ANNEXURE A

Bushfire Risk Analysis Report
Redland City Council 2017

TRAINING AND EMERGENCY MANAGEMENT

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SYNOPSIS

This document presents the analysis report into Bushfire Risk around the Southern Moreton Bay Islands (SMBI) addressing issues outlined in scope points 1 & 2 of the project description, as interpreted from Redland City Council (Council) requirements outlined in Reference A. This study seeks to quantify the difference in efficacy between no bushfire mitigation strategy versus Council's planned mitigation strategy (fuel management program) under a range fire weather scenarios at Fire Danger Index (FDI) 10, 20, 30, 40 and 50.

The quantitative risk analysis products in this report are derived by employing the best available fire spread simulation methods. This incorporates QFES' latest spatial fuel data. The fuel data used has been compared, and adjusted where needed, to accord to fuel hazard assessment sampling field work performed by QFES in the areas covered by the report.

QFES Bushfire Predictive Services Unit (PSU) has also undertaken a historical fire weather analysis to identify the estimated likelihoods of selected fire weather historically affecting the area concerned, and then using indicative historical weather of prescribed severity to undertake high-resolution gridded fire spread simulation.

Simulations were then carried out incorporating a baseline (long unburnt), untreated fuel layer (i.e. no fuel hazard management strategy, assuming long unburnt fuels) and then comparing this to a treated fuel state, i.e. as if the proposed fuel management program component of Council's mitigation strategy has been effectively implemented. The various metrics showing the difference between these various scenarios is used to estimate the general efficacy of proposed fuel management interventions at a single point in time.

The quantitative results data for each of the scenario combinations includes estimated average fireline intensity, impact frequency, impact types, house loss potential and the areas in hectares affected across several categories for each scenario etc. This information is presented in report format, a PowerPoint presentation and in a QFES online interactive analytics environment thus conveying relative bushfire risk between scenarios and permitting deeper analysis to be conducted by Council at its convenience.

DISCLAIMER

This Bushfire Risk Study ('this Study, Report and supporting tools') is provided solely for information purposes and is not to be construed, under any circumstances, by implication or otherwise, as anything other than as the opinions of the Queensland Fire and Emergency Services (QFES) Bushfire Predictive Services Unit in relation to anticipated potential bushfire risk, and only under the prescribed conditions used in the study.

The information contained in this Study is provided on the basis that the recipients will be responsible for making their own assessment of the information and potential implications of that information contained herein.

REFERENCES

A. Engagement contract for bushfire risk analysis services QFES / Redland City Council (Council) April 2017

B. Redland City Council – CFM Bushfire Action Plans 2016

C. Victorian Department of Sustainability and Environment – Overall Fuel Hazard Assessment Guide, 4th Edition, July 2010, Fire and Adaptive Management, Report no. 82.

D. Assessing Potential House Losses using PHOENIX RapidFire, Prof. Kevin Tolhurst and Derek Chong 2010. (link: http://www.bushfirecrc.com/sites/default/files/managed/resource/thu_p110a_1310_kevintolhurst.pdf)

DEFINITIONS

Terms, Abbreviations and Acronyms	Meaning
EP	Exceedance Probability (EP) refers to the probability of a given event being observed or exceeded during a given time period. The probability is expressed as a percentage. It is obtained by determining the number of times the given event is observed and exceeded divided by the total number of observations during the period. In FDI terms it would be the probability a given level of FDI was observed or exceeded during the time period.
OP	Occurrence Probability (OP) refers to the probability of a given event being observed (not exceeded) during a given time period. The probability is expressed as a percentage. It is obtained by determining the number of times the given event is observed divided by the total number of observations during the period. In FDI terms it would be the probability a given level of FDI was precisely observed during the time period.
SABRE	Simulation Analysis-based Risk Evaluation https://sabre.qfes.qld.gov.au/#/signin
FBAN	Fire Behaviour Analyst
QFES	Queensland Fire and Emergency Services
PSU	Predictive Services Unit
EBN	Executive Briefing Note
ISO	International Standards Organisation
Monte Carlo	Monte Carlo methods (or Monte Carlo experiments) are a broad class of computational algorithms that rely on repeated random sampling from a probability distribution to obtain numerical results.
BOM	Bureau of Meteorology
FDI	Fire Danger Index, which is an indication of severity of fire weather resulting from Wind strength, Relative Humidity, Temperature and Drought Factor.
FDR	Fire Danger Rating, FDI categorised into levels of threat for community notification and warning purposes.
PMO	Program Management Office
EM	Emergency Management
RFS	Rural Fire Service Queensland
QPWS	Queensland Parks and Wildlife
Phoenix RapidFire (Phoenix)	The bushfire behaviour characterisation simulation created by the University of Melbourne.

Terms, Abbreviations and Acronyms	Meaning
CSIRO	Commonwealth Scientific and Industrial Research Organisation
NWFI	Normalised weighted frequency of impact. Count of impacts by type (weighted based on impact type i.e. fire, convection, ember impact) at the grid level, the normalised across scenarios.
SABRE	Simulation Analysis-Based Risk Evaluation, a new decision support framework that permits stochastic fire spread modelling, and provides a generalised visualisation and analysis environment for all types of data.

EXECUTIVE SUMMARY

Issues at hand

The specific issue being addressed in this part of the larger project is outlined in detail in Section 2.2. In summary, the issue being addressed is a lack of quantified effectiveness of the proposed Redland City Council (Council) bushfire mitigation plans for the council areas of the mainland and the Southern Moreton Bay Islands (SMBI), excluding Stradbroke Island, under defined conditions.

The QFES Bushfire Predictive Services Unit (PSU) addressed the stated issues by employing high-resolution Phoenix bushfire spread simulation and undertaking quantitative analysis on the results. This was considered the best available approach to generate the most accurate, repeatable and scientifically sound results to support Council decision-making.

Study Conduct Main Points

Developing suitably representative simulations required detailed preparatory analysis of Council's fuels and historical weather. These comprise two of the three main variables (fuel, weather, terrain) that drive fire behaviour.

Fuel types recorded within QFES data sets were partially validated using field assessment on the SMBI and map verification on the mainland as outlined in Section '3.3 Stage 1 – Issue Definition, Fuel Data Collection and Management'.

A detailed historical fire weather analysis was conducted using hourly observations from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) at the Brisbane Airport between January 2000 and July 2015. The peak daily Fire Danger Index (FDI) was calculated for all observations falling within the months of August to January (fire season) and the return intervals of daily peak FDIs 10, 20, 30, 40, 50 estimated. It was found that FDI 20 can be expected to be met or exceeded about nine times on average during a typical fire season. FDI 20 was considered a balanced level for planning effective bushfire mitigation. The detailed fire weather analysis can be found in Section '3.4 Stage 2 – Fire Weather Analysis'.

Gridded Simulation

Phoenix Rapidfire is the bushfire simulator that was configured to light independent fires every 30m across both main Council areas. In this mode, each simulated fire develops independently, and once all fires are complete, the results across the landscape are integrated to provide frequency of impact, impact type, average fireline intensity and other metrics. These values permit the estimation of likelihoods and consequences spatially across the landscape. Results were generated for the five levels of FDI and with a baseline (long unburnt) and mitigation fuel layers resulting in 10 combinations of projects and results for each for the mainland and the SMBI. This forms the basis of quantitative bushfire risk estimation across the range of scenarios, providing Council with potential insights into bushfire risk across a range of potential planning levels.

Analysis

Analysis was conducted using visual quantitative products – SABRE Redland City Council (RCC) Bushfire Analysis site – developed using the outputs from the simulations. This enabled separate analysis for the SMBI and the mainland by comparing between the baseline (long unburnt) and the mitigation fuel treatment options in January 2027 across the FDIs used. The SABRE RCC Bushfire Analysis site has been built to allow selected Council staff to conduct further and deeper analysis as required. The key metric of DA (Direct Attack) Success is a firefighting technique involving the application of water to the flaming zone of a bushfire. The level of effectiveness of this strategy can be estimated as a function of the fireline intensity measured in kilowatts per lineal metre (kW/m) of fire front. Intensity greater than 4000 kW/m is defined as beyond DA Success. Section '3.6 Stage 4 – Create Visual Quantitative Analysis Product and Conduct Analysis' outlines how the change in risk is measured and how the primary metrics from Phoenix RapidFire are applied.

Key Findings and Recommendations

The below findings and recommendations are not exhaustive. Time and resource constraints precluded a comprehensive risk analysis of all council areas, so the findings outlined below are indicative only. Council is encouraged to use the online tools provided as part of this study to progress its own detailed findings and conclusions.

General

Finding:

- A broad conclusion from this analysis is to consider that fireline intensity mapping is not sufficient to appreciate and mitigate bushfire risk. This study shows the potential for significant ember attack to penetrate considerable distances into developed and urban areas in the council area that are far removed from large fuel blocks. This problem worsens as a function of increasing FDI.

Recommendations:

- That the FDI 20 level is recommended for general bushfire risk decision-making as to the efficacy of planned mitigation efforts. Sufficient mitigation effects achieved at this level are concluded to represent a reasonable balance of resource expenditure and payoff.
- One of the benefits of a repeatable and consistent simulation-based approach to bushfire risk analysis is it can be updated regularly with the latest fire scar history, fuel maps, disruptions etc. The QFES PSU recommends Council provide the latest fuel treatment history and fire scar data as at March each year, and that this analysis is repeated at FDI 20.

SMBI – Macleay Island

Findings:

- Mitigation in 2027 is considered likely to have a modest positive effect (~10ha reduction in area beyond DA Success) on increasing community safety at FDI 20.
- As FDI increases, the effects of mitigation remain positive on Macleay Island.
- There is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles).
- Largest payoff of mitigation is most likely at FDI 10 and below. The effects of mitigation, while still positive at higher FDIs, are not as proportionately large.

SMBI – Russell Island

Findings:

- Mitigation in 2027 is considered likely to have a generally positive effect (~38ha reduction in area beyond DA Success) on increasing community safety at FDI 20.
- As FDI increases, the effects of mitigation remain positive on Russell Island.
- There is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles), and another between FDI 30 and 40 (~40 per cent increase).
- The analysis indicates somewhere between FDI 20 and 30 is more likely to see ember transfer to Stradbroke Island. This offers a potentially important trigger range of FDIs during response to fires on the SMBI to start actively observing and managing for potential fire spread to Stradbroke Island.

Recommendation:

- A detailed fuel management plan be considered to create a buffer zone to the west of the properties in the south-east corner of Russell Island. This should also extend along the southern side of Glendale Road. Residents in this area are encouraged to apply their judgement and consider pre-emptive relocation during conditions above about FDI 20.

Mainland

Finding:

- Mitigation in 2027 is considered likely to have a generally positive effect on increasing community safety at FDI 20 on the mainland predominantly in Redland Bay and Mount Cotton areas, with lesser effect across other localities.
- There were a significant number of other localities showing no reduction in risk. The summary of reduction in area beyond DA Success for mainland areas is shown below:

	Scenario Name	
Ignition Locality	20 - Baseline (Long Unburnt)	20 - Mitigation Option 1
REDLAND BAY		-72 ha
MOUNT COTTON		-18 ha
ALEXANDRA HILLS		-9 ha
WELLINGTON POINT		-9 ha
SHELDON		-8 ha
VICTORIA POINT		-8 ha
THORNLANDS		-7 ha
BIRKDALE		-5 ha
COOCHIEMUDLO ISLAND		-2 ha
CAPALABA		-2 ha
ORMISTON		-1 ha
PRIESTDALE		-1 ha
CLEVELAND		-1 ha
ROCHEDALE SOUTH		-1 ha

Figure 1 – Ranked summary of mitigated area between baseline and mitigation options at FDI 20 for mainland localities. Those with no change are not shown. Negative numbers indicate a reduction in area beyond DA Success thresholds.

Background

The Redland City Council (Council) area is located to the south-east of Brisbane city. For this bushfire risk analysis study, the areas covered within the council area comprise the Southern Moreton Bay Islands (SMBI) (Karragarra, Russell, Macleay and Lamb Islands) and the mainland council areas as shown below, with Stradbroke Island not included.

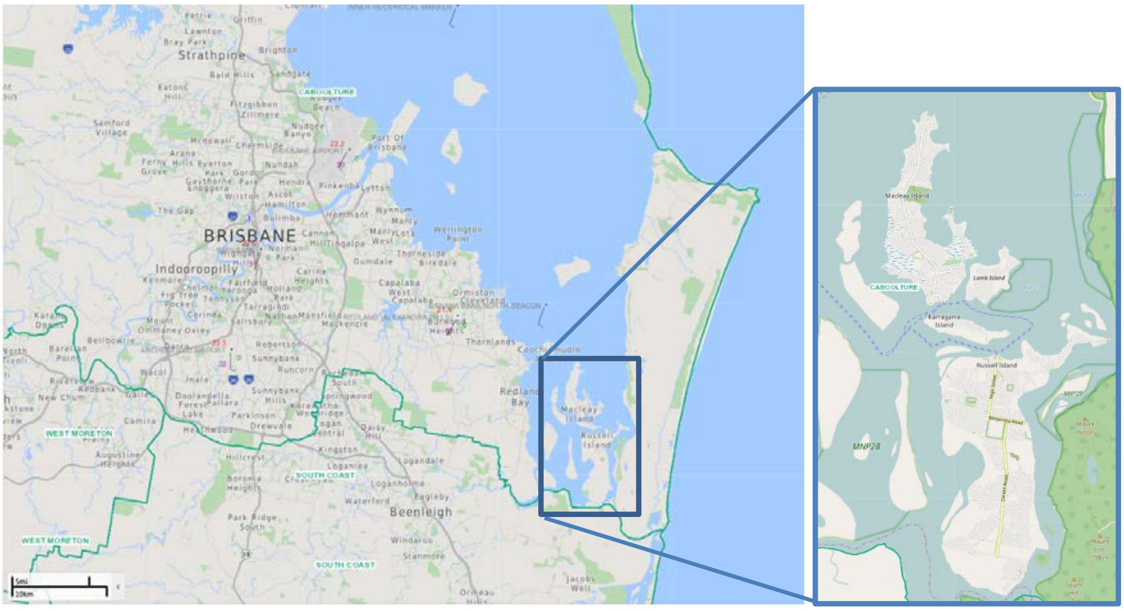


Figure 2 – Map of SMBI area.

The council area comprises a range of vegetation types mainly spanning mangroves and sedgelands through to dry and wet eucalypt species with a range of undergrowth types and loads. The complex nature of the vegetation, climate, the built environment and in the case of the SMBI, access from the mainland, requires a detailed understanding of the potential for bushfire and its prospective impacts under a range of conditions so as to properly inform the development and implementation of appropriate bushfire mitigation strategies.

As the mainland component is much larger than the SMBI areas, it will be examined solely at the recommended planning level of FDI 20. This is because the computation time and data outputs size for all five levels of FDI on the mainland are likely to be too large to be completed within the time frame to be considered in this report.

Project Description

QFES has been engaged by Council to examine a range of elements in relation to bushfire risk. This report documents the quantitative bushfire analysis sub-component of the broader project. It seeks to apply the latest data, technologies and science around bushfire behaviour modelling and simulation to quantify the potential effects of a prescribed council bushfire mitigation strategy under several different fire weather scenarios for the SMBI, and for the FDI 20 level for the mainland. So in addition to the other elements of this project which are described in Appendix A, this component underpins any general advice with quantitative estimates. This component of the project stems from the core issue facing Council, which is outlined in the next section.

Issue Being Addressed

The core of the issues being addressed in this component of the project is understood to be a lack of quantified effectiveness of Council's proposed bushfire mitigation plans (Appendix B) for the SMBI and mainland areas under defined conditions.

The effects of not having a clear quantitative understanding of the likely effectiveness of proposed bushfire mitigation plans at different levels of fire weather are manifold. They include the potential to reduce Council's ability to:

- Decide whether or not proposed mitigations plans will be sufficient to effectively meet community expectations.
- Improve the likelihood of achieving value for money when adopting selected bushfire mitigation plans.
- Better understand the benefits of a given fuel management plan relative to no plan at all as a function of increasing fire weather (FDI level).
- More clearly communicate to residents what is being done and how effective it is likely to be at different levels of fire weather.

A successful solution would provide sufficient quantitative clarity on mitigation plan effectiveness to permit Council to:

- Finalise the SMBI and mainland bushfire mitigation strategy and plans with increased confidence.
- Understand the beneficial effects of the plan across the spectrum of fire weather possibilities for the SMBI, enabling improved guidance of council actions and when they might be triggered for best effect. This information can be used by Council to formulate preparedness strategy elements for the affected communities based on forecast fire weather.
- Have a clear set of analytical products and findings, which can be referenced so as to clearly communicate with the community.

Scope of Work

Council's initial engagement of the QFES Bushfire PSU (referred to from here as Bushfire PSU) will address the above-stated issues for the SMBI, with the subsequent phase focusing on the mainland. The high-level project tasks falling within scope are:

- **General Fuels Analysis:** Review and refine fuel type layers and loads across surface/near surface, elevated and bark. This involves working with Council to obtain required data and to combine it with QFES fuels data and to verify where possible with field sampling. The primary outputs of this will be an agreed Phoenix fuel types data layer, and amended fuel accumulation curves by fuel type to best describe fuel loads through time. This stage assumes Council provides sufficient data describing their spatial fuel management plan in terms of areas to be mitigated and dates when it will be completed.
- **Historical Fire Weather Analysis:** Review detailed weather observations from Brisbane Airport between 2000 to 2015 to ascertain the indicative exceedance probabilities (EP) and occurrence probabilities (OP) of given FDI. The outputs of this will be five indicative days of hourly fire weather observations FDI 10, 20, 30, 40 and 50. These will be used to simulate fires that test the proposed mitigation program at each level of FDI for the SMBI and only FDI 20 for the mainland.

- **Simulation Preparation and Execution:** Use selected weather data to construct and test Phoenix gridded fire spread simulation projects for each scenario to quantify fire spread potential that will underpin the analysis.

- **Results Analysis and Deliverables:** Fire Behaviour Analysts (FBAN) will undertake a review of the results, develop a written report and visual presentation, and provide a suite of online interactive analysis tools to identify and communicate key findings, and to make recommendations.

Out of Scope

This section refers to just the scope associated with the Bushfire PSU project component, so the items mentioned below as being *not in scope* may be being handled by other QFES project members.

- **Legal Review:** The Bushfire PSU will not be analysing or making comments regarding the legal obligations or otherwise of Council in relation to fire mitigation.

- **Input Data Processing:** The Bushfire PSU is relying on Council's Geospatial staff to provide the required mitigation plan data in a form that requires little additional rework. Should this not be the case, a project variation may be required to accommodate unforeseen additional resources.

