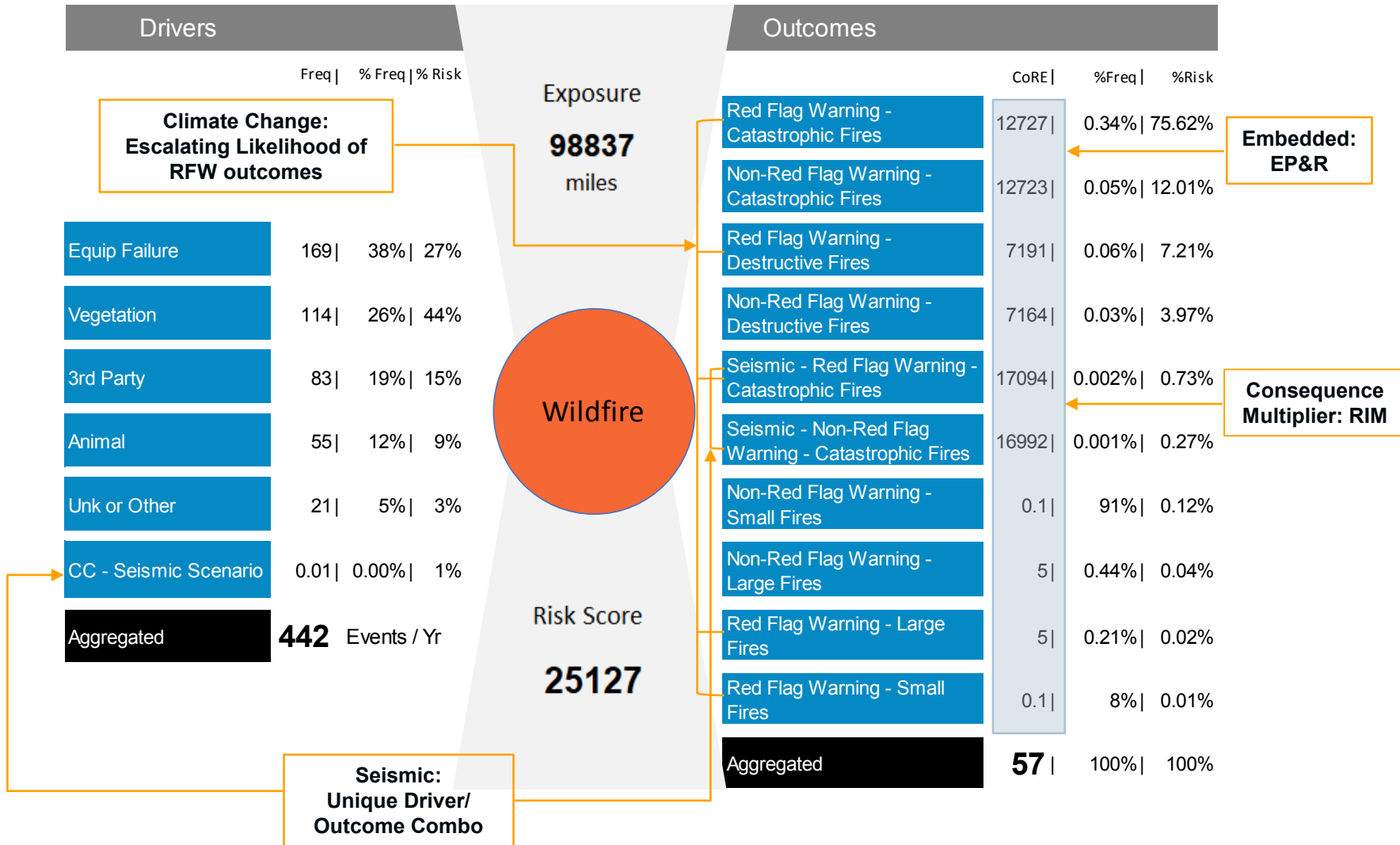
- SIF denotes Serious Injuries or Fatalities.
- Except for small fire outcomes, the financial consequence is estimated as the product of dollar damage per structure destroyed and number of structures destroyed. Dollar damage of \$1M per structure is assumed based on total dollar damage divided by total number of structures destroyed in 2017 CAL FIRE Redbook, CA total.
- For small fire outcomes, the financial consequence is estimated using 2014-2017 average dollar damage per fire by fire size bucket.
- For the catastrophic fires associated with seismic events, a multiplier (1.3 for safety and 1.5 for reliability and financial) was applied to consequence in natural units.
- On the charts, the red line indicates the mean level, and the darker shaded area indicates the tail above 90th percentile.

Four cross-cutting factors were quantified in the Wildfire risk model

Cross-Cutting Factor	Impacts Likelihood	Impacts Consequence	Methodology
Climate Change	X		Wildfire forecasts used to reallocate fire occurrences into increasing Red Flag Warning days; fires during RFW were modelled to have more severe consequences
Emergency Preparedness and Response		X	EP&R modelled as a mitigation that lessens consequences of most severe fires
Records and Information Management		X	A 2.9% multiplier was applied to heighten Financial Consequences, reflecting the state of records management maturity based on the current records management practice
Seismic	X	X	Historical likelihood of catastrophic fire given ignition is elevated to estimate frequency of catastrophic fires caused by seismic events. In addition, more severe consequences are assumed for seismic driven catastrophic fires than non-seismic driven ones.

Additional Cross-Cutting Considerations:

- **Cyber Attack and IT Asset Failure:** Data was not yet at maturity to quantify in the risk model for RAMP 2020 process; PG&E intends to integrate this cross-cutting risk as part of the GRC filing



Climate Change Integration with Wildfire Risk Additional Background

Data Source: California’s 4th Climate Assessment
(Westerling et al., 2018)

Native Metric: Average annual area burned (hectares)

Metric for Bowtie: Change in Red Flag Warnings (RFW)

Key Assumption: RFW likelihood is correlated with annual area burned by wildfire.

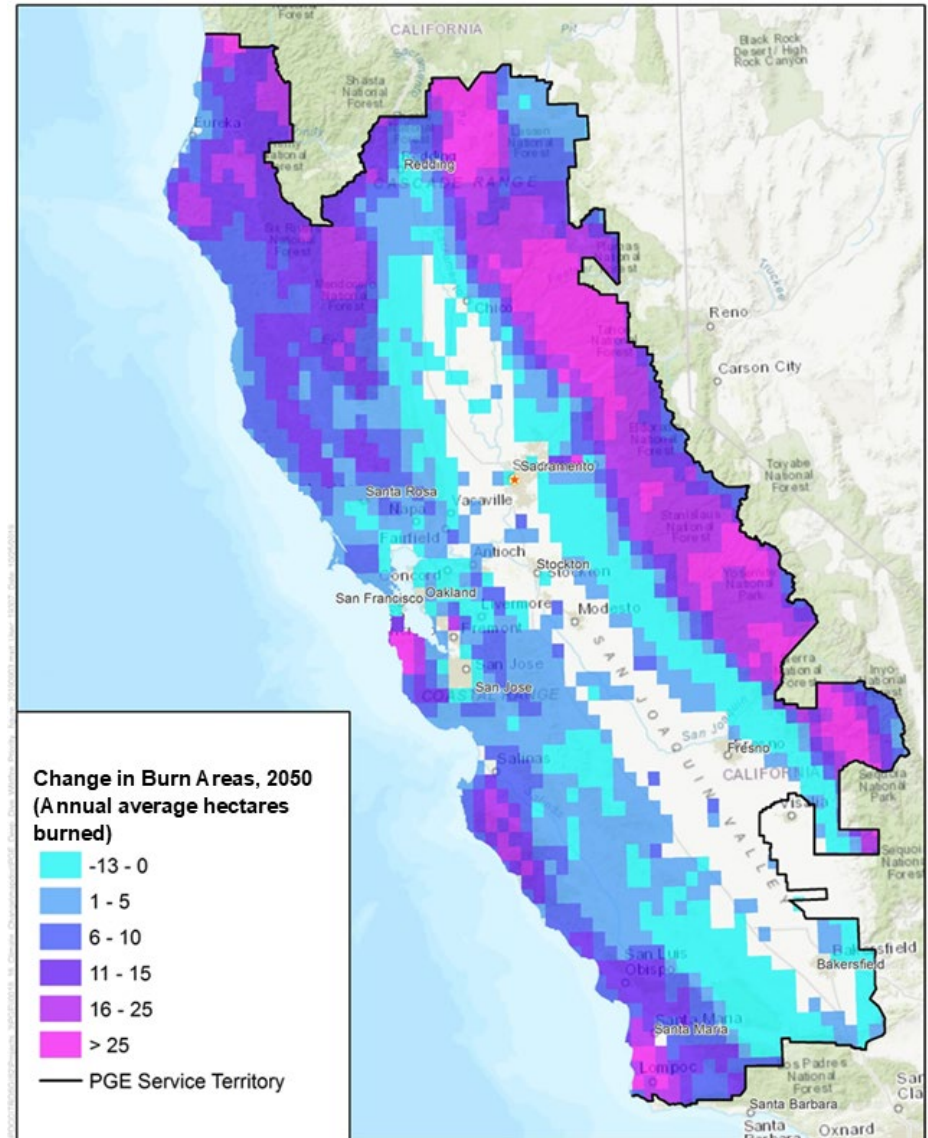
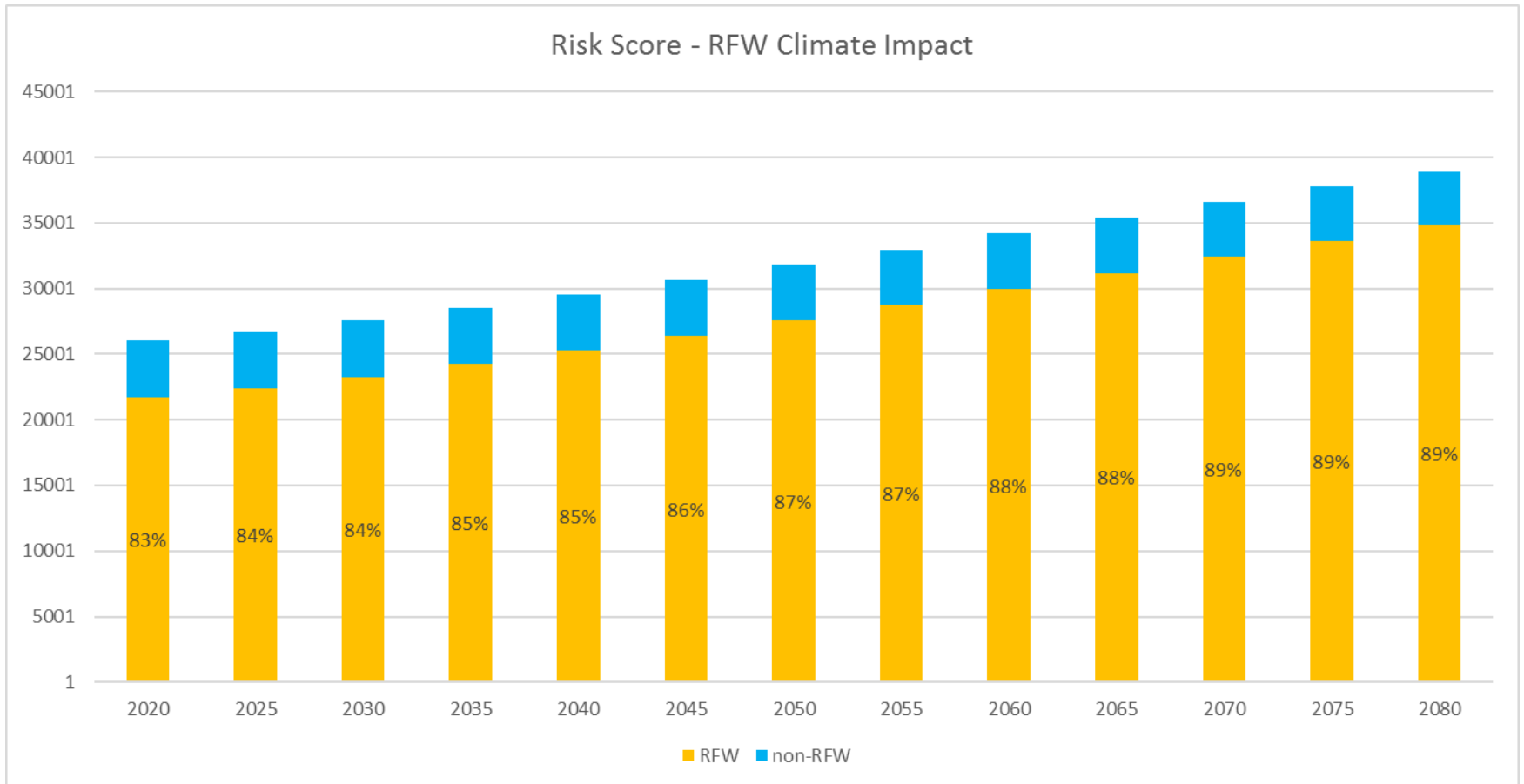


Figure 1. Projected Change in Annual Area Burned by 2050 Relative to Historical Baseline (areas that lack shading indicate no future wildfire projection; Maps for 2025 and 2035 available in Appendix)

If no further action is taken, the likelihood of Red Flag Warning days grow in PG&E's service territory, causing the overall Wildfire Risk to go up.



1

Breakdown of our ~99,000 circuit miles into 8 tranches representing various levels of risk

2

Breakdown of drivers in HFTD and non-HFTD territory
Top 2 drivers: Equipment Failure and Vegetation

3

Consequence of Risk Events vary from small to catastrophic, with varying likelihoods based on weather conditions

4

Integration of Climate Change into long-term Wildfire risk outlook

Risk Assessment – Controls & Mitigations



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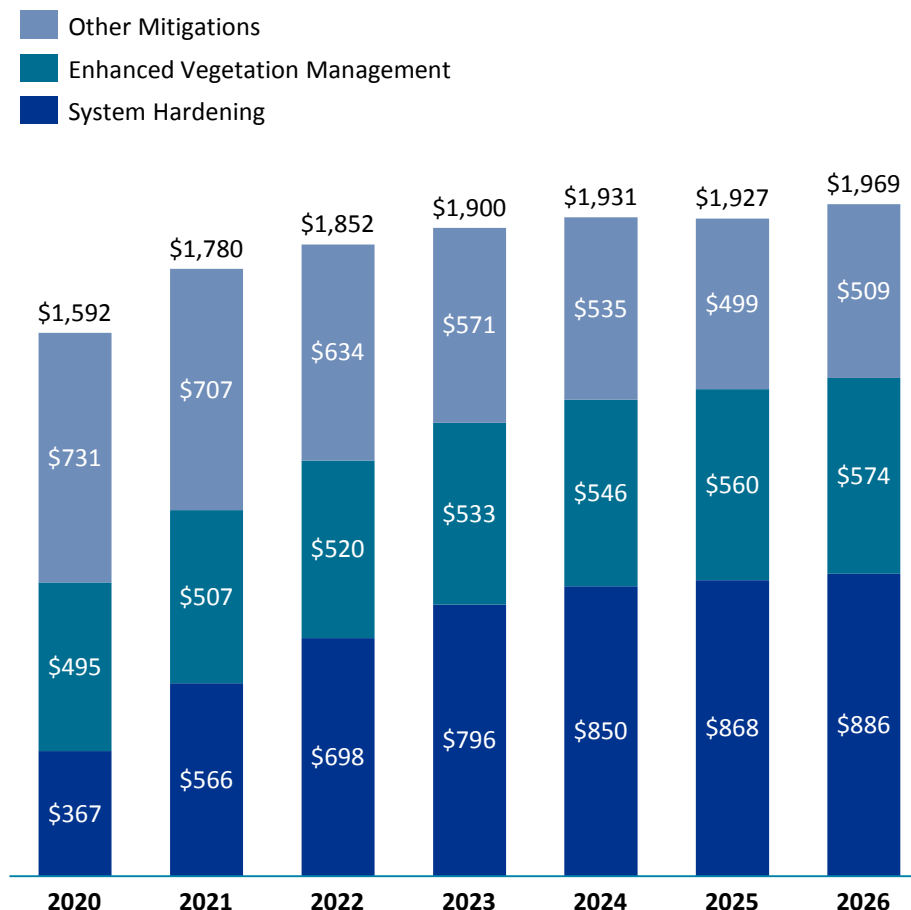