Purpose of This Report

This report forms the written deliverable component of the QFES Bushfire PSU's obligations under the 2017 council project. Its main purpose is to clearly inform Council of the QFES Bushfire PSU understanding of the problem being solved and its impact, as well as the findings. This document seeks to inform and guide Council's bushfire mitigation planning. In so doing, the report will also outline in detail how the issues are being solved in terms of approach, reasoning, methodology and conduct and will clearly convey assumptions, results analysis, findings and recommendations.

Desired End State

The desired end state upon successful delivery of the project's QFES Bushfire PSU is for Council to agree it has received sufficient quantitative evidence, analysis and guidance upon which to make improved decisions regarding the SMBI and mainland bushfire mitigation strategy and planning in the context of risk. To ensure common understanding, the definition of risk for the purposes of this study is discussed in detail below.

Defining Risk

According to International Standards Organisation (ISO) 31000, risk is the "effect of uncertainty on objectives". An 'effect' is a positive or negative deviation from what is expected. This definition implies that to conduct risk analysis there must be a reasonable approach to quantifying potential uncertainty and to analyse the magnitude of the change in the intended objective should those uncertainties be realised.

Bushfire risk for the purposes of this analysis can be taken to mean the difference in the magnitude of expected fire behaviour, impact type and frequency of impact between different sets of prescribed fuel and weather conditions. The uncertainties involved in quantifying bushfire risk broadly reside in:

- The location and timing of bushfire ignitions.

- The spatial arrangement of fuel types and their loads as well as how these can be expected to change through time (i.e. fuel re-accumulation after an intervention).
- The future frequency of occurrence of fire weather at different levels of FDI.
- How the possible combinations of future ignitions, fire weather and fuels may combine to yield fire spread, impact frequency and type and the consequences therein at a particular point in time.

Any bushfire mitigation strategy adopted will be subject to the above uncertainties. The selected strategy's effectiveness is likely to deviate somewhat from expectation. So to address risk usefully, the Bushfire PSU will use the Phoenix high-fidelity fire spread simulator employing a high-resolution gridded analysis technique, which is explained in detail in Appendix A – Phoenix. It will measure the simulated effects of bushfire at several levels of fire weather in untreated fuels (baseline, long unburnt), and again in treated fuels (mitigation plan) arranged as if the proposed mitigation strategy has been implemented effectively for 10 years. This process also estimates the number of times a given point on the landscape is impacted by fire, convection or embers or combinations therein. This results in an estimated *frequency of impact* and impact types across the landscape, which can be used as a guide to expected proneness of any given point on the landscape to a fire impact. While this approach does not account for all possible uncertainties, it does provide a methodical and transparent approach to quantifying the magnitude of expected change across a broad range of expected fire weather and fuel conditions and the relative likelihood of impact across the landscape.

Uncertainty can be thought of as a state or condition that involves a deficiency of information and leads to inadequate or incomplete knowledge or understanding. In the context of risk management, uncertainty exists whenever the knowledge or understanding of an event, consequence, or likelihood is inadequate or incomplete. By definition, any 'future' state of the weather or fuels is uncertain, and the magnitude of that uncertainty grows as a function of time, i.e. the further into the future, the greater the uncertainty as to the precise future state.

Absolute versus Relative Risk

No method of broad area risk quantification is perfect. For example, there will always be deviations in the mapped fuel state compared to the true landscape fuel state. These sorts of studies are not intended to measure absolute risk at high resolution. They seek to maximise accuracy where possible, but the more important and useful approach is to quantify the change in risk between a baseline and treatment options. To understand why this is the case, imagine creating a ruler. It might be incorrect in absolute measurement terms, but it will certainly help you quantify the change in length of something over time if it is growing. This is because the inaccuracies in the measurement marks on the ruler don't change between successive measurements. Similarly, any inaccuracies in the fuel mapping will remain consistent across both baseline and the treatment options, so relative risk measurement will work sufficiently well for judging the relative effect of mitigation. In conclusion, this method provides a reasonable basis for broad area absolute risk measurement, and a very good basis for relative risk change between treatment options.

The specifics of how the Bushfire PSU will address each element of uncertainty and meet its deliverables obligation is outlined in the next section.

Project Methodology

Overview

The QFES Bushfire PSU created and conducted high-resolution fire spread simulation using Phoenix covering the SMBI and mainland using a gridded ignition approach across two fuel layer options, with five levels of FDI (fire weather) for the SMBI and FDI 20 for the mainland. There were two fuel layer options which include a baseline (long unburnt) fuel layer and then a mitigation treatment options representing the provided council mitigation plan fuels. The treatment option assumes fuel loads as if the planned mitigation program had been implemented and maintained from 2017 for a period of 10 years, i.e. the fuels in the mitigation plan as at January 2027.

This study is deterministic, which means Phoenix is operated in a way such that a single trial of each scenario is all that is used to generate each scenario's results. This provides a reasonable basis for understanding relative risk between scenarios but offers little insight into the uncertainty (sensitivity and performance range) of each one. The alternative is a stochastic study where the input weather and fuel data for each Phoenix project is run through the QFES Simulation Analysis-based Risk Evaluation (SABRE) fire probabilistic modelling environment, specifically, the SABRE Fire ensemble manager that enables randomly drawn input data from defined probability distributions representing the level of estimated uncertainty in the input data. In stochastic approaches, each of the scenario combinations would be run 25 times, and would provide a much larger but more complete set of risk data, and more detailed understanding of the effect of uncertainties on outcomes. Due to time and resourcing constraints, SABRE Fire treatment was not adopted.

Key Assumptions

The following key assumptions have been made:

- That the fuel layer data used in this study is sufficiently close to reality averaged over broad areas so as to provide realistic average fuel load inputs to estimate the rate of spread, intensity and other fire behaviour metrics derived via simulation.

- That the historical weather between the years 2000 to 2015 as recorded at the Brisbane Airport is sufficiently representative of the next decade's weather in terms of the frequency of peak FDI days, and the detailed observations and synoptic setup at each level of FDI. In other words, the next 10 years of weather in the council area will adequately resemble the prior 15 years of observations at Brisbane Airport for the purposes of bushfire planning and risk assessment.

- That Council's fuel management component of the provided bushfire mitigation strategy will be implemented as modelled. Where dates for burning have not been defined, the PSU team will assume indicative dates. This study's results should not be extrapolated to draw conclusions about plan efficacy should there be large deviations from the plan that was modelled. Such changes may have counterintuitive effects and should be re-examined in the simulation environment.

- That the areas of fuel removal and treatment result in a uniform reduction of fuel across the entire treated area.

- That mitigation efforts by other agencies and tenures are not considered in this analysis, i.e. any areas of national park or private land holdings, etc. that engage in hazard reduction will be considered as long unburnt.

- That areas mapped as urban areas, or developed with housing are less likely to see consequential vegetation fires starting from inside them, but are rather more likely to be affected by fires impinging from surrounding vegetated areas.
- That Phoenix, in conjunction with the above input data, at 30m resolution and 30m gridded ignitions provides a sufficiently representative fire behaviour prediction environment to draw robust, quantitative conclusions about the *relative* efficacy of planned fuel management strategies relative to a baseline fuel state.

The detailed sections (mainland and SMBI) of the project as planned are outlined as follows.

Stage 1 – Issue Definition, Fuel Data Collection and Management

Review Current QFES Fuel Types and Loads for SMBI

Upon analysis, the SMBI contain numerous vegetation types in quantities significant enough to warrant verification of the QFES standard vegetation fuel loading. The vegetation types that where verified are:

- Type 3 – Wet eucalypt tall open forest – visually and physically assessed
- Type 5 – Moist to dry eucalypt open forest on coastal lowlands and ranges – visually and physically assessed
- Type 28 – Melaleuca open forests on seasonally inundated lowland coastal swamps – visually and physically assessed
- Type 41 – Shrublands and woodlands in coastal locations – visually and physically assessed
- Type 45 – Woodlands and heathlands associated scrubs and shrublands – visually and physically assessed
- Type 46 – Grassland and sedgeland communities associated with heathlands, scrubs and shrublands – visually and physically assessed
- Type 55 – Mangroves or sedgeland dominated wetlands and tidal saltmarshes – visual assessment only
- Type 59 – Low to moderate tree cover in built-up areas – visually and physically assessed

Other vegetation types evident on the SMBI were deemed to be insignificant for the purpose of modelling for this analysis, due either to limited occurrences, or they were of a vegetation type that does not contribute meaningfully to fire spread.

Review Current QFES Fuel Types and Loads for Mainland Council Area

Upon analysis, the council mainland contains numerous vegetation types in quantities significant enough to warrant verification of the QFES standard vegetation fuel loading. The vegetation types that where verified are:

- Type 3: Wet eucalypt tall open forest – map assessment only

- Type 5: Moist to dry eucalypt open forests on coastal lowlands and ranges – map assessment only
- Type 6: Moist to dry eucalypt woodland on coastal lowlands and ranges – map assessment only
- Type 8: Spotted gum dominated open forests and woodlands – map assessment only
- Type 28: Melaleuca open forests on seasonally inundated lowland coastal swamps – map assessment only
- Type 55: Mangroves or sedgeland dominated wetlands and tidal saltmarshes – map assessment only
- Type 60: Low grass or tree cover in rural areas – map assessment only

Verification of Fuel Data Via Field Sampling

The QFES project team visited each of the SMBI and conducted visual Fuel Hazard Assessments using the nationally recognised method outlined in Appendix C. Physical fuel samples were collected at various sampling locations on the SMBI. These physical samples were prepared, then dried and weighed to obtain a definitive measure of near surface and surface fuel loads. Due to time constraints, no visual or physical fuel sampling was undertaken on the mainland.

Ideally, more visual and physical fuel sampling would be advised in order to further increase the accuracy of the fuel loading input into the modelling. However, this was beyond the capacity of the QFES project team due to resource and time constraints dictated by the project.

Finalising Fuel Layers Data

The results of the SMBI field sampling were analysed, averaged and used to amend current standardised fuel loadings as contained in Phoenix. Tabulated form of these adjustments can be seen in Appendix C – Vegetation Fuel Load Adjustments. The fuel loadings for relevant vegetation for Karragarra Island were taken as an average of the loadings for the same vegetation types across the other three islands in the SMBI group.

Stage 2 – Fire Weather Analysis

Weather, fuels and terrain are the three main variables in estimating fire behaviour and its potential impacts in the landscape, and on communities. The most dynamic of these three variables is weather, but it is also the most thoroughly observed, recorded and analysed through the Bureau of Meteorology (BOM).

A large source of uncertainty in mitigation planning is the frequency or likelihood of encountering fire weather at different levels. Given that it is not possible to know the future fire weather with certainty, when considering potential bushfire mitigation strategies, it is useful to understand the likely level and frequency of fire weather in order to develop and test candidate mitigation plans against likely level and frequency. A balance needs to be struck as to the level of fire weather to plan for. A mitigation plan designed to deal with the worst previous fire weather for all areas is likely to be disproportionately and prohibitively expensive, resource intensive and potentially unnecessarily damaging to the environment. On the other hand, developing a plan just to deal with the most commonly experienced fire weather is likely to consume few resources, but may cease to be effective as that fire weather is exceeded.

Selected Weather Data

This study has selected five levels of fire weather (FDI 10, 20, 30, 40, 50) to test the SMBI against, as taken from the nearest high-quality Automatic Weather Station (AWS), which is located at the Brisbane Airport. The mainland areas were only evaluated against FDI 20. The Bushfire PSU planned to calculate the maximum daily FDI for the detailed observations (hourly or half-hourly) between the years 2000 to 2015 and only using annual observations from the months of August through to January to represent the annual fire season[1]. The years were chosen to account for changes in climate since pre-2000, i.e. the climate is now considered to be sufficiently different relative to pre-2000 observations that including those pre-2000 observations would likely underestimate severe fire weather frequency and magnitude than can truly be expected in the medium-term future (<=10 years). The months were chosen so as not to skew the percentiles down due to winter and wet season months.

Historical Frequency of Fire Weather – Maximum Daily FDI Percentiles for Brisbane Airport

Figure 3 was generated from the Bushfire PSU historical weather analysis tools. It shows the maximum daily FDIs below as percentiles of the observed data range. For example, FDI 20 indicates that 95 per cent of daily maximum FDIs between 2000 and 2015 from the fire season months fall at or below FDI 20.

Max Daily FDI Percentiles

Station Name	Max. Max Daily FDI	Percentile (95) of Max Daily FDI	Percentile (90) of Max Daily FDI	Percentile (75) of Max Daily FDI	Percentile (50) of Max Daily FDI	Percentile (25) of Max Daily FDI	Percentile (10) of Max Daily FDI
BRISBANE	FDI 50	FDI 20	FDI 15	FDI 10	FDI 7	FDI 4	FDI 1

Figure 3 – Percentiles of maximum daily FDI from observation between 2000 and 2015, August to January (fire season) at Brisbane Airport.

This table provides an indication of the likelihood of past fire weather exceeding given FDIs during fire season. It forms the basis for understanding the *past* likelihoods of the recommended testing levels for mitigation strategies. The Bushfire PSU recommends that mitigation strategies be designed to demonstrate an acceptable level of efficacy at the 95th percentile FDI level. This is usually

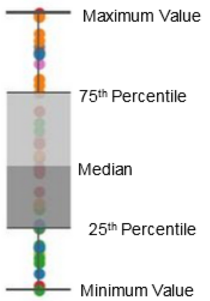
[1] Whenever the report refers to weather data statistics from this point onwards it can be assumed that the data set is based on 2000 – 2015 and August to January only, and that August to January is implied when the term “fire season” or just “season” is used.

considered to yield a cost-effective and resource-efficient plan that provides good risk reduction most of the time, and still maintains some positive effects if the FDI rises above 20. Ultimately though, the planning level of FDI is a decision for Council based on its own risk tolerance levels.

To provide a more complete understanding of the likely performance of any mitigation plan, the Bushfire PSU recommends Council should plan for FDI 20 but test the plan at different points across the possible FDI spectrum. This provides a deeper understanding of the return on investment and resulting risk reduction of the plan at different levels of FDI. It can also provide a better guide to trigger points for pre-emptive community warnings, etc. This enables a clearer picture of likely changes in bushfire risk across the FDI spectrum in the context of the likelihood of each FDI tested.

Daily Maximum FDI Grouped by Year for Brisbane Airport

To provide a more complete annual FDI context for the percentiles shown in in Figure 3, Figure 4 below shows the spreads of historical maximum daily FDI values for Brisbane grouped by year, with coloured bands indicating the fire danger rating (FDR) levels. Each year's data are displayed using a statistical visualisation tool called a box and whisker plot. A box and whisker (or simply box) plot enables rapid characterisation of a distribution of values, including its skewness. See reference image Figure 3 to understand how a box and whisker plot is built and what it communicates.



Box plots explained.

The below annual FDI plots show Brisbane Airport recorded only one maximum daily FDI in the Severe FDR category between 2000 and 2015. The box plots provide a clear view that the bulk of daily maximum FDIs cluster well below FDI 20. It also provides a good idea of the annual variability of maximum daily FDIs.

The below annual FDI plots show Brisbane Airport recorded only one maximum daily FDI in the Severe FDR category between 2000 and 2015. The box plots provide a clear view that the bulk of daily maximum FDIs cluster well below FDI 20. It also provides a good idea of the annual variability of maximum daily FDIs.

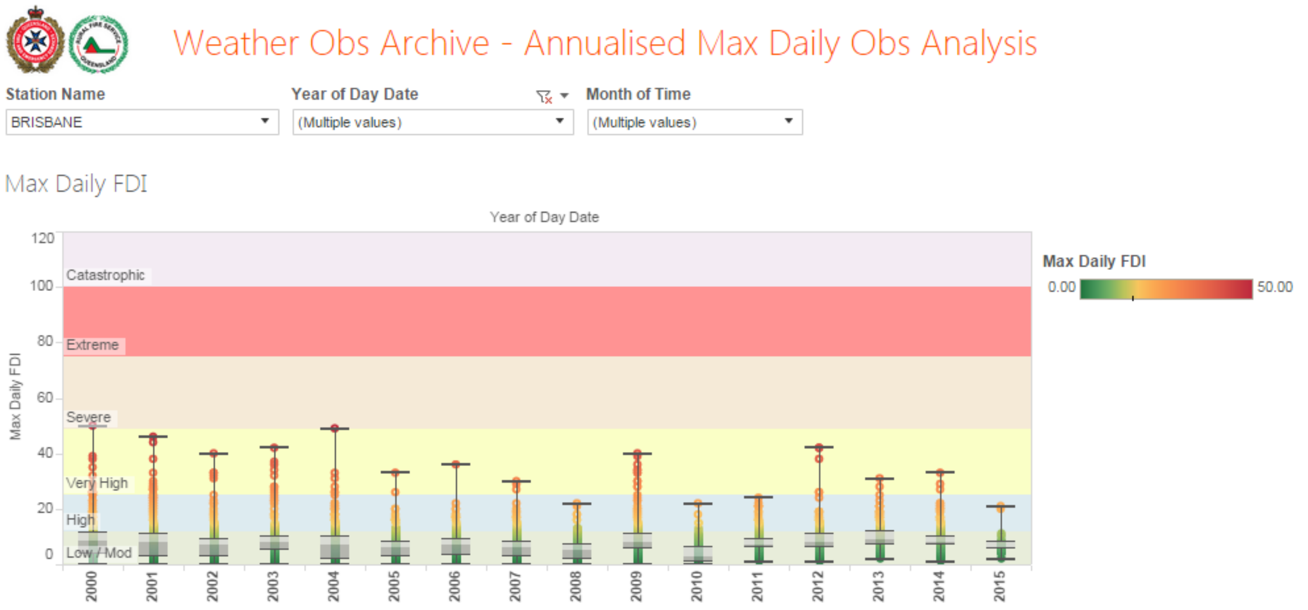


Figure 2 – Box and whisker plot showing distributions of all max observed daily FDI by year in Brisbane between 2000 to 2015 months Aug – Jan.

The next section provides specific exceedance and occurrence probabilities in increments of 10 from FDI 10 to 50 across the 2000 to 2015 period.

Daily FDI Statistics and Probabilities

The following fire weather (FDI) data was identified for use and is presented with their respective statistics of their past frequencies to provide a guide to their future likelihoods.

Daily Peak FDI	Count Days >= FDI	Count Days = FDI	Total Days	EP	OP	Expected Days Season
10	713	164	2811	25.4%	5.8%	40
20	148	19	2811	5.3%	0.7%	9
30	40	4	2811	1.4%	0.1%	2.3
40	9	2	2811	0.3%	0.1%	0.5 (~1 in 2yr)
50	1	1	2811	0.1%	0.1%	.06 (~1 in 20yr)

Figure 3 – Table of FDI levels used in the analysis and their statistics of occurrence and exceedance. Recommended mitigation planning level highlighted in green.

Perhaps the most intuitive column in the table above is the expected number of days per season that maximum daily FDI can broadly be expected to be matched or exceeded. As an example, FDI 20 would be interpreted as being expected to be matched or exceeded on about nine days, on average, per fire season. So, the fuel management component of a mitigation plan tested via simulation and found to be effective at FDI level 20 could reasonably be expected to be of benefit in managing a sufficient amount (but never all) of the bushfire risk for all but around nine days per season, on average. Some seasons will be worse than others with significantly more than nine days, and depending on the point in time in the mitigation plan's life cycle, and other variables, the degree of true mitigation achieved will vary. The reasons for this are explained further in the next section.

Interpreting Rare Events and Averages

An important concept when dealing with rare events (such as occurrences of FDI 50 in Brisbane) is that the rarer the historical event, the less is known about its true frequency, and the less able we are to estimate its likelihood in the future. The climate that the historical statistics are derived from is changing. It is accepted in scientific circles that Australia's future fire weather is expected to comprise more days with higher FDIs on average, and more years with new record high FDIs on average.

However, precisely estimating this change ahead of time is extremely difficult. So instead of taking the occurrence statistics in Figure 5 as an absolute indicator of future annual likelihood, it is prudent to consider them slightly low estimates, and to work on the assumption that fire weather is generally expected to worsen in intensity and frequency into the future. It is possible to apply regression techniques to project future weather conditions that align to published climate change scenarios, but this has not been applied in this analysis.

The most recent FDI deciles data from the BOM as at the time of writing is shown below to provide an indication of the relative change in average FDI levels since 1950 experienced in Queensland during December 2016 to February 2017.

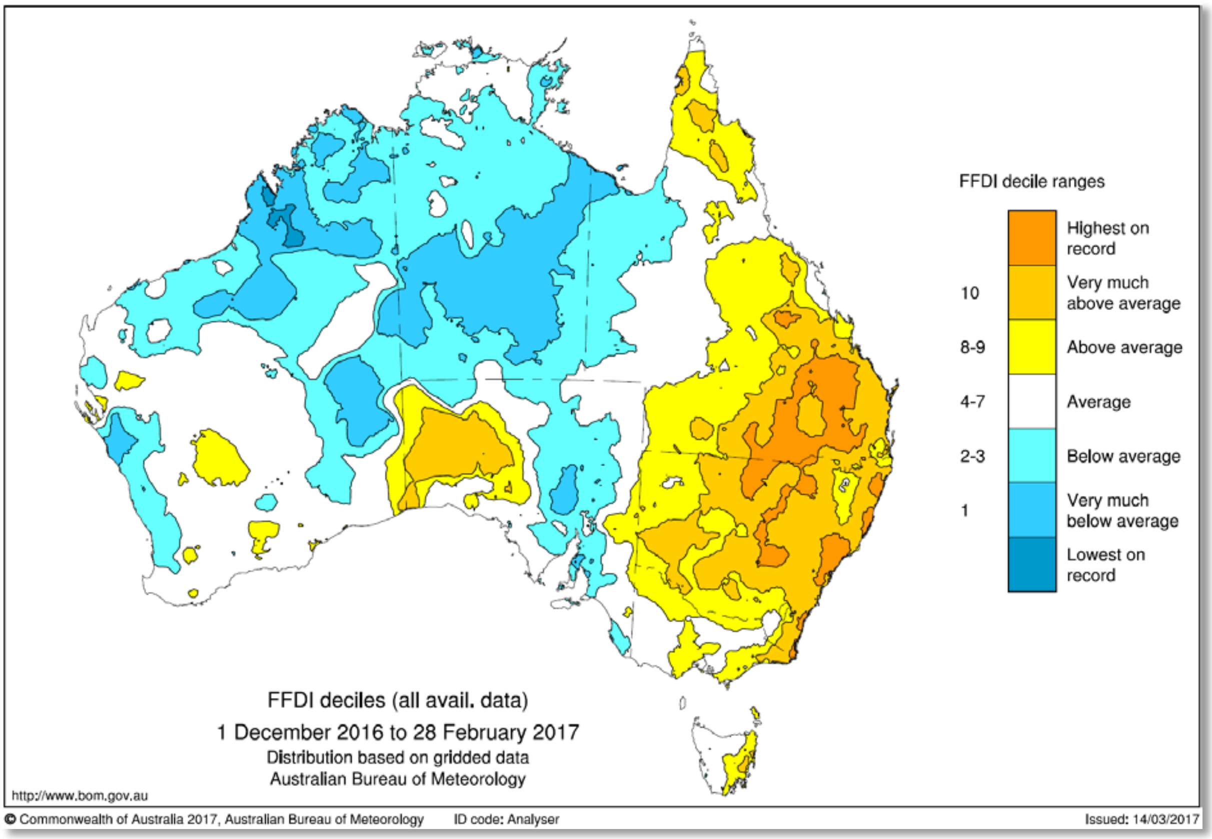


Figure 4 – BOM FDI Deciles showing the difference in the number and magnitude of peak daily FDI between December 2016 and Feb 2017 relative to the average since 1950.[i]

The recommendation is to focus more on understanding the potential efficacy of mitigation plans at different levels of FDI rather than to try to predict the exact likelihoods of each level occurring in the future. The final point is that the term 'on average' is used often. Averages can be deceptive. When we state that a day reaching or exceeding FDI 20 can be expected to be seen about nine days each season on average, this might mean a particular year may not see any, while the next year might see 18 days. This maintains the nine days per season average, but could see years with significantly more or fewer of these days.

Examining the potential efficacy of fuel management plans at 10, 20, 30, 40 and 50 FDI provides a broad understanding of spatial impact likelihood and consequences without being subjected to FDI exceedance probability prediction errors and worrying too much about their true future likelihoods. To ensure indicative weather days are selected, it is necessary to examine the average wind directions at each level to choose representative or typical days to test against. The following section discusses the general synoptic setup and average wind directions that can be expected at the given levels of FDI.

Synoptic Setup and Wind Direction Analysis

During the analysis of the Brisbane Airport weather observation time series at the selected levels of FDI it was discovered that the synoptic setup for FDI 10 and above appears to remain fairly similar, but the intensity of temperature, relative humidity (RH) and wind speed vary. The general pattern is:

- **Wind direction**: Winds tend to come from the western arc between about 230 and 300 degrees, clustering more tightly around 270 degrees the higher the FDI beyond FDI 20. These westerly winds usually build in speed through the morning, then at some point the sea breeze comes in and the wind swings to the east / northeast, and the RH tends to increase and temperatures begin to drop.
- **Sea Breeze**: A particularly important feature of Redlands fire weather is the sea breeze. At FDI 10 to 20 the sea breeze wind shift to the northeast typically comes in between 1200hr and 1700hr. As the FDI increases, the sea breeze tends to take longer and longer to come in, with FDI 35 – 40 seeing it come in as late as 1800hr to 2000hr. On some days, the sea breeze may not overcome the land-driven westerlies at all.

The table below shows the percentage of observations by wind direction (degrees) for each FDI range, with the highest-frequency wind directions highlighted to show the directions observed most often. Fire weather from specific dates in the past was chosen for the simulations to match the historically most likely wind direction and sea breeze influence in order to provide the most realistic representation for council planning purposes. The specific weather streams used can be viewed in Appendix B – Detailed Daily Weather Stream Data Used in Simulations.

FDI Range 5 to 10

Wind Dir (copy)	BRISBANE
10	1.36%
20	4.51%
30	7.91%
40	7.95%
50	10.04%
60	10.32%
70	7.99%
80	5.64%
90	7.28%
100	6.78%
110	5.72%
120	4.20%
130	3.71%
140	2.21%
150	1.30%
160	0.52%
170	0.49%
180	0.34%
190	0.30%
200	0.29%
210	0.34%
220	0.43%
230	0.51%
240	1.07%
250	1.64%
260	1.90%
270	1.58%
280	0.85%
290	0.39%
300	0.13%
310	0.14%
320	0.25%
330	0.41%
340	0.42%
350	0.53%
360	0.57%

FDI Range 15 to 20

Wind Dir (copy)	BRISBANE
10	0.54%
20	0.91%
30	1.36%
40	1.09%
50	1.91%
60	3.27%
70	1.36%
80	0.45%
90	0.45%
100	0.36%
110	0.36%
120	0.09%
130	0.54%
140	0.45%
150	0.18%
160	0.09%
170	0.09%
180	0.27%
190	0.82%
200	0.91%
210	1.72%
220	1.45%
230	3.90%
240	5.08%
250	13.16%
260	23.59%
270	18.15%
280	8.35%
290	4.26%
300	2.18%
310	0.54%
320	0.82%
330	0.64%
340	0.27%
350	0.09%
360	0.27%

FDI Range 25 to 30

Wind Dir (copy)	BRISBANE
30	0.31%
50	0.31%
70	0.31%
150	0.31%
180	0.62%
190	0.62%
200	0.31%
220	1.56%
230	2.49%
240	5.92%
250	14.64%
260	23.36%
270	29.91%
280	10.59%
290	4.36%
300	1.87%
310	0.62%
320	0.31%
330	0.93%
340	0.31%
360	0.31%

FDI Range 35 to 40

Wind Dir (copy)	BRISBANE
220	1.35%
230	6.76%
240	6.76%
250	12.16%
260	21.62%
270	31.08%
280	13.51%
290	5.41%
300	1.35%

Figure 5 – Wind direction percentages of observations by FDI range, most frequent observation directions shaded red.

Most Dangerous Weather

Bushfire risk analysis is complex. In some circumstances the most severe fire weather is not always the most dangerous to communities and ecosystems, based on where they are sited in relation to the prevailing weather. The fire weather analysis established that the most severe fire weather around Brisbane Airport sees mainly westerly winds. This implies communities to the east (i.e. downwind) of major fuel blocks are at increased risk. Where there are communities, infrastructure or high-value ecosystems to the west of some more volatile fuel types like coastal heath, it is possible that the most dangerous bushfire risk occurs at lower FDIs with easterly winds. Heath fuels can be more resistant to changes in relative humidity, and can ignite and burn readily at high intensities even though relative humidity is high, temperatures are low and winds are light. This includes burning through the night when conditions indicate the fire should self-extinguish. So while this analysis does not include scenarios with easterly winds and low FDIs, consideration should be given to identifying potential areas where this scenario could be an issue.

Stage 3 – Experiment Design, Scenario Generation and Simulation

Experiment Design and Scenarios

The primary variables in this analysis are locality (area in question), peak daily FDI level and fuel treatment state. On the SMBI, there are four Islands (localities), five levels of peak daily FDI and two fuel treatment states resulting in 40 individual combinations requiring specific Phoenix projects to be built and run to generate the required quantitative data for analysis, just for the SMBI.

The mainland was run in a single block of localities, and the ignition grid extends three kilometres beyond the council boundary to account for fires igniting from outside and impinging into the council area, which is a legitimate fire risk that should be considered. So across five FDI levels, and two fuel treatment options, there were 10 individual mainland Phoenix runs. At FDI 20, a single Phoenix run requires approximately 24 hours of computation time, FDI 50 is expected to require about eight to 10 days of computation time for a single run. Computation time is the reason the mainland FDI scenarios beyond FDI 20 are not included in the written report, although they will be uploaded to the RCC SABRE analysis site as they are completed.

Selection of Areas for Gridded Ignitions

When attempting gridded simulation of fire spread, it is not typically useful to ignite simulated fires in those areas mapped as houses or developed areas. This is mainly due to the following factors:

- The complexity of the real world fuels and their arrangement are not captured and addressed in sufficient detail within the simulator to draw meaningful conclusions.
- Most vegetation fires of consequence are usually ignited in bushland areas outside of the specific built-up areas, and so we are more interested in developed fires impinging into developed areas rather than them starting there.
- Built-up areas are usually more populated and bounded by mowed lawns, paths and roads, so fires starting in these areas are more likely to be seen and dealt with early. Fires do not usually develop due to mown lawns and paths, but if they do they are more likely to convert to a structure fire.

During this analysis the Bushfire PSU created an ignition grid (fires starting every 30m) in just those areas that fall outside those the QFES has mapped as being built-up areas and water bodies shown as brown and blue respectively in the image below. The same ignition grid was used across all scenarios.

Figure 6 – Coloured blocks showing different areas of vegetation fuel types. Ignition points in Phoenix were only generated outside the areas that are brown or blue.

How Council's Fuel Management Regime was Simulated

A fuel management regime for the purposes of this analysis can be taken to mean a plan that comprises the removal or reduction of fuels in defined areas at defined dates into the future. The fuel management regime is usually just one component of an overall bushfire management strategy. Community education,triggers for local fire bans and dedicated efforts to prepare properties are just some of the many other components.

Baseline Fuel Layer

The first planned fuel option to be modelled was the baseline (long unburnt) fuel layer. This is also referred to as the long unburnt fuels option. This means fire behaviour is simulated as if no mitigation or fire history of any kind was present, thus the fuel loads were maximised for their particular vegetation type. It represents an upper end, 'do nothing' case of fuel loads and provides a reasonable baseline against which to measure any planned mitigation or fuel removal.

Mitigated Fuel Layer

The second fuel option planned for modelling was the mitigation option or treated fuel layer as if Council's planned fuel management program had been operating effectively for 10 years. This layer was represented in Phoenix using council provided data comprising shapes defining the areas where fuel is planned to be periodically reduced or treated irrespective of the mechanism, i.e. fire, spraying, slashing etc. These areas were assigned a treatment date, i.e. the month and year in which the fuel block would be reduced in accordance with Council guidance. These shapes and their reduction dates were saved into a single shape file which in turn was loaded into the Phoenix simulator for the mitigation option runs, and removed for the baseline runs.

For the mitigation option, Phoenix was then run with a time of January 2027 and the time difference between the listed areas reduction/treatment date and January 2027 yields the value of *time since last fire*. Phoenix contains a detailed, layered fuel re-accumulation model where every 30m grid of any fuel type in Phoenix is evaluated against its time since last fire. The specific amount of fuels in the surface/near surface layer, elevated layer and bark fuels are then calculated based on re-accumulation curves for each fuel type as a function of time since last fire. This means Phoenix simulates the adjusted fuel load in each layer (tonnes per hectare) for every mitigation area based on how much fuel has likely re-accumulated since it was treated. The result is a fuel layer that represents the quantitative difference between baseline and mitigation fuel loads, by layer, as a function of time since last fire.

Stage 4 – Create Visual Quantitative Analysis Products and Conduct Analysis

Measuring the Change in Risk (i.e. Residual Risk)

There are a number of potential ways to determine the change in risk between the baseline and mitigation options (i.e. the residual risk) and FDI levels. The gridded analysis approach in Phoenix lets us examine the normalised weighted frequency of impact (NWFI)[2] across every 30m grid on the landscape. Normalise means to convert a numerical series to a scale of 0 to 1, which is effectively a percentage ranking. Phoenix discerns between fire, convection and ember impact types. Since fire impact is more dangerous than convection, which in turn is more dangerous than embers, these have been subjectively weighted using local FBAN judgement, but users with access to Council's Analysis area on SABRE can change these weightings if they wish. Fire is weighted as 2, convection 1.8 and embers 1. This basically means fire impacts are considered twice as bad as embers, and convection is 80 per cent worse than embers, but 20 per cent better than fire.

Phoenix also outputs multiple average fire behaviour metrics per grid. Those areas with higher NWFI can be interpreted as having higher relative likelihood of impact under the conditions simulated, given fires begin anywhere with equal probability (i.e. equiprobable gridded ignition).

Risk can be viewed as likelihood combined with consequence. Those areas of higher NWFI correlate to the increased 'likelihood of impact' component of the risk equation, or in more general terms 'proneness' to impact. Similarly with consequences, the average fireline intensity categorised into Direct Attack success categories and other metrics like conditional house loss potential can be thought of as the consequence part of the risk equation, i.e. the likely average result given an impact. These metrics are outlined and explained in detail below to enable Council staff to appropriately interpret their meaning.

[2] This is essentially the number of times each grid was impacted by fire, convection or embers, but placed in a ranked scale of 0 to 1.

Primary Metrics

Weighted Frequency of Impact

Phoenix counts the number of times each grid was impacted by fire, convection and/or embers. From these counts it is possible to categorise the landscape into the estimated types of impact and their frequency. The one additional element QFES has introduced to this frequency of impact by type is weighting the frequency based on *type* of impact. This is essentially a way to try to account for the fact that a fire impact is generally worse than convection, which is in turn worse than just ember impact. So in general QFES applies a weighting of 2, 1.8 and 1 for fire, convection and ember impacts respectively. This yields a combined weighted frequency of impact (WFI) score to provide a more complete relative analysis of the landscape under the defined conditions. For example, a grid which recorded 10 fire impacts, five convection impacts and one ember impact would have a final weighted frequency of impact score calculated as follows:

Fire Impact Weight (FIW) = 2
Convection Impact Weight (CIW) = 1.8
Ember Impact Weight (EIW) = 1

Fire Impact Count per Grid = FIC_{grid}
Convection Impact Count per Grid = CIC_{grid}
Ember Impact Count per Grid = EIC_{grid}

Formula for $WFI_{grid} = (FIW \times FIC_{grid}) + (CIW \times CIC_{grid}) + (EIW \times EIC_{grid})$

Or for example in a single grid we might see:

$(2 \times 10) + (1.8 \times 5) + (1 \times 1) = 20 + 9 + 1 = 30$

Users can change the weighting interactively if they wish on the SABRE RCC Bushfire Analysis site using the NWFI Series tab. The weightings adopted by the PSU are subjective and based on rough guidance from fire scientists. They are not definitive.

Global Normalised Weighted Frequency of Impact (NWFI)

To provide a common scale for comparing between all grids, the WFI described above is normalised, i.e. the WFI for all grids are put on a scale of 0 to 1, and this value is expressed as a percentage. This can be done at different levels. For example, a global NWFI would take the current WFI score for a given grid and divide it by the maximum observed WFI score across the whole council area (mainland and SMBI) and across all scenarios. Usually this results in the maximum WFI being found in the baseline (long unburnt) scenario are FDI 50. This global NWFI compares every grid to the worst possible observed WFI. At the time of writing this report, the mainland simulation results only include up to baseline FDI 30[3], but the SMBI include baseline and mitigation up to FDI 50. As a result, the next level of NWFI (outlined in the below section) is used to essentially treat the mainland and SMBI separately for the purposes of WFI (i.e. impact proneness) only. Conditional House Loss potential is the only other metric impacted by the level of NWFI as it includes the mainland/SMBI NWFI in its calculation. None of the other metrics include the NWFI so are not affected. Once the mainland FDI 50 results are generated, the global NWFI can be used to compare both SMBI and mainland locations relative proneness on a single scale.