Wildfire Mitigation Programs Overview

Wildfire has 11 mitigation programs identified for 2020 RAMP; of these, Enhanced Vegetation Management and System Hardening are the largest proportion of 2020-2026 spend

ID	Mitigation Program
M1	Enhanced Vegetation Management
M2	System Hardening
M3	Non-Exempt Surge Arrester Replacement Program
M4	Expulsion Fuse Replacement
M5	Public Safety Power Shutoff
M6	Public Safety Power Shutoff Impact Reduction Initiatives
M7	Situational Awareness and Forecasting Initiatives
M8	Safety and Infrastructure Protection Teams
M9	Community Wildfire Safety Program Project Management Office
M10	Additional System Automation and Protection
M11	Remote Grid

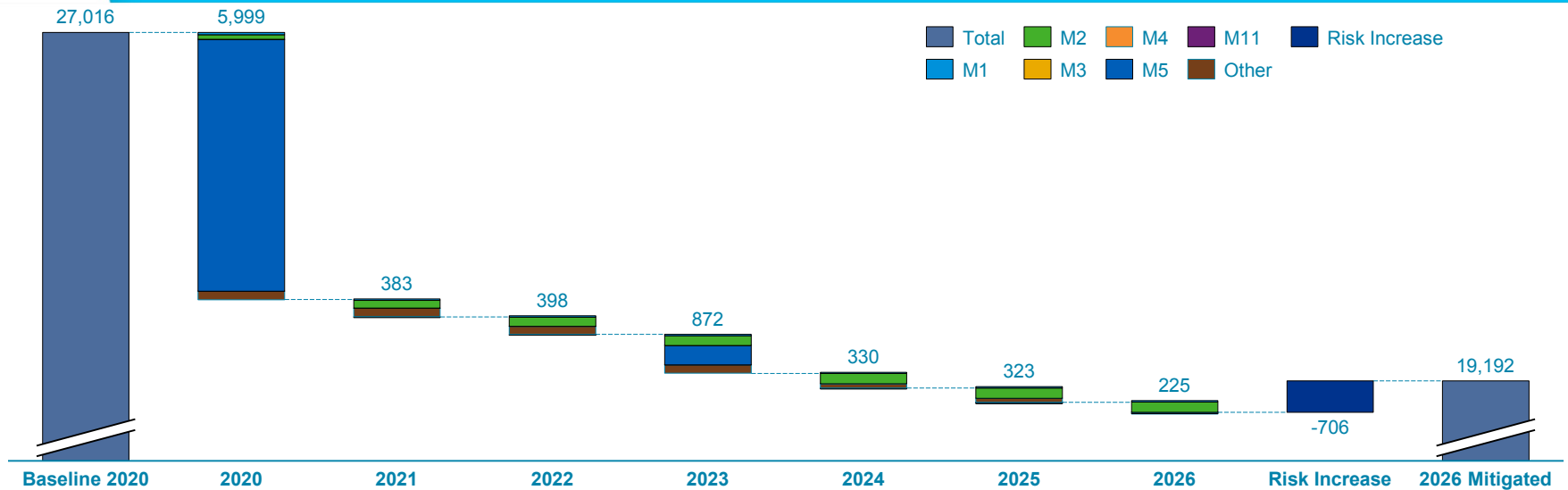
Wildfire Mitigation Cost Forecast 2020-2026 (\$M)¹



(1) Nominal values with cost escalation of 2.5% applied; includes both capital and expense.



Risk Reduction Overview



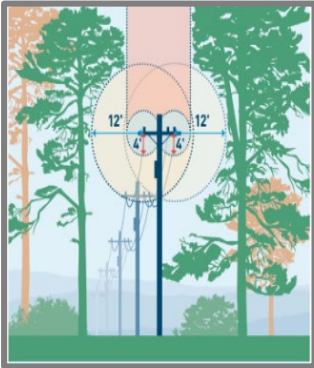
#	Mitigation Programs ¹	2020	2021	2022	2023	2024	2025	2026
M1	Enhanced Vegetation Management	50	81	114	141	168	196	228
M2	System Hardening	105	276	477	700	931	1161	1394
M3	Non-Exempt Surge Arrester Replacement Program	5	13	14	14	14	14	14
M4	Expulsion Fuse Replacement	0	0	0	1	1	1	1
M5	Public Safety Power Shutoff ²	5649	5634	5615	6046	6024	5996	5972
M11	Remote Grid	1	1	1	1	1	1	1
Other	Cross-cutting mitigation programs	189	376	559	750	844	936	920
	Risk Increase due to Climate Factors in Baseline	0	0	0	-706	-706	-706	-706
	Total	5999	6382	6780	6946	7276	7599	7824

(1) Excludes Foundational Mitigations.
 (2) Includes PSPS's Reliability Impact as reducing overall risk reduction.
 (3) Risk reduction by program reflects July 17th errata.



Reducing the risk of catastrophic wildfires from electrical equipment by mitigating the known causes of ignitions

Enhanced Vegetation Management



- Conduct 1,800 line-miles of 12 foot radial clearance and remove high-risk trees and overhangs
- Focus on expanding Rights-of-Way on lower voltage transmission to reduce wildfire risk and footprint of future PSPS events

System Hardening

- Replacing line-miles of existing overhead conductor through asset elimination, installing covered conductors with stronger and more resilient poles, or targeted undergrounding

Asset Repair and Inspection

- Incorporating enhanced inspection process and tools from 2019 Wildfire Safety Inspection Program into routine inspection program: annual inspection of Tier-3 areas and 3-year cycles for Tier-2

System Automation

- Continuing to SCADA-enable devices and reclosers to allow operators to remotely prevent a line from automatically reenergizing after a fault

Public Safety Power Shutoffs

- Utilizing PSPS during extremely high-risk conditions to eliminate ignition risks; 2020 PSPS events will be smaller in scope, shorter in duration, and smarter in performance

Description

The EVM Program is targeted at overhead distribution lines in Tier 2 and Tier 3 HFTD areas and exceeds the requirements of PG&E’s annual Routine Vegetation Management that maintains compliance with CPUC mandated clearances.

Drivers, Sub-drivers, and Consequences

This mitigation targets the vegetation driver.

Tranche Level Analysis

Analysis of effectiveness was calculated per outage and ignition by tranche. Application of program in HFTD only.

RSE Analysis

RSE 2.6
EVM targets the largest driver to risk events in HFTD short term, while establishing ongoing control for further clearance long term.

Mitigation Changes

PG&E reduces scope of EVM from 2,498 miles in 2019 to 1,800 miles. PG&E plans to conduct 1,800 miles per year from 2020-2026.