Mainland / SMBI NWFI

Mainland / SMBI NWFI is determined by using the maximum observed WFI score across just the mainland council area for all current scenarios (i.e. up to baseline FDI 30). This means the SMBI

[3] Due to very long computing times for mainland areas at high FDIs.

NWFI is *treated separately* to the mainland NWFI and is calculated by taking each SMBI grid WFI and dividing it by the maximum observed grid at FDI 50 baseline of just those grids on the SMBI. It is this level of NWFI currently used on the RCC SABRE site. The graded NWFI colour map will grade colours on the SMBI relative to the worst WFI found just on the SMBI (FDI 50), and the mainland just for the worst found on the mainland (FDI 30). As a result, the SMBI and mainland should be *viewed and treated separately* using the filters on the online RCC SABRE site and users should not draw conclusions about relative proneness of a SMBI location relative to a mainland location as they are not on the same scale. They only make sense within each area, not between them. Once the mainland FDI 50 results are uploaded, the Bushfire PSU can update Council's online site to use global NWFI, and put all areas on the same scale if desired. It is recommended that the current overlays be left using mainland / SMBI NWFI, but that several more overlays be added to the site based on global NWFI. This will provide Council the ability to analyse both.

Locality NWFI

Finally, the concept can be extended down to the locality level. This, and the above levels simply provide a relative percentage figure for the given area/level contained in the calculation. A value of say 12 per cent for the locality NWFI indicates this grid matches or exceeds the proneness to impact of 12 per cent of all other grids just in that locality. Similarly, this same grid might have a mainland NWFI of just 2.5 per cent indicating it matches or exceeds the proneness to impact of just 2.5 per cent of all other grids just on the mainland. Finally, at the global level it may show just 0.4 per cent. As the number of grids included in the calculation grows from locality, to mainland/SMBI to global (all of the council area across mainland AND SMBI), it is more likely to be exceeded by other grids, so its impact proneness at that level drops.

NWFI Summary

While the NWFI map overlays will be coloured by the mainland/SMBI NWFI until the complete dataset is produced taking the mainland to FDI 50, the maps tool tips which popup when the user hovers their mouse pointer over any grid will show all three levels of NWFI for every grid. This provides a good idea of proneness across the different levels considered.

Direct Attack Success

DA is a firefighting technique involving the application of water to the flaming zone of a bushfire. The level of effectiveness of this strategy can be estimated as a function of the fireline intensity measured in kilowatts per lineal metre (kW/m) of fire front. Phoenix calculates the average fireline intensity per 30m grid. In turn, the average fireline intensity is categorised into the average estimated DA Success level by grouping average fireline intensities into the categories shown below. Broadly speaking, average fireline intensities above about 4000 kW/m are too dangerous for ground-based DA to be employed, and if it is employed tend to have reduced effect and poses greater risks to firefighter safety. Beyond about 10000kW/m, intensity is too high for water to really have any substantial effect on suppression success. Most of the water applied at the rates fire appliances can deliver it is turned to steam prior to it having a significant effect on intensity.

Table 1 - table of DA Success categories as a function of fireline intensity measured in kW/m.

Average DA Success	
a. Certainly Not Effective	>30000kW/m
b. Not Effective	>10000kW/m to 30000kW/m
c. Probably Not Effective	>4000kW/m to 10000kW/m
d. Probably Effective	>2000kW/m to 4000kW/m
e. Effective	<2000kW/m

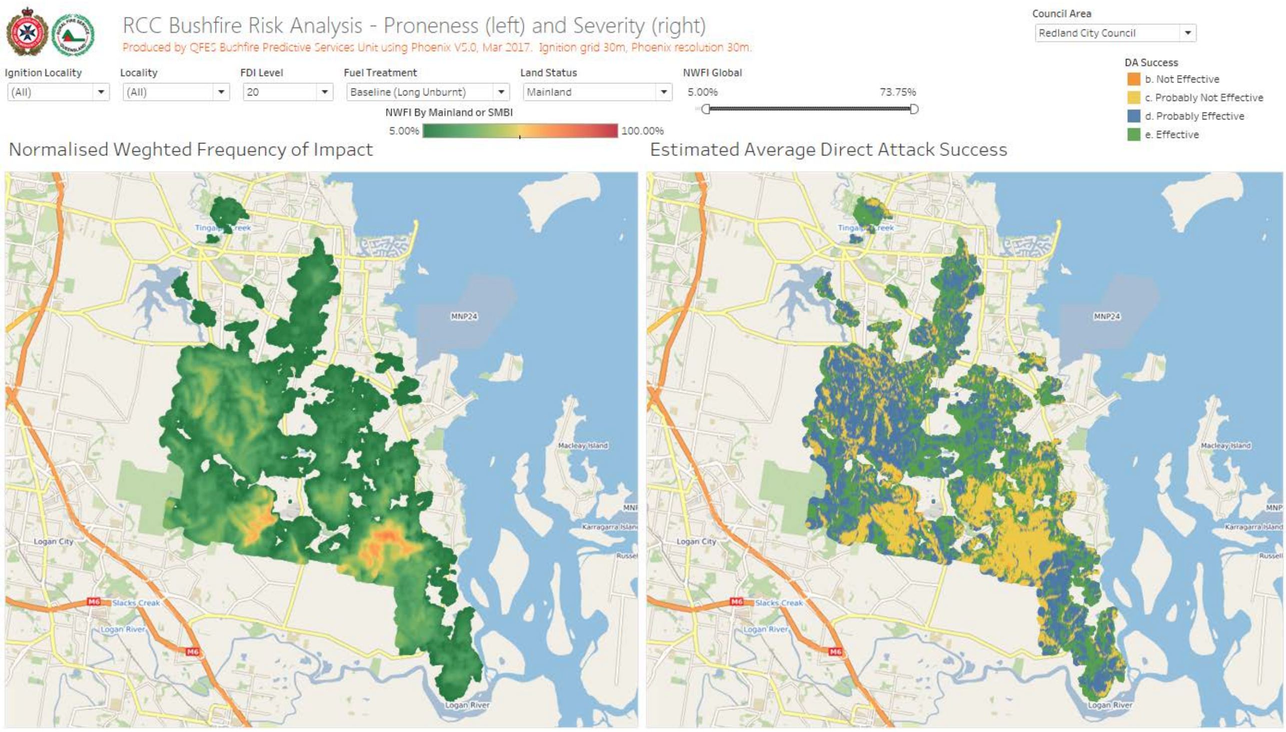


Figure 7 – Mainland / SMBI NWFI on left map above indicates relative proneness, and DA Success category map on the right above indicates consequences. Together these provide a rounded view of Bushfire risk under the simulated conditions.

Area by DA Success

This metric is calculated by summing up the total area falling within each DA Success category. It is measured in hectares (ha). The intuition for how this metric is calculated can be visualised by observing the DA Success map in the above right image, and imagining all the yellow and orange cells (30m x 30m each) being selected and stacking them up to create a bar of area within each DA Success category. The bar chart below then lets users select the particular scenarios for which to display these stacked bars.

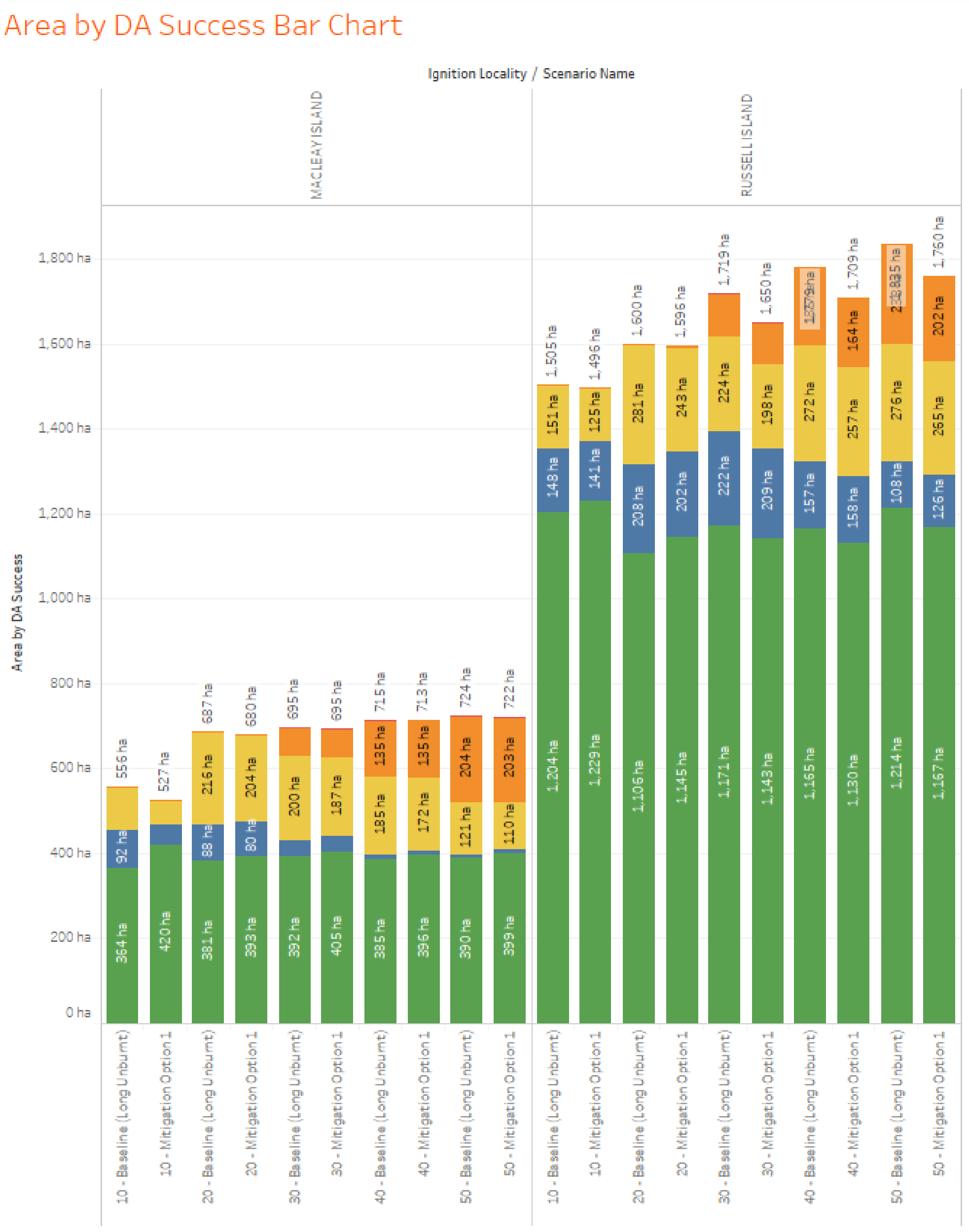


Figure 8 – Example of the SMBI stacked bar chart of area by DA Success category.

Impact Type

Phoenix results contain the number of times each grid was impacted by fire, convection and embers. Post-processing can then indicate which combination of impact types occurred in each grid under the simulated conditions. This metric is important as it provides additional bushfire risk guidance in addition to simple fireline intensity metrics. Due to the spotting and embers modelling in Phoenix, this metric can indicate broad areas where Council should consider an ember attack or convection risk. Some of these will likely be in built-up areas potentially some distance away from fuel blocks. This is because Phoenix simulates ember transport and convection as a separate part of the fire spread modelling process. The image below shows a comparison map containing impact types. The warmer colours are associated combinations of impact involving fire impact, and the cooler colours are just combinations of impact type involving convection and embers only without fire impact.

To interpret the image below the user would conclude those areas shown in blue, particularly those over built-up areas may be prone to ember and convection effects from fires burning upwind and some distance away at FDI 20. Given winds are predominantly from the western quadrant at FDI 20 and above, the ember impacts are more likely to appear on the eastern side of the council areas.

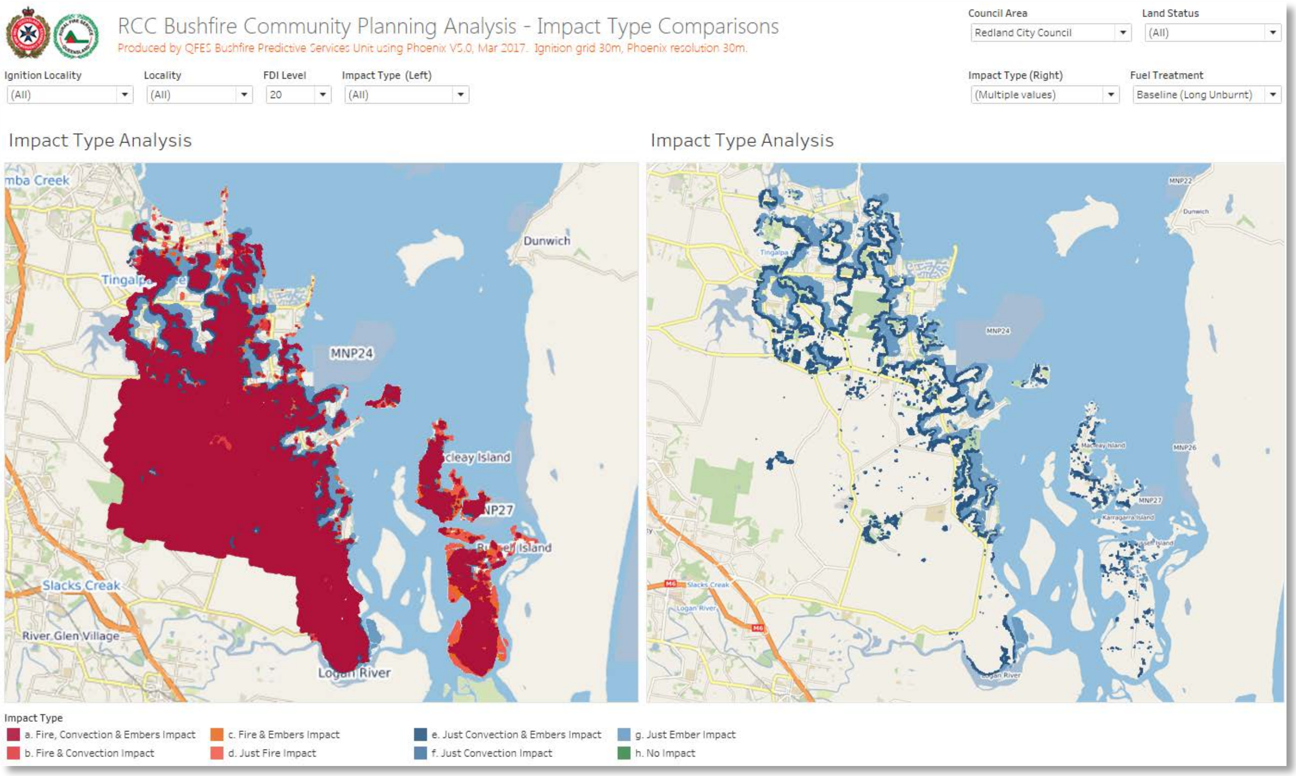


Figure 9 – Impact Type analysis tab. Both maps contain the same data, but can be filtered differently to allow comparisons between the various impact type areas.

The left image above includes all impact types, and the right image uses the same data and filters out those types containing direct fire impact to leave just areas where ember and convection impact without fire impact are indicated. This map can help with community planning and tailoring messages to the public in terms of how best to prepare their properties. These maps should not be interpreted as hyper-accurate, but rather be considered to provide broad area-based guidance only.

Average House Loss Probability and Conditional House Loss Probability

Phoenix generates an estimated probability of loss for a standard dwelling in each grid. This calculation is not dependent on a dwelling being present, but is an estimate that assumes a fire impact occurred, and if a standard dwelling was present, the resultant probability of loss under the average fire conditions calculated by Phoenix. Phoenix estimates house loss empirically, and the formula is based on examining the losses of several thousand homes in past fires where fire impacts were either known or able to be reconstructed with confidence. A more complete explanation of the Phoenix house loss calculation method can be found at Appendix C or by clicking here. There are other methods of calculating house loss probability post-process, and the Bushfire PSU will be exploring these in the future.

This analysis adjusts the Phoenix house loss probability figure to account for the relative likelihood of fire impact (mainland and SMBI NWFI). It does not simply assume an equal likelihood of impact but uses the above-described NWFI multiplied by the Phoenix house loss probability. This makes the house loss figure conditional on impact frequency within either the mainland or the SMBI areas. So it seeks to adjust the Phoenix house loss value down based on how likely fire was to affect the given grid under the conditions simulated. It is considered a more reasonable probability of loss figure for bushfire risk planning purposes. It should also be noted that these values would decrease significantly if dwellings are well prepared ahead of fire impact, and again if they are defended by their occupiers, and again if they are defended by firefighters. It should also be noted that once again, it is not appropriate to compare a conditional house loss potential score on a SMBI with that on the mainland because the NWFI is calculated separately for mainland and SMBI at this stage.

Results and Discussion

Results are presented for the SMBI and mainland areas separately.

Filtering Lower Likelihood Grids

Of all the grids (30m x 30m bocks on the landscape) that were impacted, this analysis generally filters out those with a mainland / SMBI NWFI score less than or equal to five per cent[4]. This means that those grids that were impacted the least number of times are removed because they already have a relatively low likelihood of being impacted. This approach shifts the planning focus more towards areas with greater proneness for impact, which usually implies a higher potential need for mitigation should they also have estimated dangerous fire behaviour characteristics.

SMBI

Compared to Council's mainland areas, the SMBI are much smaller land areas, bounded by ocean with less space and fuel for fires to grow large. So while dangerous fires are certainly possible, even somewhat likely on the SMBI each year at or below FDI 20, they are constrained in their potential size, but still may exhibit high intensities and present dangerous conditions for community and firefighters.

The Area by DA Success chart below shows that mitigation has positive effects at FDI 20 on all of the SMBI. Macleay and Russell Islands will be analysed in detail in the next sections.

[4] This is a subjective level and depends on the users' tolerance for risk. Removing the lesser impacted grids (i.e. <=5%) permits the focus to remain on grids estimated to be more prone to impact.

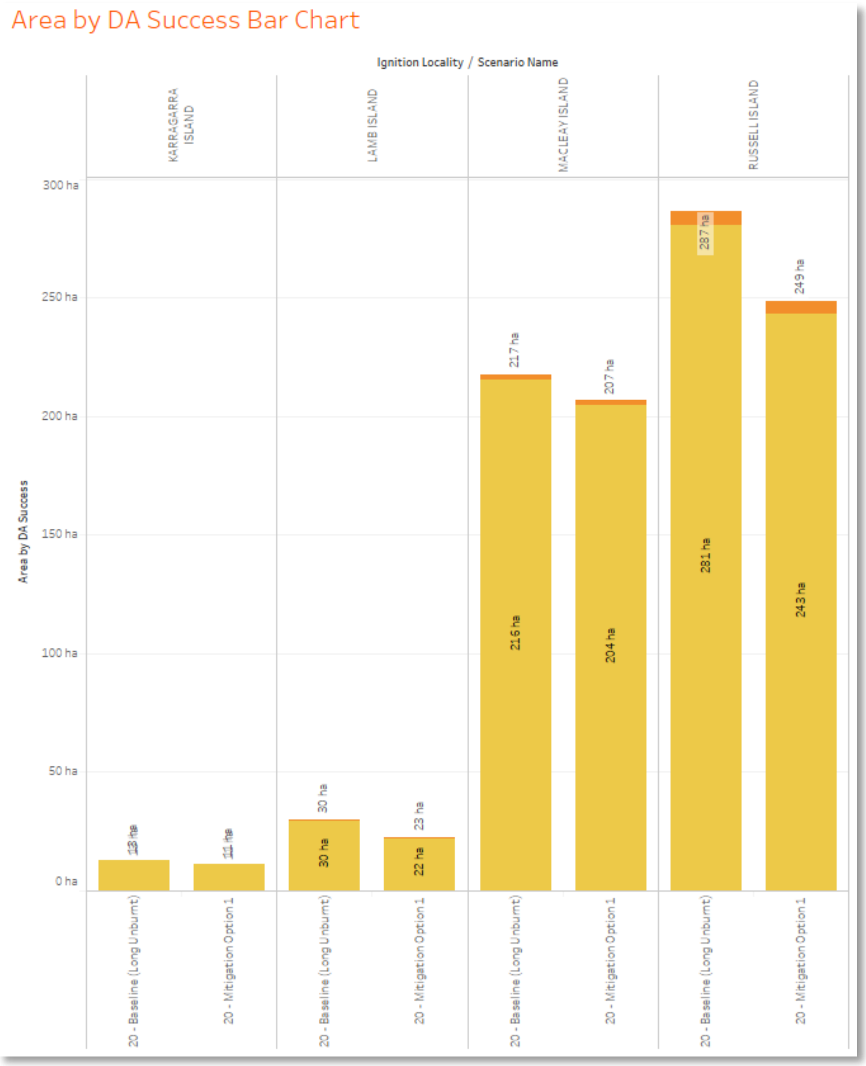


Figure 10 – Change in the area falling within DA Success categories that are considered to be beyond the safe employment of DA as a strategy. Shows benefit of mitigation compared to baseline at FDI 20.

The above chart is constrained to show just the SMBI DA Success areas at FDI 20, and compared the change in area affected between the baseline and mitigation fuel treatment options. The impact of mitigation in January 2027 is reflected in the decrease in area simulated to be beyond DA Success. It can be seen that mitigation is having a positive effect at FDI 20 (recommended planning level) in January 2027, with Russell Island showing the largest decrease in area. This is the primary metric that answers 'yes' to the stated issue of whether mitigation is effective in Scope points 1 & 2 of the project description for the recommended planning level of FDI 20. While the area beyond DA success thresholds is reduced indicating some mitigation efficacy, it is also important to identify the locations of reduction and to ensure these reduction areas are in suitable locations that make the community safer. Given the large area and complexity of this task and time constraints, the RCC SABRE site will permit Council's fire management team to undertake this type of analysis themselves.

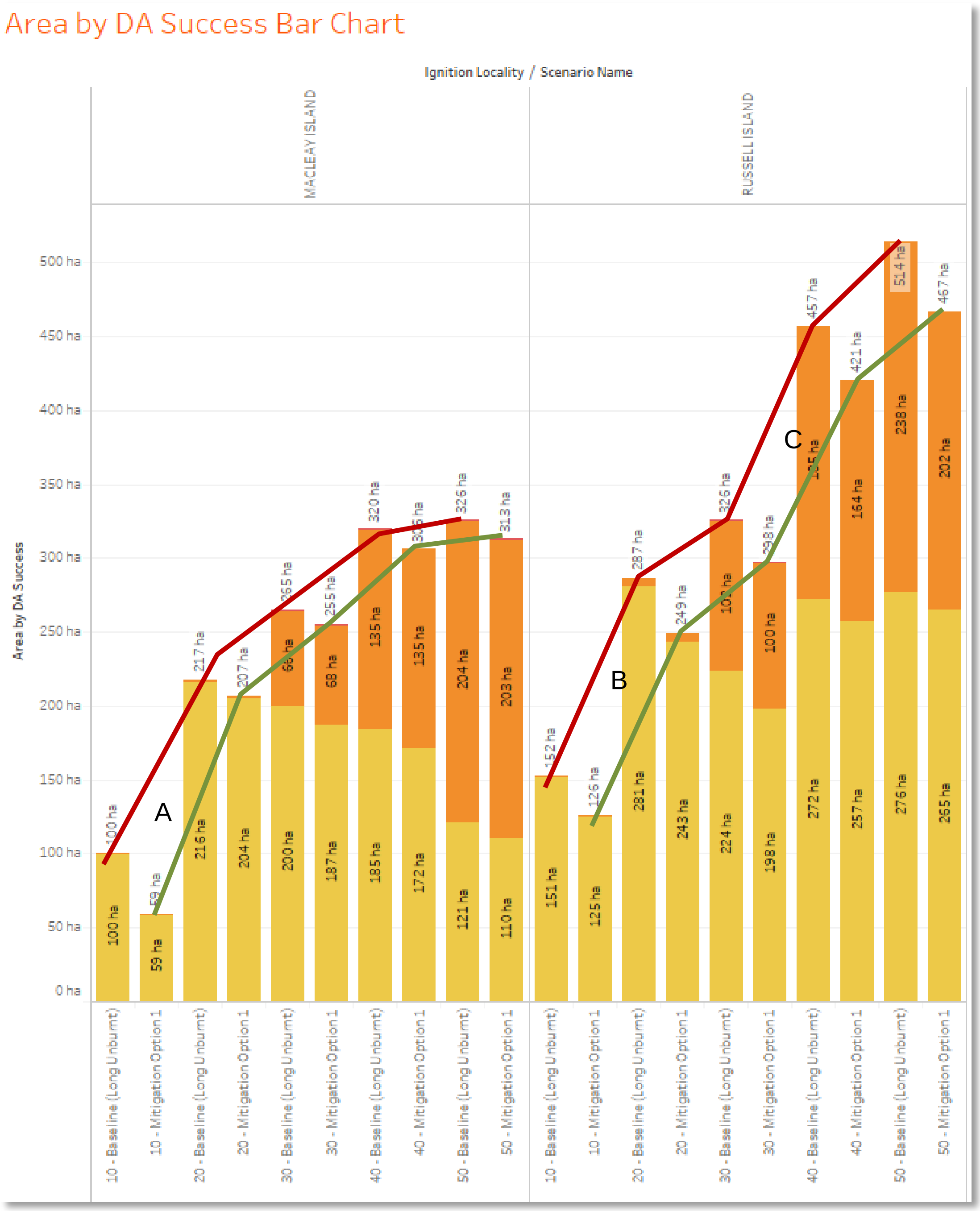


Figure 11 – SMBI DA Success areas beyond effective for Macleay and Russell Islands across all simulated FDIs.

The above chart expands on Figure 12 to include all FDI and fuel treatment options but for just Russell and Macleay Islands. This chart provides an idea of the potential impact of mitigation in January 2027 as the FDI increases. Generally speaking it is favourable to see a decrease in areas beyond DA Success thresholds between baseline and mitigated fuel options. This trend is observed across both Islands for all FDI. This is the primary metric that answers 'yes' to the stated issue of whether mitigation is effective in scope points 1 & 2 of the project description across all FDI modelled.

For Macleay Island, there appears to be a relatively large change in area affected between FDI 10 to FDI 20 (labelled A in Figure 13). This may indicate that when fire conditions exceed FDI 10, conditions on the ground could potentially become increasingly more dangerous in terms of area affected by dangerous fire as FDI increases from 10 to 20.

A similar effect is also observed on Russell Island between FDI 10 and 20 (labelled B in Figure 13), so the same conclusion also holds there. Additionally on Russell Island, there is potentially another large change between FDI 30 and 40 (labelled C in Figure 13). The causes for these changes are not discernible in this level of analysis. Generally speaking though, because Phoenix models disruptions among much else, there is potential to observe step changes in effects sometimes, i.e. up to a certain FDI, fires do not breach a given disruption or obstacle, so their area affected does not change much, perhaps growing only on the flanks with forward spread checked by the obstacle. Once that fire weather threshold is exceeded however, fires may breach the obstacle and run rapidly in new fuel blocks on the downwind side of an obstacle resulting in a step change in area affected for only a small change in FDI. While we cannot isolate particular causes in this study, it is the cumulative effects of phenomenon such as this that are most likely to cause these changes.

Macleay Island – Areas of Potential Risk at FDI 20

Macleay Island has shown a modest decrease in area beyond DA Success of 12ha in the mitigation option at FDI 20. Given the small area of Macleay Island these are hard to identify in NWFI maps below. There is a positive effect in reducing the proneness of some areas due to mitigation. Counterintuitively, there can be circumstances under which some mitigation efforts can indicate a net increase in localised risk. This can stem from changing the path over which fires develop due to fuel changes, and critically, the timing of when fires arrive in particular grids. Some mitigation efforts may slow the progress of some fires earlier in the day, meaning they can arrive under worse FDI conditions in higher fuel areas thus pushing up the average fireline intensity. Similarly, mitigation can direct more fires down particular paths, acting like an obstacle that changes the directional flow of water. This can sometimes result in local increases to the NWFI when mitigation is in place. These circumstances are not common, but can explain some locally worse areas in the mitigation option maps. Generally speaking though, there should be an overall decrease in both NWFI and areas above DA Success thresholds with mitigation in place. This circumstance can be an analytical pointer to consider expanding mitigation in that area until the resultant risk decreases.

1.1.1.1 Macleay Island – Impact Proneness

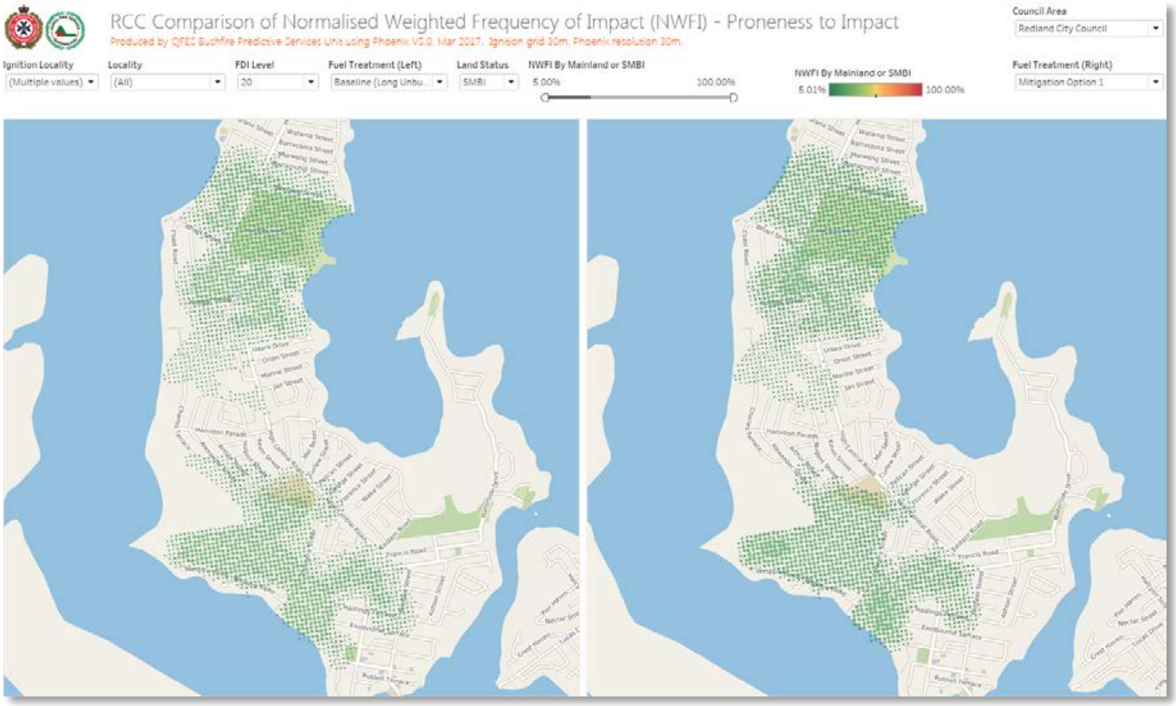


Figure 12 – Comparison of Macleay Island SMBI NWFI >5% across baseline (left map) and mitigated (right map) fuels.

While it is difficult to discern specific changes to the proneness to impact across Macleay Island at FDI 20, the above map comparing baseline to mitigation options shows a significant reduction in impact proneness in the centre of the island in built-up areas. This indicates a positive mitigation effect in these locations.

Macleay Island – DA Success

The DA Success spatial map below compares baseline to mitigation fuels at FDI 20 for Macleay Island. Generally speaking, mitigation should result in a net increase in area categorised as effective or probably effective (blue or green), having been reduced and transferred to these categories from categories beyond DA Success thresholds. In other words, mitigation aims to turn yellow and orange grids into blue and green ones. It is difficult to detect in the spatial map below, but there appears to be a modest improvement in the mitigation option at FDI 20 on Macleay Island. Shapes in green on Figure 15 below appear to show a reduction in fire behaviour, and red an increase relative to baseline.

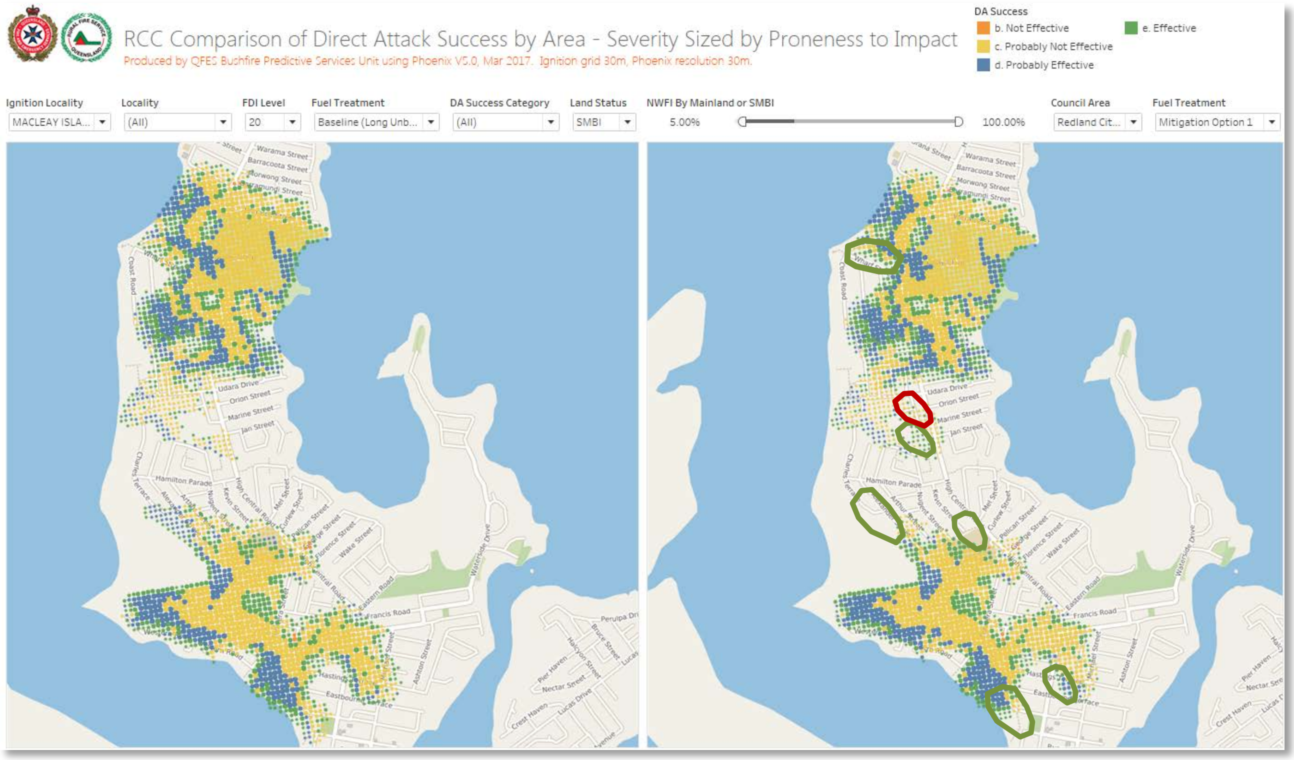


Figure 13 – Comparison of Macleay Island spatial DA Success SMBI NWFI >5% across baseline (left map) and mitigated (right map) fuels. Green circles on Mitigation map indicate areas of fire behaviour reduction, and in red indicate worsening relative to baseline.

Macleay Island – Impact Type Analysis

The below maps indicate impact type analysis on Macleay Island at FDI 20 baseline. The right side map excludes direct fire impact and leaves those not involving direct fire impact (those in blue shades). These areas indicate an increased potential for ember attack under the simulated conditions and should be considered in community education and property preparation as part of a cohesive mitigation strategy.