Mitigation Effectiveness

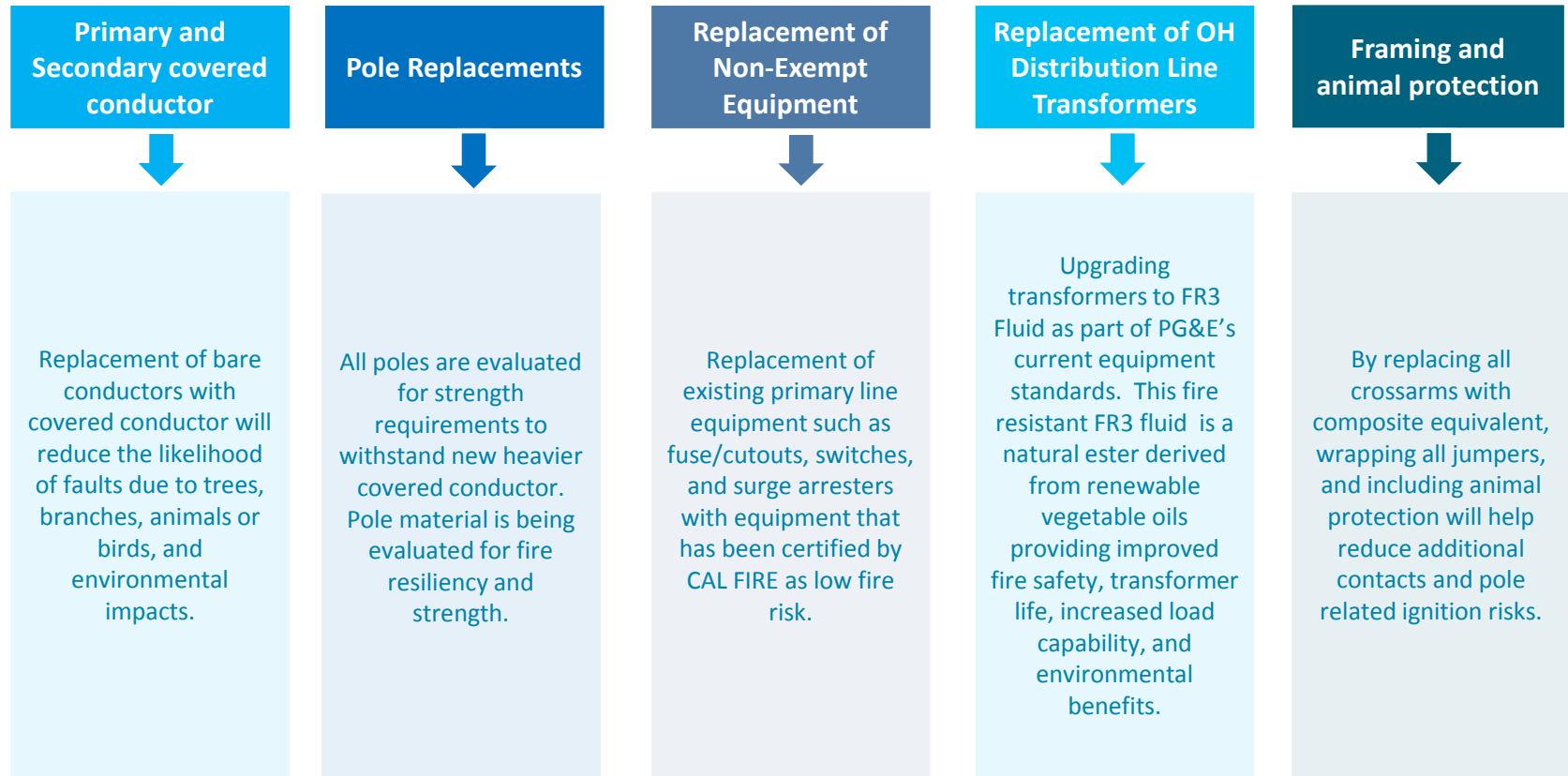
Varies per Vegetation Sub-driver

Details Chapter 10 workpaper ‘EO-WF-25_Mitigation Effectiveness WP’

- Based on justification of effectiveness by Veg Sub-Driver Category
- Applied justification criteria against historical vegetation caused events
- Determined effectiveness per vegetation caused category

Vegetation Sub-driver	RFW	non RFW	Effectiveness	Justification for Effectiveness
Branch (Not overhanging, > 12ft)	1.9%	1.3%	0%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Branch (Not overhanging, 4-12ft)	0.8%	0.6%	50%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Branch (Not overhanging, Distance Unknown)	7.0%	4.7%	0%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Branch (Not overhanging, within 4ft)	0.4%	0.3%	90%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Branch (Overhanging)	17.1%	12.1%	90%	EVM scope designed to eliminate 100% of overhang outages. Estimate a 90% effectiveness rate.
Dead	7.8%	4.9%	0%	Routine and Catastrophic Emergency Memorandum Account (CEMA) scopes already designed to prevent all instances of dead trees. Added EVM patrol not expected to further reduce occurrence.
Fell into (Moderate-Severe defect)	5.4%	5.2%	95%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Fell into (No defect)	24.9%	34.8%	0%	The removal of healthy trees with no sign of defect falls outside of the EVM hazard tree removal scope.
Fell into (slight defect)	6.6%	6.9%	50%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.
Grow Into	0.8%	0.5%	50%	Routine scope already designed to prevent all instances of growth into primary. Added EVM patrol expected to reduce occurrence by estimated 50%.
Other/Unknown	27.2%	28.8%	0%	Includes hazard tree removal, increased clearance, overhang elimination and associated tree removals.

PG&E's Fire Rebuild Design Guidance is based on these foundational elements:





M3/M4 – Non-Exempt Surge Arrestor & Expulsion Fuse Replacement

Description

M3 mitigation program replaces non-exempt surge arresters with exempt surge arrestors
M4 mitigation program replaces non-exempt expulsion fuses with exempt fuses
Both reduces the potential for release of electrical arcs, sparks, or hot material

Drivers, Sub-drivers, and Consequences

These mitigations targets a subset of the Equipment Failure driver incidents.

Tranche Level Analysis

These two mitigations focus in HFTD for Wildfire risk.
Non-exempt surge arrestor program continues in non-HFTD for public safety as part of Distribution Overhead Risk.

RSE Analysis

M3 Surge Arrestor RSE: 2.7 (up through 2021) | M4 Expulsion Fuse RSE: 1.0
Programs target non-exempt equipment that causes ignition

Mitigation Changes

PG&E continues replacement of non-exempt equipment in HFTD areas until replacements are complete.

Mitigation Effectiveness

M3: 90% effective on Equipment Failure – Arrestor
M4: 90% effective on Equipment Failure – Cutout/Fuse

<p>Description</p>	<p>The System Hardening Program is an ongoing, long-term capital investment program to rebuild portions of PG&E’s overhead electric distribution system to reduce fire risk.</p>
<p>Drivers, Sub-drivers, and Consequences</p>	<p>This mitigation targets the Equipment Failure driver, with additional benefits mitigating Vegetation, Animal, and Other drivers.</p>
<p>Tranche Level Analysis</p>	<p>Analysis of effectiveness was calculated per outage and ignition by tranche. Application of program in HFTD only.</p>
<p>RSE Analysis</p>	<p>RSE: 7.4 System hardening targets the largest drivers to risk events and provides long term mitigation benefits</p>
<p>Mitigation Changes</p>	<p>PG&E plans to progressively increase the pace of program from 241 miles in 2020 up to 509 miles by 2026.</p>
<p>Mitigation Effectiveness</p>	<p>Varies Per Sub-Driver; details in further slide</p>



A3/A4 – Targeted System Upgrades & System Hardening Hybrid

Description

A3 alternative where PG&E does not replace its existing bare wire but focuses on system modifications to reduce the potential for outages that could result in ignitions.

A4 alternative is a package of system modifications that falls somewhere between the existing M2 System Hardening and the A3 alternative.

Drivers, Sub-drivers, and Consequences

Targets the Equipment Failure driver, with additional benefits mitigating Vegetation, Animal, and Other drivers to a lesser extent compared to M2.

A3 does not target Vegetation driver.

Project Status

Evaluation of this option is still in early stages; no pilot or workplan yet developed

Considerations

Allows for wider deployment of fire resilience programs; to be deployed in combination with M2 System Hardening.