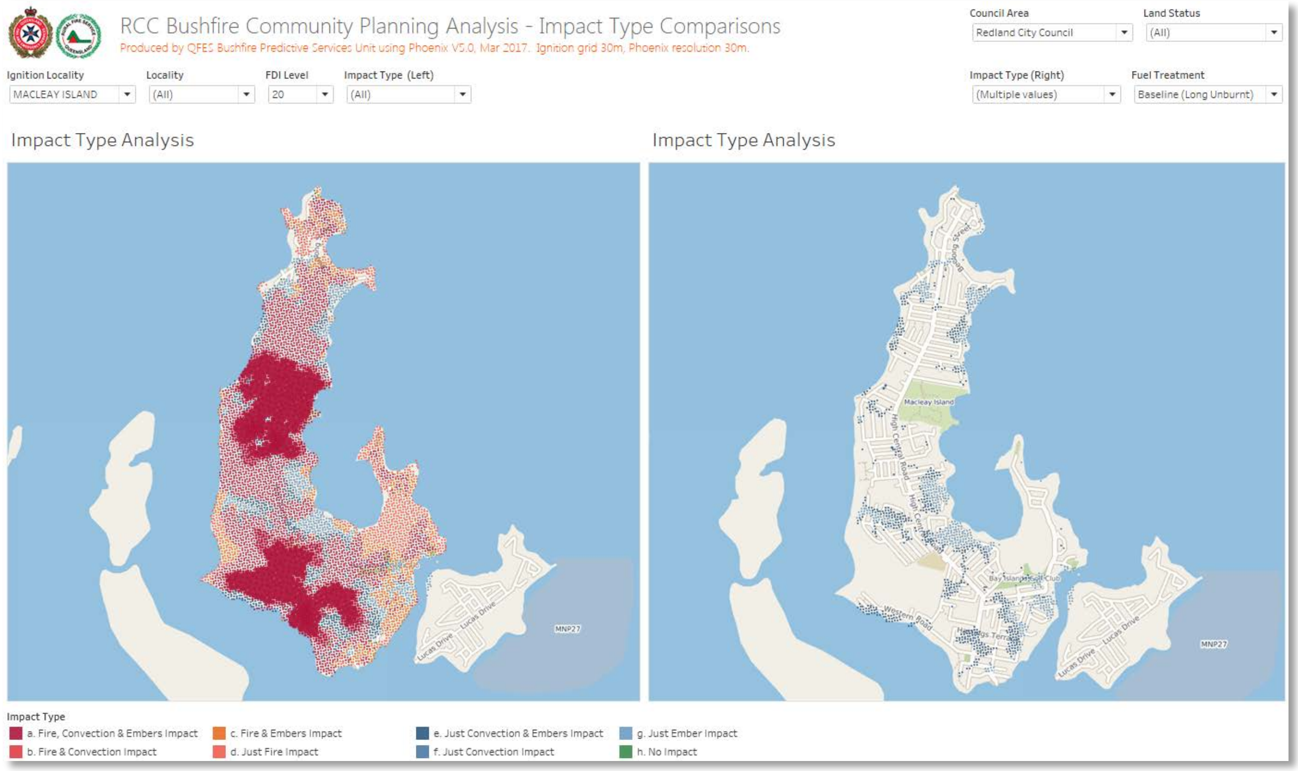


Figure 14 – Comparison of Macleay Island spatial Impact Type Analysis. All impact types shown at FDI 20 baseline (left map) and just non-fire type impacts at FDI 20 baseline (right map) fuels.

Conclusion – Macleay Island

- Mitigation in 2027 is considered likely to have a modest positive effect on increasing community safety at FDI 20.
- As FDI increases, the effects of mitigation remain positive on Macleay Island.
- There is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles).
- Largest payoff of mitigation is most likely at FDI 10 and below. The effects of mitigation, while still positive at higher FDIs are not as proportionately large.

Russell Island – Areas of Potential Risk at FDI 20

Russell Island has shown a decrease in area beyond DA Success of 38ha in the mitigation option at FDI 20. Given the small area of Russell Island these areas are hard to identify in the NWFI maps below. There is a positive effect in reducing the impact proneness of some areas due to mitigation.

Russell Island – Impact Proneness

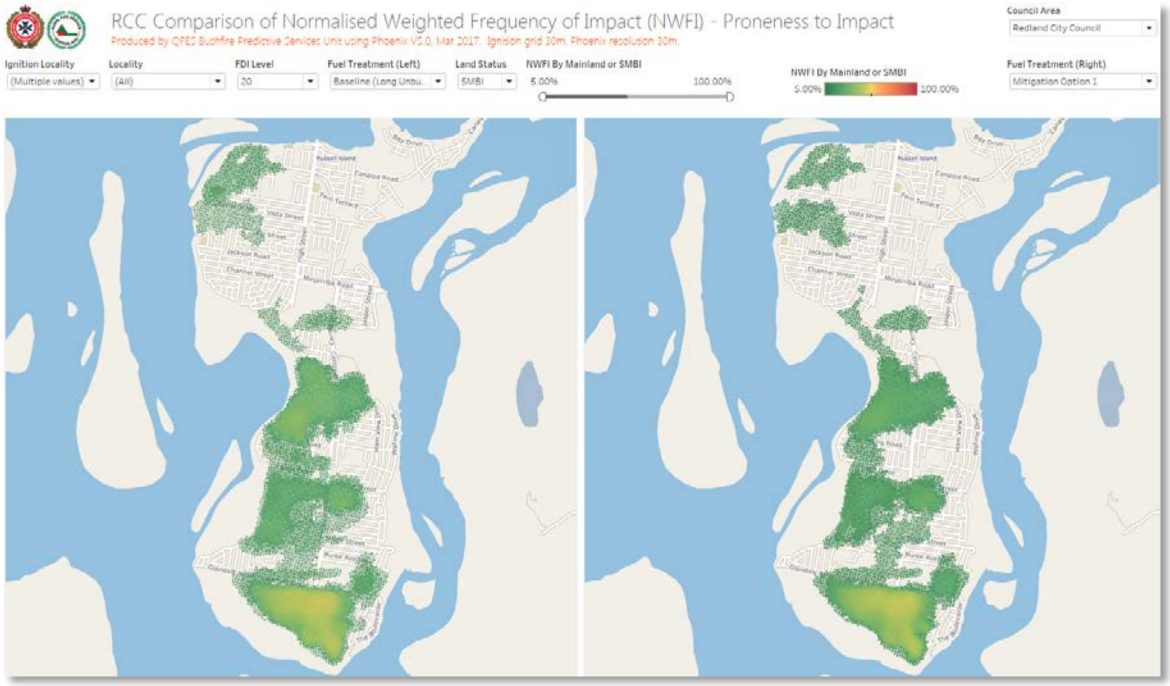


Figure 15 – Comparison of Russell Island SMBI NWFI >5% across baseline (left map) and mitigated (right map) fuels.

1.1.1.2 Russell Island – DA Success

The DA Success spatial map below compares baseline to mitigation fuels at FDI 20 for Russell Island. Generally speaking, mitigation should result in a net increase in area categorised as effective or probably effective (blue or green), having been reduced and transferred to these categories from categories beyond DA Success thresholds. In other words, mitigation aims to turn yellow and orange grids into blue and green ones. It is difficult to detect in the spatial map below, but there appears to be a modest improvement in the mitigation option at FDI 20 on Russell Island. Shapes in green on Figure 18 below appear to show a reduction in fire behaviour.

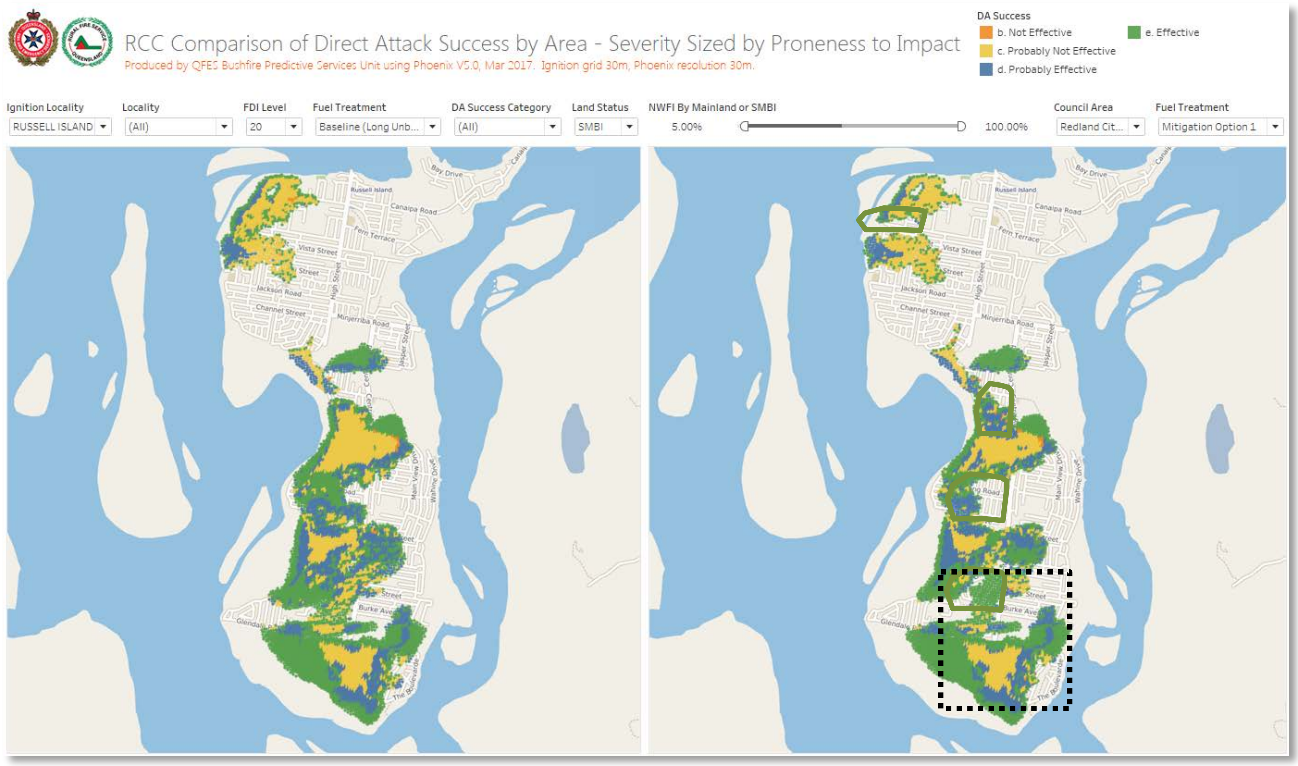


Figure 16 – Comparison of Russell Island spatial DA Success SMBI NWFI >5% across Baseline (left map) and Mitigated (right map) fuels. Green circles on Mitigation map indicate areas of fire behaviour reduction.

The reduction areas circled in green look to coincide with built-up areas and properties, so it is broadly concluded that the mitigation plan is likely to result in improving the safety of residents and properties in these areas.

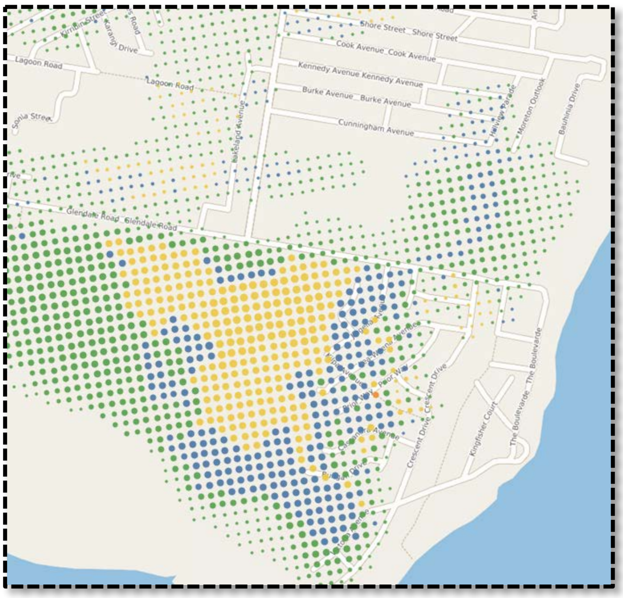


Figure 17 – Elevated risk area for residents.

The image at left indicates a potentially dangerous area for local community. Properties to the west of Crescent Drive in the Islands far south-east are potentially downwind of a large fuel block, and their only route of escape is along Glendale Road. Given FDI 20 and above mainly has winds from SW to NW, this may mean Glendale Road will possibly be impacted by thick smoke, and embers making driving conditions extremely dangerous. It will always depend on the specific fire situation, but generally speaking it may be a safer option for these residents to evacuate east towards the beach if evacuation is indicated. Council is advised to examine scenarios in this area to identify the optimal community safety approach.

Russell Island – Impact Type Analysis

The impact type analysis shown below indicates the fire impact prone areas in dark red. Where these overlay developed areas, these areas should be considered a high priority for mitigation. Additionally, it should be noted that the blue areas in the map on the right in Figure 20 below show potential for ember attack to impinge on both sides of the High Street area in the central north of the Island, and also in isolated pockets on the east of the of Island elsewhere. Developed areas where traditional fire intensity risk analysis techniques may have indicate little to no risk, may in fact be at risk of ember and convection impacts which should guide community education in a more targeted way as part of integrated mitigation planning efforts.

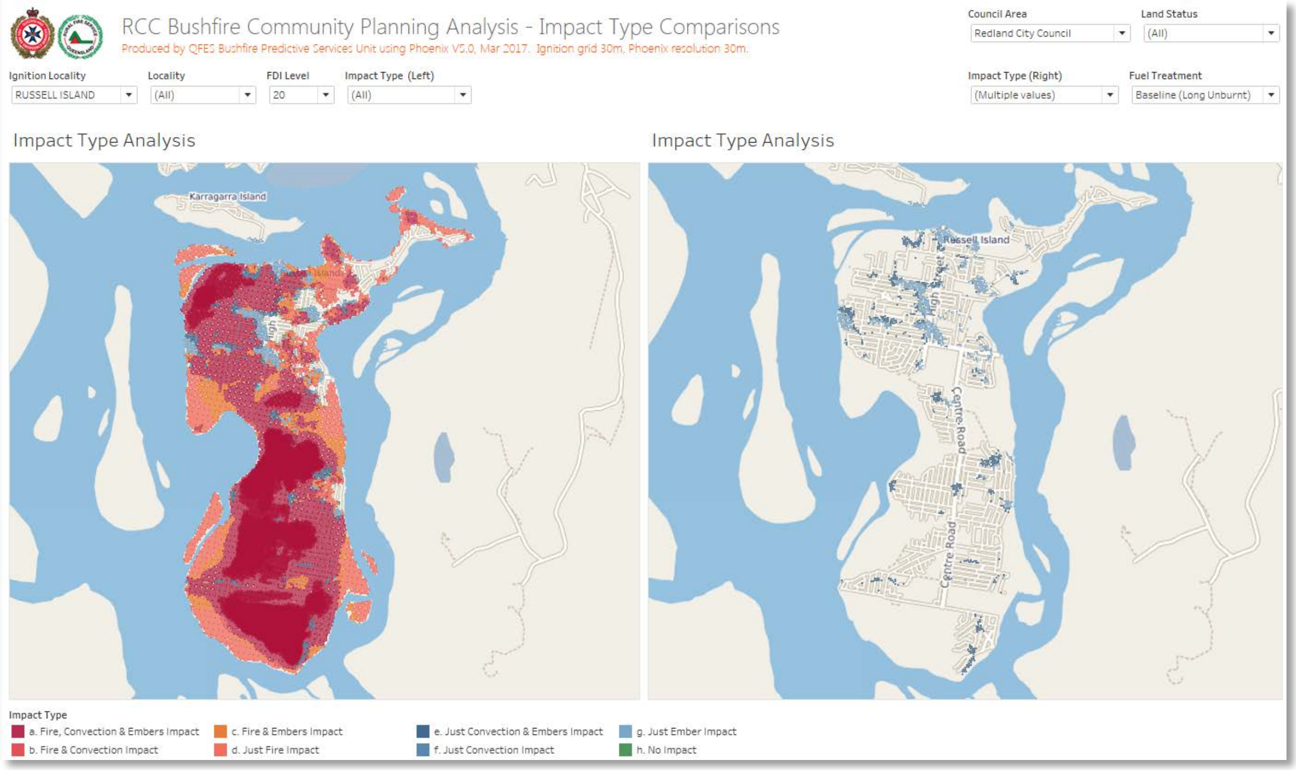


Figure 18 – Comparison of Russell Island spatial Impact Type Analysis. All impact types shown at FDI 20 baseline (left map) and just non-fire type impacts at FDI 20 baseline (right map) fuels.

Conclusions – Russell Island

- Mitigation in 2027 is considered likely to have a generally positive effect on increasing community safety at FDI 20.
- As FDI increases, the effects of mitigation remain positive on Russell Island.
- There is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles), and another between FD30 – 40 (~40 per cent increase).
- Properties in the south-east of the island are considered to be at considerable potential risk, especially if trying to evacuate up Glendale Road.

SMBI Combined Insights

SMBI Potential Ember Attack Zones as FDI Increases

The below series of maps showing just ember and convection impact types on the SMBI as a function of increasing FDI is designed to indicate roughly at which fire weather level going fires could be expected to begin transferring embers to Stradbroke Island. The analysis indicates somewhere between FDI 20 and 30 is more likely to see ember transfer to Stradbroke Island, so offers a potentially important trigger during response to fires on the SMBI to start actively observing and managing for potential fire spread to Stradbroke Island. This is not a definitive level FDI for this to occur. It may occur at lower FDI, but it is considered more likely once into the FDI 20s.

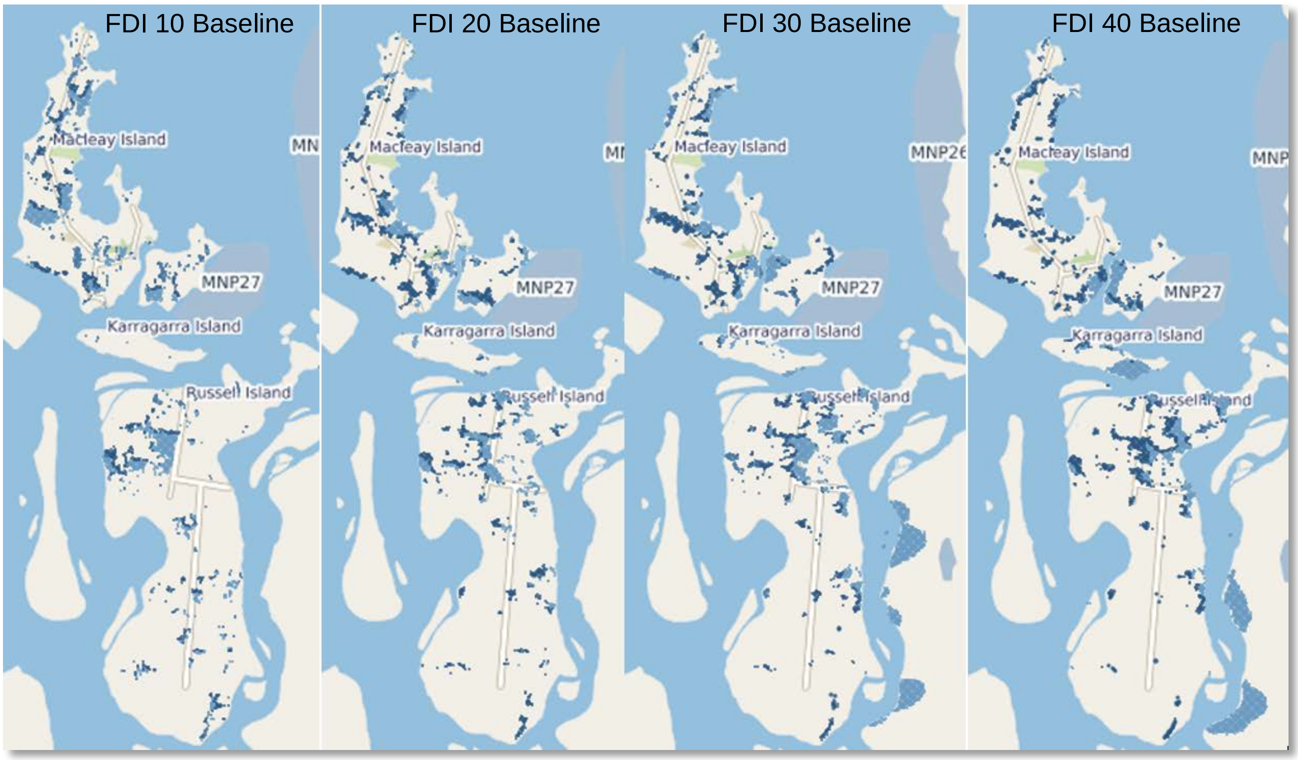


Figure 19 – Baseline ember impact analysis as FDI increases. Note ember transfer indicated somewhere between FDI 20 and 30.

From the above maps it can also be seen that on the SMBI themselves, as FDI increases, the ember attack regions tend to move further east. This is because as the westerly winds increase in speed as FDI increases, ember transport sees greater distances travelled. So this analysis can provide guidance as to which parts of the communities on the SMBI may become more prone to ember attack as FDI levels increase.

SMBI DA Success as FDI Levels Increase

The map series below shows the SMBI DA Success maps for baseline (top row) and mitigation (bottom row) with increasing FDI from left to right. It is included here to provide a quick visual guide as to the changes in expected fireline intensity areas as a function of FDI, but also to enable comparison between baseline and mitigation at each level of FDI. This series perhaps provides the most complete all round summary of severity potential across all scenarios.


Baseline (Top Row, FDI 10 to 50)
Mitigation Option 1 (Bottom Row, FDI 10 to 50)
Normalised Weighted Impact Score
5.00%
100.00%
DA Success
b. Not Effective
c. Probably Not Effective
d. Probably Effective
e. Effective
MNP26
MNP27
Karragarra Island
Russell Island

Mainland Areas

Generally speaking the mainland areas are very large, and mapping of results in such high resolution that it makes it very difficult to see visible reductions in NWFI and DA Success between baseline and mitigation options. As a result, this analysis has selected one area in Redland Bay where there appear to be reasonable mitigation reductions and explains it. The interactive RCC SABRE site is designed to enable Council's fire managers to conduct their own detailed analysis in the same vein as that presented below.

Mainland – Impact Proneness (NWFI)

The most noticeable areas where mitigation appears to reduce the NWFI on the mainland occur in Redland Bay, Mount Cotton and Alexandra Hills. Some of these are highlighted in the image below, with Redland Bay then zoomed in for the following sections to examine it more closely.

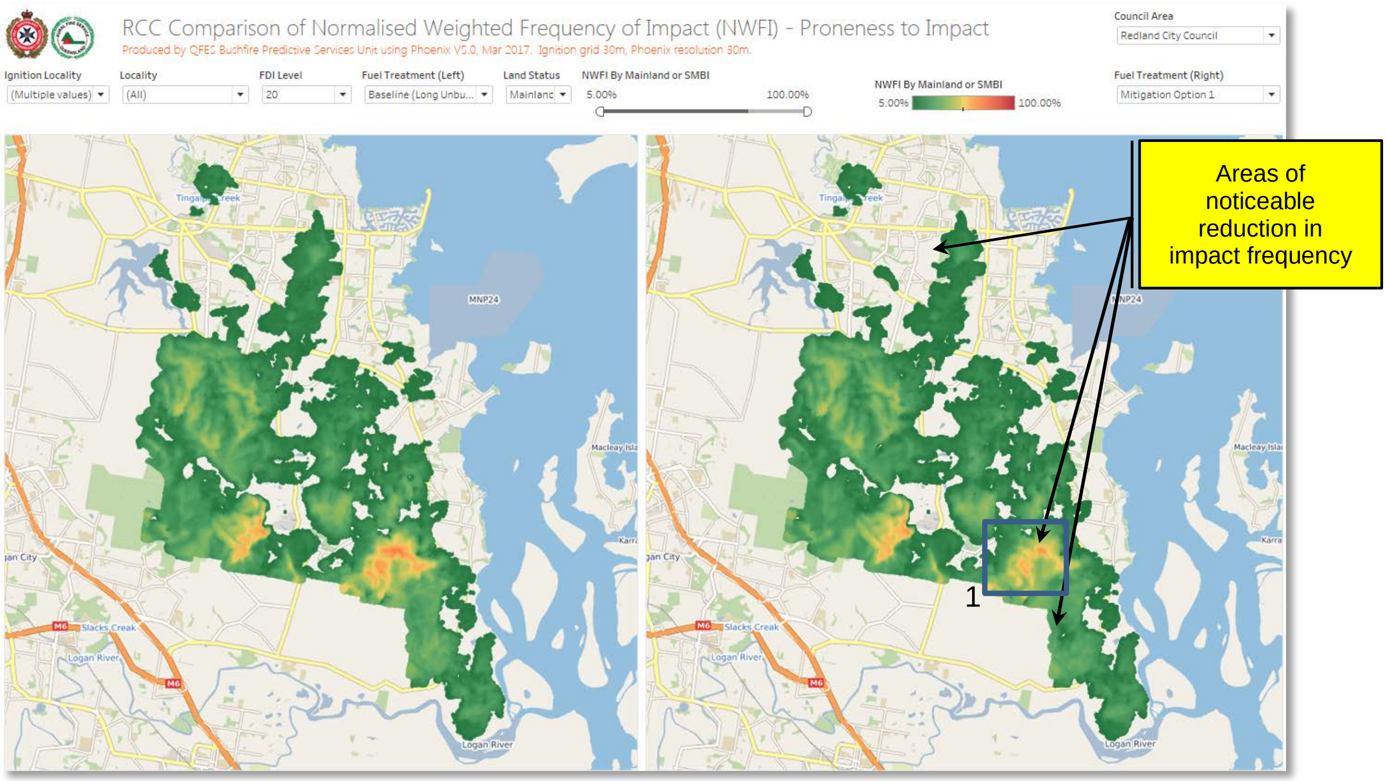


Figure 20 – Comparison of mainland NWFI >5% across baseline (left map) and mitigated (right map) fuels.

DA Success – Mainland

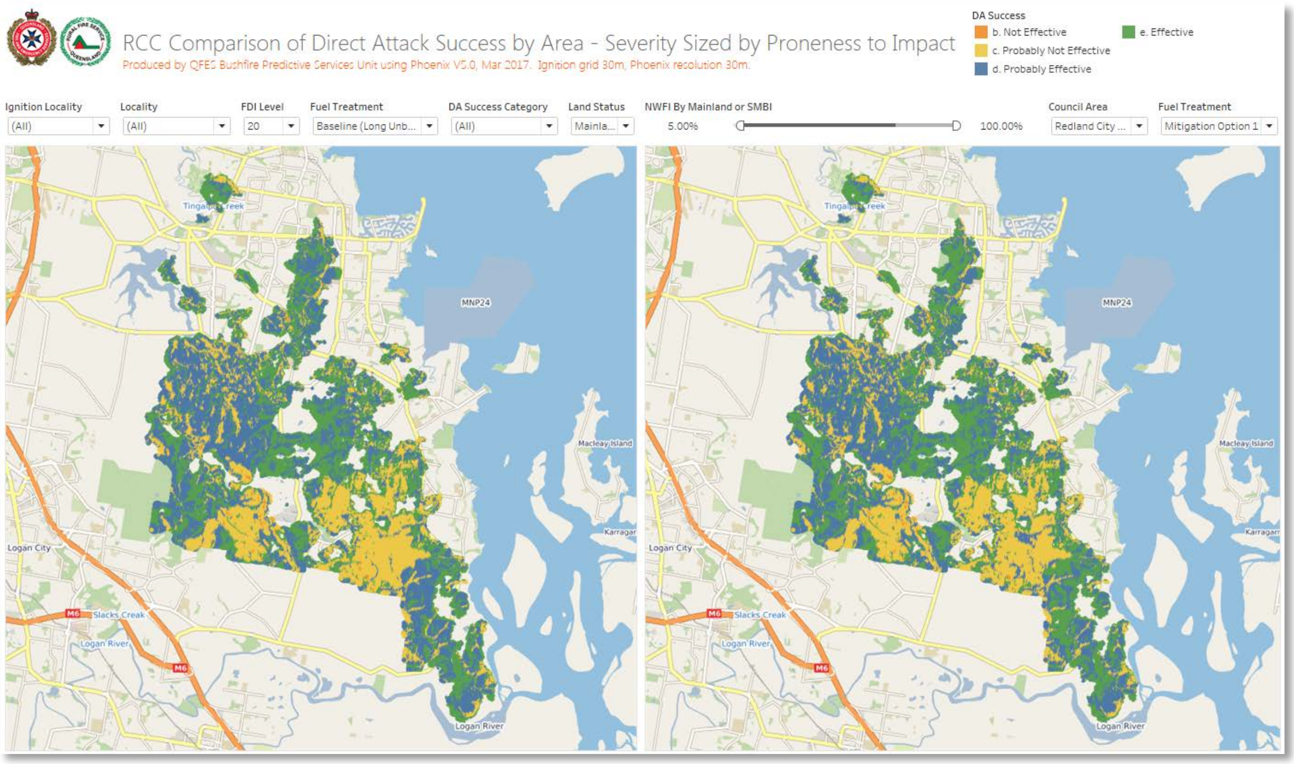


Figure 21 – Comparison of part of mainland DA Success with mainland NWFI >5% at FDI 20 across baseline (left map) and mitigated (right map) fuels.

DA Success – Redland Bay

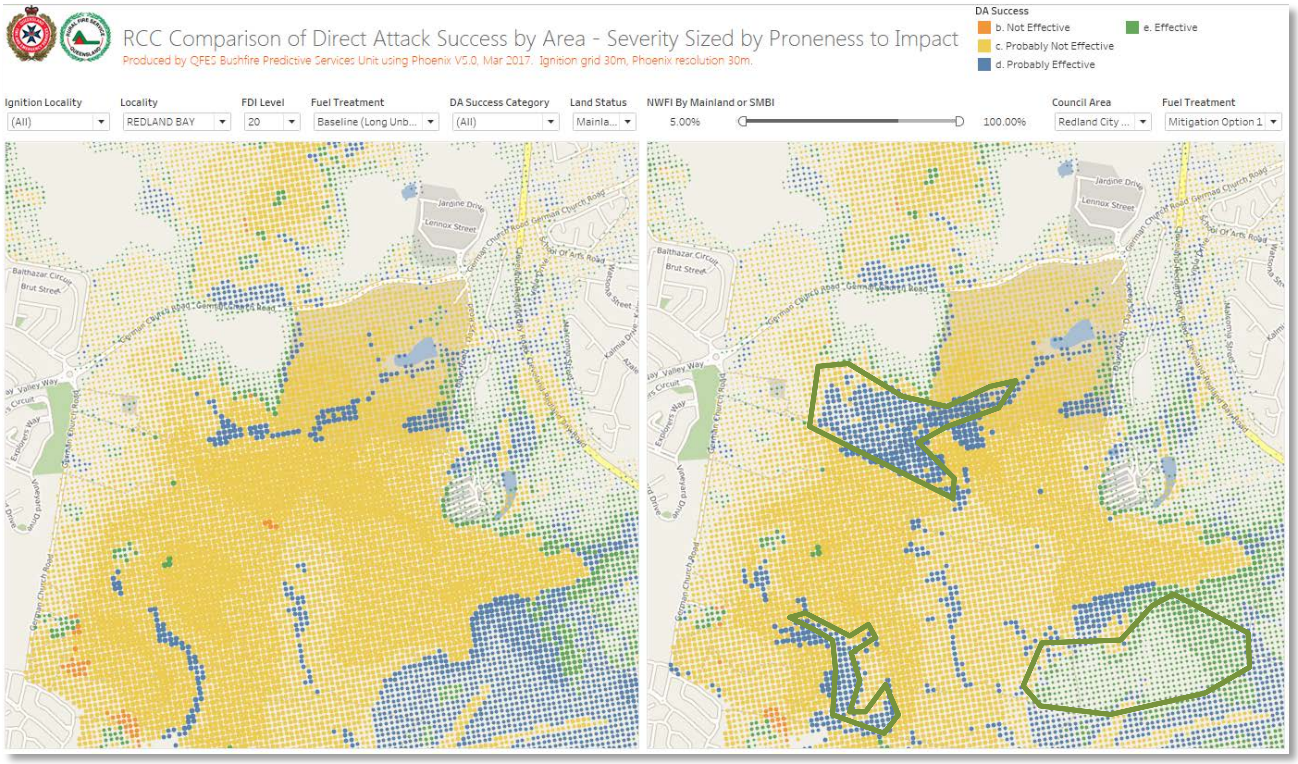


Figure 22 – Comparison of part of Redland – mainland DA Success beyond 4000kW/m and mainland NWFI >5% at FDI 20 across baseline (left map) and mitigated (right map) fuels. Maps to box 1 in **Figure 22**.Green circles on mitigation map indicate areas of fire behaviour reduction.

The above close-up of the Redland area in Figure 24 to the south of German Church Road provides a good indication of the potential positive effects of mitigation in 2027. The grids in this map are sized by mainland NWFI so there is also an indication that mitigation has reduced the proneness to impact of significant areas in the centre of this map.

Mainland – Wide Area Impact Type Analysis

The map below seeks to provide a broad indication of the areas prone to ember attack across Council's mainland localities. There is a very high percentage of the mainland areas prone to direct fire impact. What may be less obvious is the potential for ember attack towards the east of the mainland areas. This analysis indicates there is significant potential for ember attack into developed areas on the east of the mainland area. Given wind directions for FDI 20 and above come from the western quadrant, properties in the east of the mainland area are at increased risk of both smoke and ember attack given a fire occurs under these conditions. Similar to Figure 21 showing the change in ember attack patterns as a function of FDI, it is recommended Council conduct a similar analysis once the mainland results above FDI 30 are posted to the RCC SABRE site. This will provide valuable information as to the potential for ember attack extent as FDI rises.

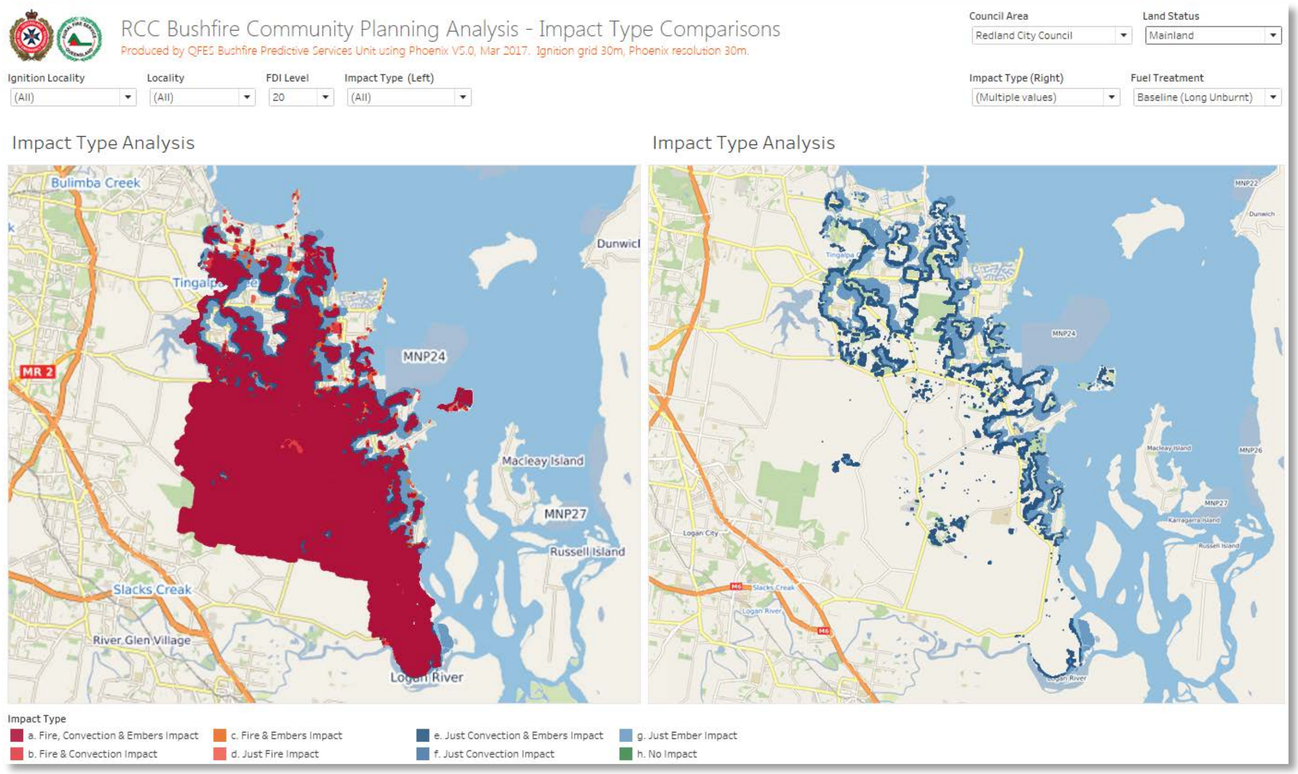


Figure 23 – Comparison of mainland area spatial Impact Type Analysis. All impact types shown at FDI 20 baseline (left map) and just non-fire type impacts at FDI 20 baseline (right map) fuels.

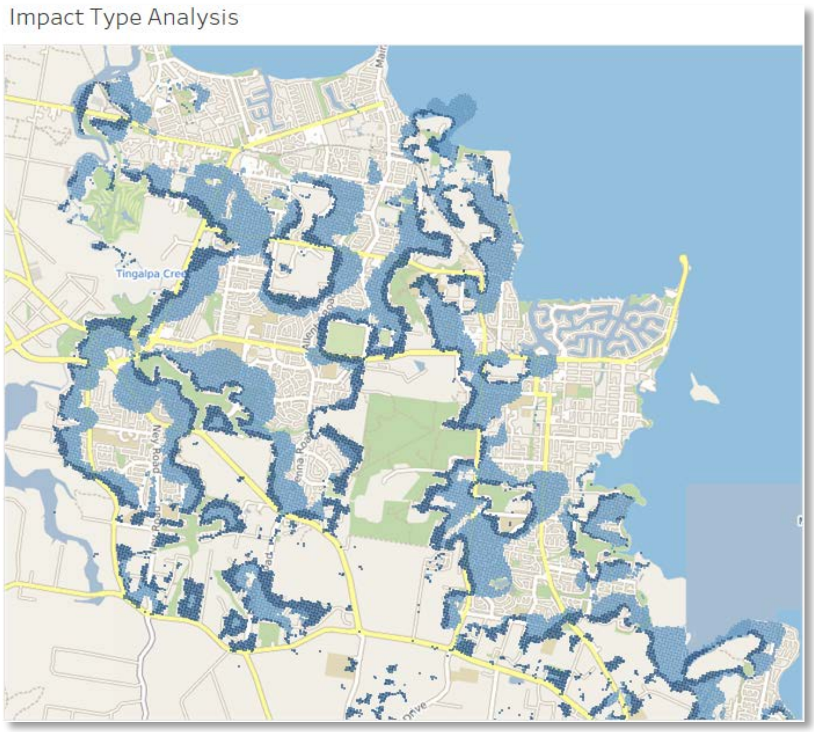


Figure 24 – Example of zoomed in ember impingement into developed areas at baseline FDI 20 in the northern areas of mainland.