RSE

A3 Wildfire – Targeted System Upgrades RSE: 5.1

A4 System Hardening Hybrid RSE: 7.6

Mitigation Effectiveness

Varies Per Sub-Driver; details in further slide



System Hardening Mitigation Effectiveness - Ignition

Ignition Cause	Sub-Cause	Level 1 System Hardening Effectiveness	Level 2 Hybrid Effectiveness	Level 2 Percent Effectiveness	Level 3 Firming Effectiveness	Level 3 Percent Effectiveness
3 rd Party	3rd Party - Other	44%	same as SH	44%	None	0%
	3rd Party - Unknown	41%	same as SH	41%	None	0%
	Balloons	77%	Medium	40%	Low	20%
	Vehicle	47%	step down from SH	37%	Low	20%
Animal	Animal	60%	step down from SH	48%	Medium	40%
Equipment Failure	Capacitor Bank	8%	None	0%	None	0%
	Conductor	50%	step down from SH	40%	Low	20%
	Crossarm	68%	Medium	40%	Medium	40%
	Equip Failure - Other	41%	same as SH	41%	None	0%
	Equip Failure - Unknown	73%	same as SH	73%	None	0%
	Fuse	70%	None	0%	None	0%
	Guy/Span Wire	73%	Medium	40%	None	0%
	Insulator	53%	Medium	40%	Medium	40%
	Lightning Arrestor	90%	None	0%	None	0%
	Pole	52%	step down from SH	42%	Medium	40%
	Recloser	62%	None	0%	None	0%
	Sectionalizer	40%	None	0%	None	0%
	Splice/Clamp/Connector	70%	step down from SH	56%	Low	20%
	Switch	69%	None	0%	None	0%
	Transformer	73%	None	0%	None	0%
	Voltage Regulator	35%	None	0%	None	0%
Unknown or Other	Unk or Other - Other	34%	same as SH	34%	Low	20%
	Unk or Other - Unknown	55%	same as SH	55%	Medium	40%
Vegetation	Branch (Not overhanging, > 12ft)	65%	same as SH	65%	None	0%
	Branch (OverHanging)	54%	same as SH	54%	None	0%
	Dead	48%	same as SH	48%	None	0%
	Fell into (Moderate-Severe defect)	46%	same as SH	46%	None	0%
	Fell into (No defect)	55%	same as SH	55%	None	0%
	Fell into (slight defect)	38%	same as SH	38%	None	0%
	Grow Into	20%	same as SH	20%	None	0%
	Other/Unknown	53%	same as SH	53%	None	0%
Vegetation - Unknown	37%	same as SH	37%	None	0%	

Details Chapter 10 workpaper 'EO-WF-25_Mitigation Effectiveness WP'

- Based on justification of effectiveness by Cause, Equipment, and Condition Combination
- Over ~4000 combinations of incidents reviewed
- Applied criteria against historical ignition and outage events
- Determined effectiveness per driver category

Pacific Gas and Electric Company
2020 RAMP Report
Mitigation Effectiveness Workpapers - M2 System Hardening SME Input
Wildfire

Line No.	Basic Cause	Supplemental Cause	Failed/Involved Equipment	Equipment Condition	System Hardening	Narrative
2529	Equipment Failure/Involved	Overhead	Capacitor	Broken	Low	Capacitors are routinely inspected. Hardening is not addressing the equipment specifically but replaces non exempt fuses.
2530	Equipment Failure/Involved	Overhead	Capacitor	Broken- wire on ground	Medium	Significant external force broke the conductor and brought wire to the ground/object. System Hardening will make circuitry more robust. System Hardening moderately reduce ignition risk.
2531	Equipment Failure/Involved	Overhead	Capacitor	Broken- wire on object	Medium	Significant external force broke the conductor and brought wire to the ground/object. System Hardening will make circuitry more robust. System Hardening moderately reduce ignition risk.
2532	Equipment Failure/Involved	Overhead	Capacitor	Burned/flushed	Low	Capacitors are routinely inspected. Hardening is not addressing the equipment specifically but replaces non exempt fuses.
2533	Equipment Failure/Involved	Overhead	Capacitor	Leaking	Low	Capacitors are routinely inspected. Hardening is not addressing the equipment specifically but replaces non exempt fuses.
2534	Equipment Failure/Involved	Overhead	Capacitor	Normal	All	Covered conductor will eliminate the line slap and risk associated with this outage.
2535	Equipment Failure/Involved	Overhead	Conductor- Overhead	Annealed	All	Covered conductor will eliminate the line slap and risk associated with this outage.
2536	Equipment Failure/Involved	Overhead	Conductor- Overhead	Arcing	All	Covered conductor will eliminate the line slap and risk associated with this outage.

Description

PG&E’s PSPS Program proactively de-energizes select transmission and distribution circuit segments within Tier 2 and Tier 3 HFTD areas when elevated fire danger conditions occur. De-energization is determined necessary to protect public safety when PG&E reasonably believes there is an imminent and significant risk of strong winds impacting PG&E assets, and a significant risk of a catastrophic wildfire should an ignition occur.

Drivers, Sub-drivers, and Consequences

This mitigation targets the Equipment Failure and Vegetation drivers, only during Red Flag Warning conditions.

Tranche Level Analysis

Focused on HFTD

Cost / RSE Analysis

RSE: 15.0 (Combined with M6)
 PSPS targets the drivers that lead risk during Red Flag Warning conditions; takes into account adverse reliability impacts and M6 PSPS impact reductions

Mitigation Changes

Further described in M6 – PSPS Impact Reduction Initiatives

Mitigation Effectiveness

89% effective based on 2019 events; only possible for execution in select conditions

EVENT DETAILS	JUNE 8 - 9	SEPT 23 - 26	OCT 5 - 6	OCT 9 - 12	OCT 23 - 25	OCT 26 - NOV 1	NOV 20 - 21
CUSTOMERS IMPACTED	~22,000	~50,000	~12,000	~735,000	~179,000	~968,000	~49,000
COUNTIES IN SCOPE	5	7	3	35	17	38	11
CRCs OPEN	4	8	3	33	28	77	34
PEAK WIND GUSTS	63 mph	58 mph	51 mph	77 mph	80 mph	102 mph	75 mph
DAMAGE/HAZARDS	5	4	2	116	26	554	15
AVG. OUTAGE DURATION AFTER ALL CLEAR	5 HRS	7 HRS	4 HRS	25 HRS	5 HRS	14 HRS ¹	10 HRS
AVG. OUTAGE DURATION TOTAL	16 HRS	16 HRS	14 HRS	37 HRS	25 HRS	55 HRS	25 HRS

Note: All data is subject to change based on ongoing data reconciliation.

¹Restoration time is calculated using the "all clear" time associated with the Oct 29 event after which final restoration occurred for customers who were impacted by both Oct 26 and Oct 29 events but not restored between events. Further analysis of outage metrics for these consecutive events in progress.

Description

The key objective of the PSPS Program is to implement measures to reduce the customer impacts of PSPS events as much as possible while still getting the full fire risk reduction benefits of PSPS. PG&E's goal in 2020 is to reduce PSPS event impact so that fewer customers are affected than would have been for a comparable weather event in 2019 and to restore power more quickly after a PSPS event.

Drivers, Sub-drivers, and Consequences

Minimizing Reliability Consequence during M5 Public Safety Power Shutoff

Tranche Level Analysis

Focused on HFTD

Cost / RSE Analysis

RSE: 15.0 (Combined with M5)
 PSPS targets the drivers that lead risk during Red Flag Warning conditions; takes into account adverse reliability impacts and M6 PSPS impact reductions

Mitigation Changes

In 2020 and beyond, PG&E will be building on lessons learned in 2019 to expand and refine its initiatives to reduce the scope and duration of PSPS events.

Mitigation Effectiveness

30% Reduction in Customer Minutes Interrupted



Make any future PSPS events smaller in scope, shorter in duration and smarter in performance

Reduce Frequency

- More accurate weather and fire risk forecasting plus improvements that continue to drive down ignition risks can reduce need for PSPS
- Analyzing all ~550 transmission lines in HFTDs to determine if risk has been reduced enough that the PSPS threshold for a line could be materially increased.

Reduce Duration

- Deploying additional helicopters to speed daylight post-PSPS inspections and fixed-wing aircraft with infrared technology to allow for nighttime inspections
- Improving restoration goal by 50%, to 12 daylight hours

Reduce Impacted Customers

- Improving meteorological data and forecasting
- Safely minimizing transmission impacts
- Deploying customer-centric solutions that include:
 - Temporary and permanent generation at substations
 - Mid-feeder microgrids
 - Supporting community-enabled microgrids
- Installing additional automated sectionalizing devices to separate the distribution grid into smaller sections – helps with emergency response, outages and microgrid operations
- Targeting to have any 2020 PSPS events affect ~1/3rd fewer customers than a comparable event would have in 2019 (based on an analysis of planned programs under the conditions of October 2019 PSPS events).

Improve Coordination with and Support Communities and Customers

- Continued extensive county and tribal engagement
- Additional community open houses
- Additional listening sessions
- Additional joint identification of critical facilities
- Designated PG&E community and government liaisons
- Improve access and functional needs (AFN) community support

Mitigation		Risk Reduction ¹	Cost Forecast \$ Millions (2023-2026)	RSE ¹ (2023-2026)	Commentary
M1	Enhanced Vegetation Management	4,301	2,211.89	2.6	<ul style="list-style-type: none"> Focuses on largest driver in HFTD
M2	System Hardening	18,499	3,400.80	7.4	<ul style="list-style-type: none"> Focuses on largest drivers overall in HFTD
M3	Non-Exempt Surge Arrester Replacement Program	3	-	-	<ul style="list-style-type: none"> Focuses on specific equipment failures that causes sparks
M4	Expulsion Fuse Replacement	19	24.72	1.0	<ul style="list-style-type: none"> Focuses on specific equipment failures that causes sparks
M5	Public Safety Power Shutoff	17,712	1,593.55 ²	15.0	<ul style="list-style-type: none"> Focuses on risk events during Red Flag Warning conditions Considers adverse reliability impacts and M6 PSPS impact reductions initiatives

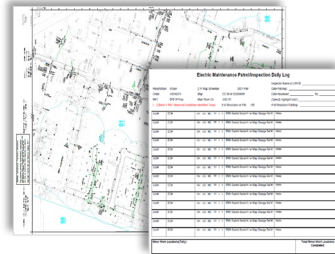
(1) Results reflect July 17 errata

(2) Includes costs of M6 PSPS Impact Reduction Initiatives

Wildfire has 17 control programs identified for 2020 RAMP

ID	Control Program	Summary
C1 – C3	Patrols and Inspections	PG&E patrols and inspects its facilities to identify damaged facilities, compelling abnormal conditions, regulatory conditions, and third-party-caused infractions that may negatively impact safety or reliability, including conditions that could cause a wildfire ignition.
C4 – C7	Vegetation Management	The program includes “routine” compliance-based vegetation management, including periodic inspections, clearing of vegetation around lines and around poles with equipment that poses a fire risk, and quality assurance.
C8 – C10	Equipment Preventative Maintenance and Replacement	Proactive identification and repair or replacement of critical overhead Equipment is identified through the Patrol and Inspections control or through ad hoc inspection. In 2019, the inspection program was accelerated and significantly improved in Tier 2 and Tier 3 HFTD areas. This enhanced scope and process will continue to be used in 2020 and going forward.
C11	Animal Abatement	The installation of new equipment or retrofitting of existing equipment with protection measures intended to reduce animal contacts.
C12	Pole Programs	This control includes multiple activities related to distribution poles, including intrusive testing, remediation, and loading assessment.
C13	Transmission Structure Maintenance and Replacement	This control covers the maintenance repairs and targeted replacements of PG&E’s approximately 150,000 transmission structures (steel towers and transmission wood poles).
C14	System Automation and Protection	The installation of new equipment (e.g., fuses, reclosers, and SCADA installations enabling remote operation) that isolates equipment when abnormal system conditions are detected.
C15	Reclose Blocking	To reduce ignition risk, beginning in 2018, PG&E disabled the automated reclosing functionality during elevated fire conditions on all reclosing devices located in protection zones that intersect with Tier 2 and Tier 3 HFTD areas.
C16	Design Standards	This control relates to the general standards for proper application of equipment to ensure safe and reliable operation in high fire-threat areas.
C17	Restoration, Operational Procedures and Training	This control relates to work standards for high fire-threat areas. Utility Standard TD-1464S establishes requirements for PG&E employees and contractors to follow when travelling over, performing work on, or operating in any forest, brush, or grass-covered lands.

Pre-WSIP & date-driven 2018 & prior



- ✓ **Reliability and compliance focused inspection process**
 - Asset inspection & maintenance cycles based on date-driven compliance
 - Inspection criteria leveraged expertise of QEWs
 - Inspection results aggregated to plat (map) level
 - Asset-specific data collected only for corrective actions (identify and fix only compelling issues)

Maintenance / Planning Assumptions

- ✓ **Inspections:** asset field condition will remain consistent between 5-year inspection cycle
- ✓ **Patrols:** used to detect actual or imminent failures that occur between inspections

WSIP & wildfire risk-driven 2019

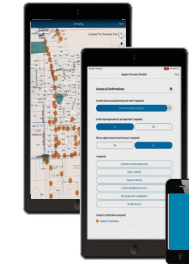


- ✓ **Wildfire-risk focused approach and process enhancements**
 - Detailed and objective inspection criteria based on asset wildfire risk analysis (e.g., FMEA)
 - Visual enhanced inspections on all overhead HFTD T2 and T3 assets
 - GO 165 inspections in non-HFTD areas
 - Expanded EC tag creation guidance (5-year horizon) led to subsequent field reassessments

Maintenance / Planning Assumptions

- ✓ **Inspections:** perform inspections in all High Fire Threat Districts to prevent asset failures

Risk-informed & data-driven 2020 & beyond



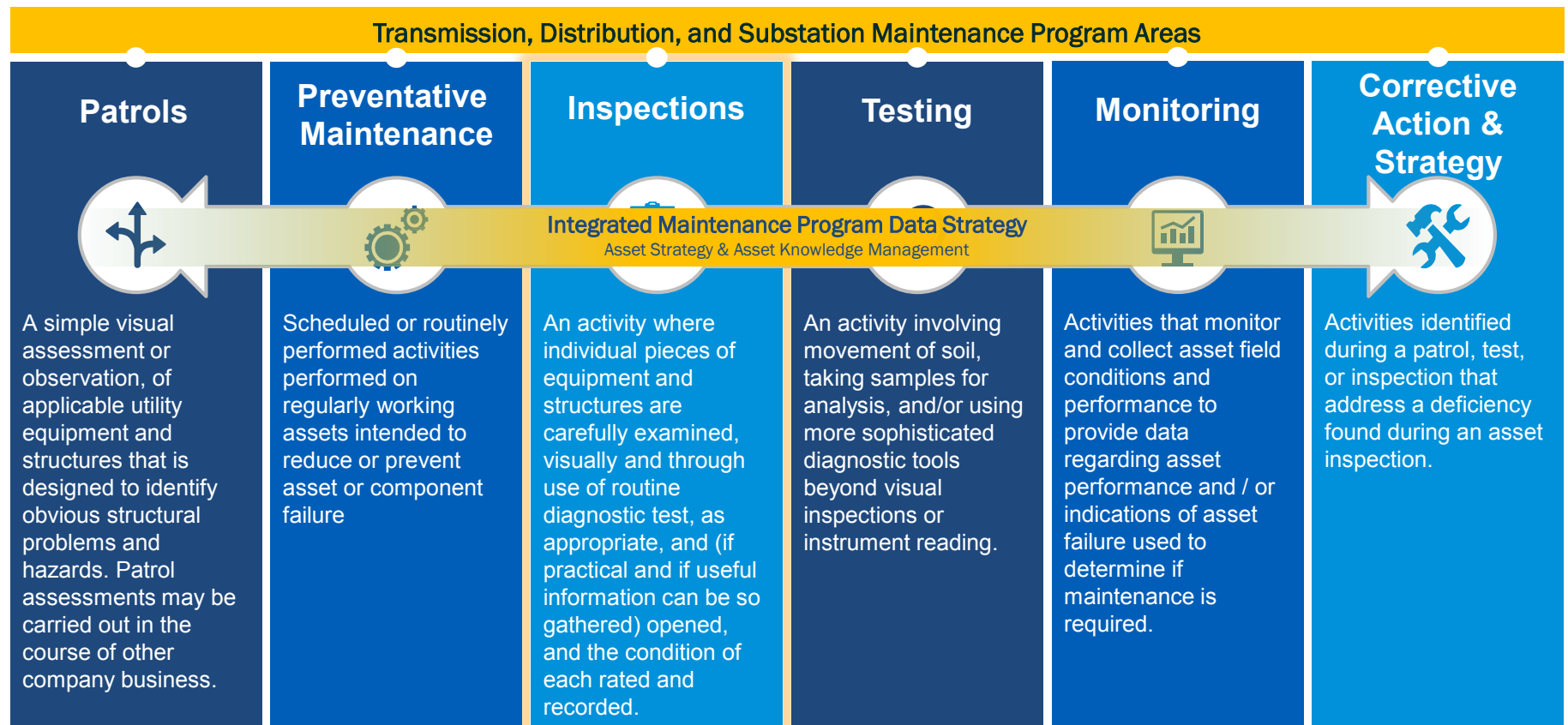
- ✓ **Expansion of WSIP inspection approach to include public safety & reliability risks**
 - Detailed and objective inspection criteria based on increased understanding of field conditions and failure modes
 - Broadened risk consideration to beyond wildfire and using data for targeted inspection cycles
 - Condition assessments of tags with gradients beyond repair / replace
 - Introduce detection technology to optimize measurement methods

Maintenance / Planning Objectives

- ✓ **Inspections:** use data to determine the appropriate inspection cycle commensurate to risk
- ✓ **Other maintenance programs:** coordinate cycles and methods across multiple maintenance programs

What does a complementary maintenance program look like?

The combination of improved (1) data quality for field data inventories with (2) defined criteria / triggers for each maintenance activity will allow for the strategic planning of efficient maintenance strategies at each asset (e.g., an enhanced pole test & treat process to meet GO 165 and detailed inspection requirements at a single asset).



Questions?

APPENDIX



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2023 Test Year Baseline Count



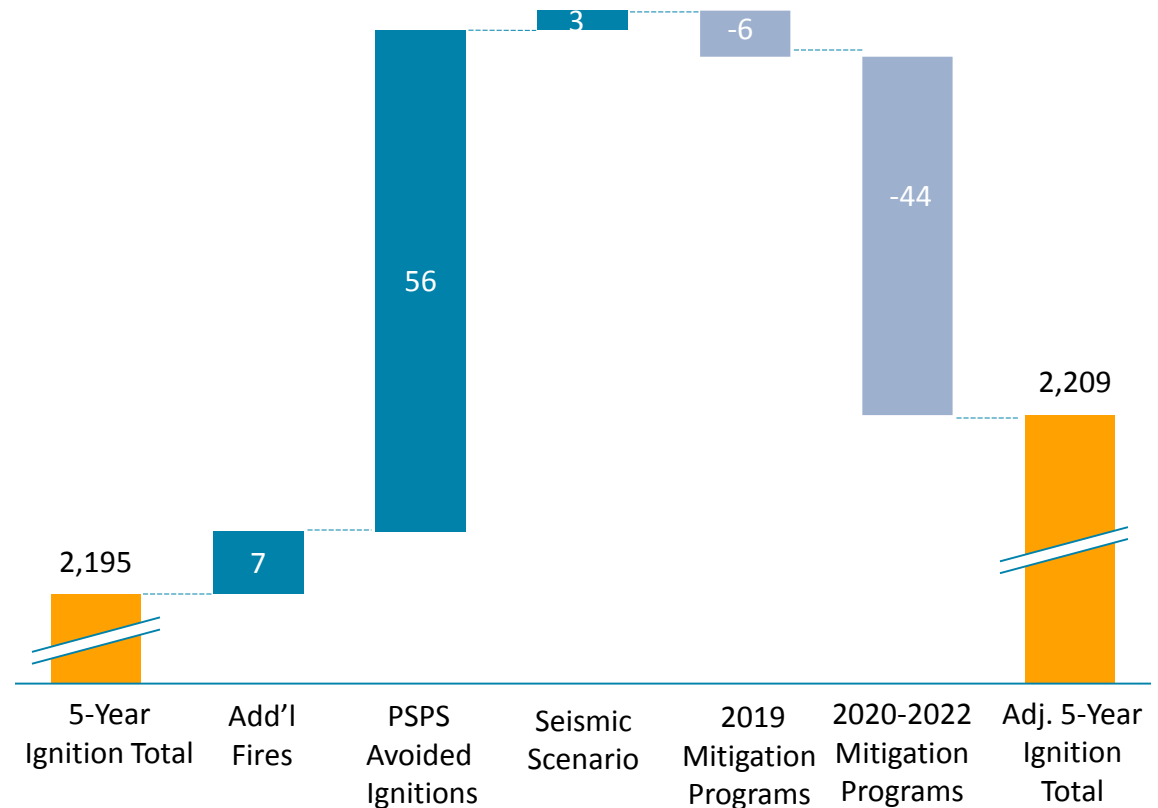
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442 risk events (ignitions) are expected per year in the Test Year 2023 Baseline case.

This estimate was developed by adjusting the historical 2,195 reported ignitions associated with PG&E facilities during the 5-year period of 2015-2019.

Adjustments

- **Additional Fires.** 7 additional fires previously unreported due to events being under investigation
- **PSPS.** Ignitions added to account for ignitions avoided in 2019 due to PSPS.
- **Seismic Scenario.** Ignitions added to account for estimate of possible ignitions due to a Seismic scenario
- **2019 Mitigations.** Ignitions subtracted to account for ignition frequency reduction due to 2019 programs.
- **2020 Mitigations.** Ignitions subtracted (approx. 8 / year) to account for annual ignition frequency reduction due to 2020 programs.



Adjustments net new 5-year estimate of 2,209, or baseline of 442 ignitions per year

Foundational Mitigations



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Improving understanding of upcoming and real-time weather and fire conditions, to reduce fire ignitions, respond faster, and minimize PSPS event scope

Situational Awareness

- Create highly localized weather and fire risk forecasts (2x better granularity than 2019) and real-time conditions to identify high-risk locations, share with first responders and activate field response
- additional weather stations
- additional HD cameras
- Wire-down detection
- Automated rapid earth fault current limiters
- Access to multiple real-time weather feeds

Wildfire Safety Operations Center and Meteorology



- Operate 24/7 Wildfire Safety Operations Center to monitor fire threats
- Coordinate and mobilize response efforts with first responders, government, media and others during potential or active wildfires
- Using satellite fire detection system that compiles data from 5 satellites and one of the largest, high-resolution climatological datasets in the utility industry
- Direct operational modifications and fire safety resources

Foundational Mitigations

Description

	Foundational Mitigations	Description
M7	Situational Awareness and Forecasting Initiatives	PG&E proposes several mitigations related to forecasting and situational awareness, including additional weather stations, cameras, sensors, and advanced modeling of weather and fire conditions. Taken together, these mitigations will help PG&E identify times and areas of high fire risk, which will inform decisions about PSPS timing and scope and provide information that will be valuable for asset management and risk analysis.
M8	Safety and Infrastructure Protection Teams	SIPTs consist of two-person crews composed of International Brotherhood of Electrical Workers-represented employees who are trained and certified safety infrastructure protection personnel. They provide standby resources for PG&E crews performing work in high fire hazard areas, pretreatment of PG&E assets during an ongoing fire, fire protection to PG&E assets, and emergency medical services.
M9	Community Wildfire Safety Program Project Management Office	The CWSP PMO was established in 2018 to oversee and coordinate multiple lines of business' implementation of PG&E's wildfire risk mitigation activities. The CWSP PMO is focused on project and program development and management for wildfire mitigation efforts.
M10	Additional System Automation and Protection	The additional system automation and protection mitigation consists of additional system and protection work. This includes installation of SCADA capability on reclosing devices in HFTD areas to support remote Reclose Blocking. This mitigation also includes evaluating new system protection technologies that may reduce wildfire risk.

Foundational Mitigation: Because these programs support other mitigations that reduce Wildfire risk, but do not reduce the risk themselves, PG&E considers them foundational and does not calculate a risk reduction or RSE.

System Protection & Wire Down Detection

- **Automatic Recloser Disablement** deactivating reclosing capability, primarily through remote device control, based on fire risk forecast
- **Fast Trip Alternate Settings** deploying system protection settings and schemes to trip (de-energize) faster during high risk seasons
- **SmartMeters** using enhanced wire-down detection technology and data to flag high-risk outages and specify locations to send field crews; Program will expand from the ~4.4 million today to ~5.4 million by Q2 / Q3 2020 (capturing all SmartMeters in PG&E's service territory)
- **Rapid Earth Fault Current Limiter (REFCL)** can automatically reduce the electrical current in a downed wire, reducing likelihood of a fire; technology anticipated to be operable by summer 2020

Advance Modeling

- **Predictive Models** using multiple data inputs (GIS, weather, SmartMeter, SCADA and others) to predict line maintenance work
- **Neural Networks** – computer systems modeled on the human brain – to enhance our vegetation management efforts by identifying tree species that have a higher risk of breaking or falling on powerlines
- **Machine learning vision analysis** using millions of high-resolution photos of PG&E electric assets taken during wildfire safety inspections to build models and algorithms to help detect assets that require repair

Additional Alternative Mitigations



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Description

Remote grid is an effort to use decentralized energy sources to permanently supply energy to certain remote customers instead of using hardened traditional utility infrastructure for electricity delivery.

Drivers, Sub-drivers, and Consequences

This mitigation targets the Equipment Failure, Vegetation, Animal, and Other drivers.

Project Status

Pilot Assessment Phase

Considerations

PG&E is evaluating the program efficiency by conducting M11 pilot projects. If successful, PG&E proposes to expand the mitigation to additional feeders in 2021-2022 and subsequently 2023-2026

RSE

RSE: 17.8

Mitigation Effectiveness

95% of all drivers

Description

PG&E is evaluating the use of commercially available long-term chemical fire retardants to pre-treating right of ways, areas around equipment and devices, switchyards, substations and critical facilities to reduce the potential for ignition and fire spread and potentially limit the need for PSPS.

Drivers, Sub-drivers, and Consequences

This mitigation targets the Equipment Failure, Vegetation, Animal, and Other drivers.

Project Status

Pilot Assessment Phase

Considerations

PG&E is evaluating the program efficiency by conducting pilot project.

RSE

RSE: 2.2

Mitigation Effectiveness

10% for HFTD – Distribution
22% for HFTD - Transmission

Financials



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2020-2026 Proposed Mitigation Plan Financials

Wildfire Mitigation Cost Forecast (\$M)¹

Mitigation	2020	2021	2022	2023	2024	2025	2026	Total	%
M1 Enhanced Vegetation Management	494.63	506.99	519.67	532.66	545.98	559.63	573.62	3,733.17	28.8%
M2 System Hardening	366.72	565.64	698.36	796.32	850.04	868.05	886.39	5,031.53	38.9%
M3 Non-Exempt Surge Arrester Replacement Program	62.45	53.29	0.00	0.00	0.00	0.00	0.00	115.74	0.9%
M4 Expulsion Fuse Replacement	5.42	5.56	5.70	5.84	6.14	6.29	6.45	41.39	0.3%
M5 Public Safety Power Shutoff	170.70	174.97	179.34	183.82	188.42	193.13	197.96	1,288.34	9.9%
M11 Remote Grid	4.75	0.00	0.00	0.00	0.00	0.00	0.00	4.75	0.0%
M6 Public Safety Power Shutoff Impact Reduction Initiatives	385.49	353.69	331.00	261.95	218.19	174.21	175.87	1,900.40	14.7%
M7 Situational Awareness and Forecasting Initiatives	43.39	44.75	38.65	38.50	39.47	40.45	41.46	286.67	2.2%
M8 Safety and Infrastructure Protection Teams	24.34	38.21	41.29	42.32	43.38	44.46	45.57	279.56	2.2%
M9 Community Wildfire Safety Program Project Management Office	18.53	19.07	19.63	20.12	20.62	21.13	21.66	140.76	1.1%
M10 Additional System Automation and Protection	15.90	17.57	17.91	18.35	18.92	19.39	19.88	127.92	1.0%
Total	1,592.33	1,779.74	1,851.53	1,899.89	1,931.15	1,926.75	1,968.85	12,950.23	100%

(1) Nominal values with cost escalation of 2.5% applied; includes both capital and expense.



2019 Recorded Costs for Controls

	Controls	2019 Recorded Expense Costs	2019 Recorded Capital Costs
C1 – C3	Patrols and Inspections	\$470,243,683	\$270,883,643
C4 – C7	Vegetation Management	\$867,569,101	\$271,089,530
C8 – C10	Equipment Preventative Maintenance and Replacement	\$409,432,715	\$763,049,684
C11	Animal Abatement	\$23,287,243	\$245,636,220
C12	Pole Programs	\$20,583,370	\$114,297,726
C13	Transmission Structure Maintenance and Replacement	\$314,207,710	\$269,729,157
C14	System Automation and Protection	\$1,320,600	\$111,715,554
C15	Reclose Blocking	\$108,434,904	N/A
C16	Design Standards	N/A	N/A
C17	Restoration, Operational Procedures and Training	\$2,065,529	\$193,655

Mitigation and Control Mapping



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Control Mapping from 2017 RAMP to 2020 RAMP

Control Name and Number	2017 RAMP (2016 Controls)	2020 RAMP (2020-2022)	2020 RAMP (2023-2026)
C1 (2017) – Overhead Patrols and Inspections	X	Split into C1-C3	
C2 (2017) – Vegetation Management	X	Split into C4-C6	
C3 (2017) – Catastrophic Event Memorandum Account - Vegetation Management	X	Becomes C7	
C4 (2017) – Non-Exempt Equipment Replacement	X	Becomes M4	
C5 (2017) – Overhead Conductor Replacement	X	Replaced by M2	
C6 (2017) – Animal Abatement	X	Becomes C11	
C7 (2017) – Protective Equipment	X	Included in C14	
C8 (2017) – Overhead Equipment Replacement	X	Split into C8-C10	
C9 (2017) – Pole Replacement	X	Becomes C12	
C10 (2017) – Wood Pole Bridging	X	Incorporated into C12	
C11 (2017) – Design Standards	X	Becomes C16	
C12 (2017) – Restoration, Operational Procedures and Timing	X	Becomes C17	
C1 – Patrols and Inspections – Distribution Overhead (was part of C1 (2017))		X	X
C2 – Patrols and Inspections – Transmission Overhead (was part of C1 (2017))		X	X
C3 – Patrols and Inspections – Substation (was part of C1 (2017))		X	X

Mitigation Mapping from 2017 RAMP to 2020 RAMP

Mitigation Name and Number	2017 RAMP (2016 Controls)	2020 RAMP (2020-2022)	2020 RAMP (2023-2026)
M1 (2017) – Wildfire Reclosing Operation Program (System Control and Data Acquisition (SCADA) Programming)	X		
M2 (2017) – Wildfire Reclosing Operation Program (SCADA Capability Upgrades)	X		
M3 (2017) – Fuel Reduction and Powerline Corridor Management	X		
M4 (2017) Overhang Clearing	X		
M5 (2017) Non-Exempt Surge Arrester Replacement	X	Becomes M3	
M7 (2017) – Targeted Conductor Replacement (WF)	X		
M10 (2020 GRC) – Resilience Zones		Becomes part of M6	
M11 (2020 GRC) – Light Duty Steel Poles for Transmission Lines		Becomes part of C13	
M12 (2020 GRC) Wildfire System Hardening		Becomes M2	
M13 (2020 GRC) – Public Safety Power Shut Off		Becomes M5	
M14 (2020 GRC) – Reclose Blocking		Becomes C15	
M15 (2020 GRC) – Automation and Protection		Some of this becomes M6, some becomes M10 and some becomes part of C15	