The above map is included to provide a general guide to the potential extent of ember and convection impact into urbanised and developed areas that can be broadly expected at FDI 20. It is important the user bears in mind that these areas on the maps can give the perception of being precise, but they should be considered general and may be larger or smaller. The conclusion is that ember extent should be considered as part of Council's mitigation planning in addition to more traditional fireline intensity analysis.

Conclusions – Mainland

The table below summarises the change in hectares above an average of 4000 kW/m between baseline and mitigation. This is the most direct statistic to answer the question of efficacy of mitigation at January 2027. Negative numbers in the table indicate a good result, i.e. there has been a reduction in area beyond which DA is likely to be effective at FDI 20. Redland Bay and Mount Cotton appear to be the most positively impacted localities for the proposed mitigation plan. Given these reduction values are absolute, and some localities are much larger in land area than others, a proper analysis requires these values to be expressed as a percentage of the localities' burnable area to rank them properly. This is beyond the scope of this analysis, so absolute numbers will be used as the primary measure.

	Scenario Name	
Ignition Locality	20 - Baseline (Long Unburnt)	20 - Mitigation Option 1
REDLAND BAY		-72 ha
MOUNT COTTON		-18 ha
ALEXANDRA HILLS		-9 ha
WELLINGTON POINT		-9 ha
SHELDON		-8 ha
VICTORIA POINT		-8 ha
THORNLANDS		-7 ha
BIRKDALE		-5 ha
COOCHIEMUDLO ISLAND		-2 ha
CAPALABA		-2 ha
ORMISTON		-1 ha
PRIESTDALE		-1 ha
CLEVELAND		-1 ha
ROCHEDALE SOUTH		-1 ha

Figure 25 – Ranked summary of mitigated area between baseline and mitigation options at FDI 20 for mainland localities. Those with no change are not shown. Negative numbers indicate a reduction in area beyond DA Success thresholds.

Conclusion and Recommendations

General

FDI 20 level is recommended for general bushfire risk decision-making as to the efficacy of planned mitigation efforts. Sufficient mitigation effects achieved at this level are concluded to represent a reasonable balance of resource expenditure and payoff. The question around whether Council considers the improvements shown above in Figure 27 sufficient to improve community safety is a choice for Council.

Consideration of Embers and Convection in Bushfire Risk

A broad conclusion from this analysis is to consider that fireline intensity mapping is not sufficient to appreciate and mitigate bushfire risk. This study shows the potential for significant ember attack to penetrate significant distances into developed and urban areas that are far removed from large fuel blocks. While the specific risk of house loss in these areas remains low, a confluence of conditions involving strong winds, an aggressive fire upwind in spotty fuel types, etc. could cause smoke and ember problems well outside those areas normally considered to be at risk of bushfire. While some residents on the coast of mainland areas may feel they are at no risk in the event of a fire in the council area, this may not be the case. At the very least, residents should be made aware that embers may be a problem in the event of a large fire under conditions beyond FDI 20.

SMBI Conclusions and Recommendations

Mitigation Effects at FDI 20 in January 2027

Mitigation in 2027 is considered likely to have a generally positive effect on increasing community safety at FDI 20 on Russell and Macleay Islands.

It is concluded that the quantified effectiveness of Council's proposed bushfire mitigation plans for Russell Island is estimated to yield an estimated 13 per cent reduction in area falling beyond direct attack thresholds at the recommended planning level of FDI 20, with benefits likely continuing to lesser degrees (averaging about eight per cent reduction) up to FDI 50, but with increasing uncertainty.

It is concluded that the quantified effectiveness of Council's proposed bushfire mitigation plans for Macleay Island is estimated to yield an estimated five per cent reduction in area falling beyond direct attack thresholds at the recommended planning level of FDI 20, with benefits likely continuing to similar degrees (averaging about four to five per cent reduction) up to FDI 50, but with increasing uncertainty.

Lamb and Karragarra Islands are too small to draw meaningful conclusions from an analysis at this resolution.

Increase in Area Affected as FDI Increases

As FDI increases, the effects of mitigation remain positive on Russell and Macleay Islands. On Russell Island there is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles), and another between FD30 – 40 (~40 per cent increase). This indicates the potential for dangerous fires on Russell Island at relatively low FDIs.

On Macleay Island there is potentially a disproportionate step change in area covered by area beyond DA Success between FDI 10 – 20 (area almost doubles). Again, this indicates the potential for dangerous fires on Russell Island at relatively low FDIs.

Consideration of more frequent smaller mitigation activities that cumulatively reduce more fuels in dangerous areas more often may assist in further reducing risk as FDI increases above 10.

Potentially Dangerous Locations – Russell Island

While fire can pose serious danger anywhere on the SMBI where there sufficient is fuel, this analysis has identified that properties in the south-east corner of Russell Island are at potentially elevated risk. It appears this area has a single evacuation route (Glendale Road) which runs east-west. In the event of dangerous fires to the west of these properties, such fires are more likely to be driven by SW to W winds. If residents choose to evacuate down this route, they may be heading into the fire's path, and smoke and embers may make this extremely dangerous. There may be other pockets on the SMBI where these sorts conditions exist, but the time frame for this analysis did not enable a thorough examination of them.

It is recommended that a detailed fuel management plan be considered to create a buffer zone to the west of this area and along the southern side of Glendale Road, and that residents are encouraged to apply their judgement and consider pre-emptive relocation during conditions above about FDI 20.

Transfer to Stradbroke Island

As FDI increases, it was observed that fires on Russell Island exhibit ember transfer to Stradbroke Island between FDI 20 and 30. It is advised that if fires do occur on Russell Island, particularly in the south under such conditions (westerly winds), arrangements be made to monitor and rapidly respond to spot fires appearing on Stradbroke Island. Failure to do this increases the potential for a multi-island fire scenario, and once on Stradbroke Island, fires can escalate quickly into a major incident.

Mainland Conclusions and Recommendations

Mitigation Effects at FDI 20 in January 2027

Mitigation in 2027 is considered likely to have a generally positive effect on increasing community safety at FDI 20 on the mainland, predominantly in Redland Bay and Mount Cotton areas, with lesser effect across other localities. There were a significant number of other localities showing no reduction in risk. These can all be found in Figure 27.

Self-Directed Analysis

It is recommended that Council uses the RCC SABRE site created for this study to undertake its own detailed analysis of the mainland area. Due to time and budget constraints, the bulk of the project time was spent preparing mainland data, running scenarios and testing results, then re-running if needed. Council analysts can proceed locality by locality through the mainland areas across the NWFI, DA Success and Impact Type Analysis overlays and draw deeper conclusions that can guide future Council approaches to mitigation.

Property Level Change in Risk Using House Loss Potential

The Phoenix results data has been intersected with substantial property level data provided by Council. This has permitted a property level risk analysis tab to be created in the RCC SABRE site. It permits a very detailed examination of the mitigation effects modelled at the property level. An example of this capability is shown below.

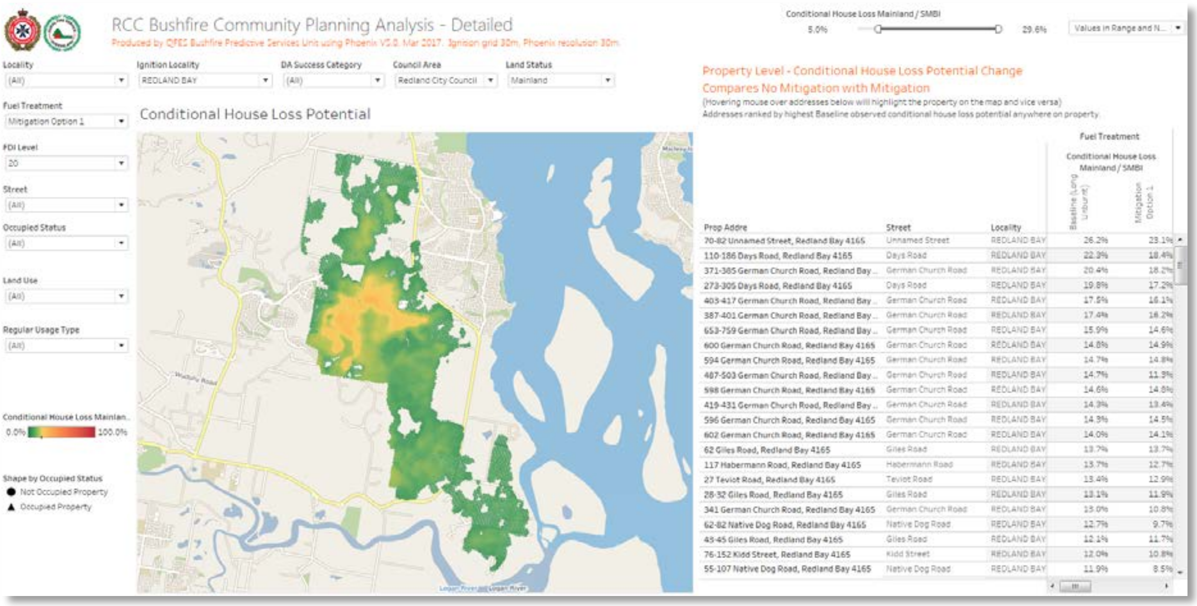


Figure 26 – Detailed community planning analysis tab in the RCC SABRE site showing Redland Bay at FDI 20.

General Recommendations

Recommendation – Dynamic Annual Mitigation Area Identification and Prioritisation

One of the benefits of a repeatable and consistent simulation-based approach to bushfire risk analysis is it can be updated regularly with the latest fire scar history, fuel maps, disruptions, etc. The QFES PSU can rerun the high-resolution RCC gridded analysis in about March each year so as to include the prior seasons fire scar history, completed hazard burns, mechanically cleared breaks, etc. Then to identify the highest-priority areas for mitigation action before the coming season, we assume no mitigation from March, then run the simulator in October of that year with accumulated fuel growth over the non-fire season months. The areas with highest NWFI and intensity that are proximal to high-value areas become the places to focus on mitigation for the upcoming season. Then in about August, we update what mitigation was actually conducted, and run it again as if it were October to indicate estimate the residual risk areas for the upcoming season. This dynamic approach removes the need to try to schedule 10-year mitigation programs, and instead guides the next season's mitigation based on current landscape risk.

The QFES PSU recommends Council considers the above approach annually to better target each year's mitigation efforts based on such quantitative analysis.

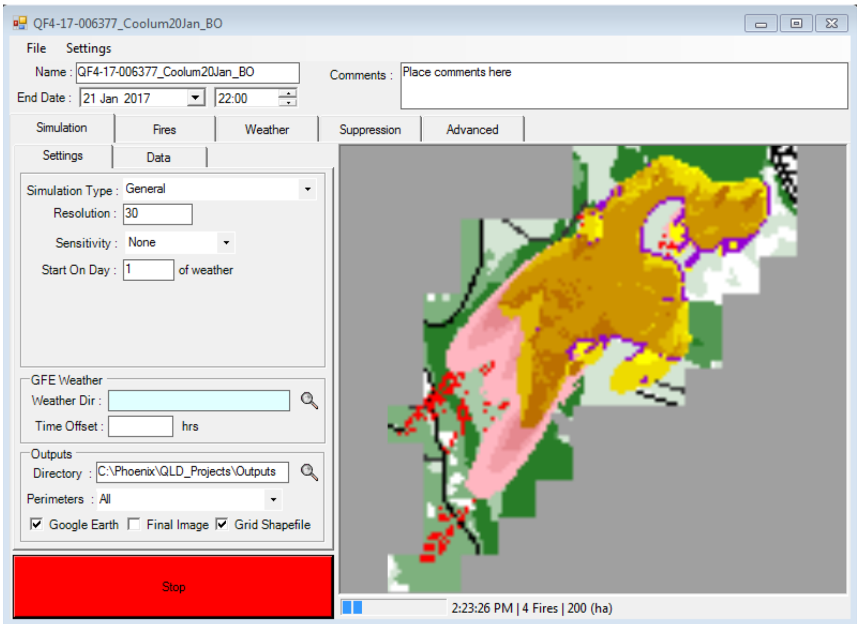
End of Main Report

Appendix A – Phoenix

Phoenix is a fire spread simulation tool, developed and funded by Melbourne University, Department of Environment Land and Water Planning (DELWP) Victoria and the Bushfire CRC used operationally across most States in Australia. It has undergone, and continues to undergo significant scientific and operational validation and has been shown to be a very good predictor of fire spread in Queensland when fed high-quality data. The QFES Bushfire PSU has developed nationally recognised expertise in this tool. Its prediction quality also stems from the number and quality of internal models used in Phoenix to represent various parts of fire behaviour and how they interact. These models include:

Internal Phoenix Models

1. Rate of Spread Models ((modified) McArthur Mk5, CSIRO Grass)
2. Spotting and embers (in-draft, ember transport & distribution, secondary ignitions)
3. Digital Terrain Model (15m grid resolution terrain elevation)
4. Slope Correction (wind-slope interaction)
5. Wind Field Modifiers (corrects wind direction for terrain and other surface effects)
6. Road, River Bank and Break Impacts (fuel free linear disruptors to surface fire spread)
7. Solar Radiation Model (Fuel Moisture in space (aspect) and time)
8. Fuel / Fuel Accumulation (vegetation type, time since last fire, fuel regrowth rates by layer)
9. Fuel Moisture (time, date, cloud cover, latitude)
10. Convection / Heat Centres (heat output, extent, feedback into spotting)
11. Point spread Modelling of fire propagation and growth
12. Self-extinction (fires go out below 120kW/m as a function of fuel load, fuel moisture, topography etc.)
13. Spot Fires (ember density, ignition probability, build-up, coalescence)
14. House loss / Vulnerability



Gridded Ignitions Mode Explained

Phoenix can operate in several different modes to facilitate the aim of the tool in supporting both research efforts to characterise bushfire development and behaviour and also to support specific operational fire predictions of a working fire.

The gridded analysis mode is used in this analysis. It is useful for quantifying large areas of land in terms of average bushfire behaviour that can be expected under defined conditions. Rather than a single fire, which requires a defined point of ignition, the gridded mode lights many fires equally spaced in a grid across the area of interest. Each fire is allowed to develop independently. In other words even though potentially many thousands of fires may be ignited, none of these fires 'knows' about or interacts with any of the others. Once all of these fire have been allowed to propagate, every grid on the landscape counts the number of times any fire impacted it, the impact type (fire, convection, embers or combinations therein) and average fireline intensity, convective strength, flame height, etc.

Based on this information each grid on the landscape can be weighted by the number of times it was impacted by fire. Those grids with higher numbers of impacts indicate areas on the landscape that are more prone to fire impact irrespective of ignition point. These areas are considered at greater risk (likelihood) of being affected by fire under the conditions modelled. While not providing a precise measure of absolute risk across the landscape, it is a very useful method for quantifying relative risk of impact between locations under the defined conditions, and to gain an idea of the average fire behaviour metrics at that location given an impact were to occur.

Appendix B – Detailed Daily Weather Stream Data Used in Simulations

1.2 FDI 20 Selected Date and Weather Stream

Date Time	Temp (C)	Rh (%)	Wind Dir	Wind (km h)	Drought Factor	Generated FFDI
8/09/2009 11:00	23.5	46	250	9	9.1	6
8/09/2009 11:30	24.6	36	210	8	9.1	9
8/09/2009 12:00	25.5	30	220	8	9.1	11
8/09/2009 12:30	25.5	23	260	17	9.1	18
8/09/2009 13:00	25.8	29	280	17	9.1	15
8/09/2009 13:30	26.4	24	270	18	9.1	18
8/09/2009 14:00	25.6	17	230	13	9.1	20
8/09/2009 14:30	26.9	19	230	11	9.1	19
8/09/2009 15:00	27	20	230	11	9.1	18
8/09/2009 15:30	26.8	18	240	13	9.1	20
8/09/2009 16:00	25.3	19	270	15	9.1	20
8/09/2009 16:30	25	19	260	11	9.1	18
8/09/2009 17:00	24	23	260	5	9.1	13
8/09/2009 17:30	21.5	54	60	11	9.1	5
8/09/2009 18:00	21.2	56	40	9	9.1	4
8/09/2009 18:30	20.7	57	40	8	9.1	4
8/09/2009 19:00	19.9	60	60	4	9.1	3

Sea Breeze From ~1700hr

1.3 FDI 30 Selected Date and Weather Stream

Time (copy)	Temp (C)	Rh (%)	Wind Dir	Wind (km h)	Drought Factor	Curing	Cloud	Generated FFDI
17/08/2001 11:00	23.9	28	280	18	10	80	0	16
17/08/2001 11:30	24.1	27	270	26	10	80	0	20
17/08/2001 11:32	23.6	26	270	28	10	80	0	22
17/08/2001 12:00	24.1	28	260	22	10	80	0	18
17/08/2001 12:30	24.1	30	260	22	10	80	0	17
17/08/2001 13:00	24.2	32	270	26	10	80	0	17
17/08/2001 13:30	24.5	32	270	30	10	80	0	19
17/08/2001 14:00	25.4	30	270	21	10	80	0	17
17/08/2001 14:30	24.8	26	260	26	10	80	0	21
17/08/2001 14:34	24.3	24	260	28	10	80	0	24
17/08/2001 14:53	24	21	260	28	10	80	0	26
17/08/2001 15:30	23.7	18	260	21	10	80	0	24
17/08/2001 16:00	22.7	14	260	26	10	80	0	30
17/08/2001 16:30	22	15	260	26	10	80	0	29
17/08/2001 17:00	21.2	14	260	21	10	80	0	26
17/08/2001 17:30	20.1	17	270	18	10	80	0	21
17/08/2001 18:00	19.2	19	260	15	10	80	0	17

17/08/2001 18:30	18.7	21	270	15	10	80	0	16
17/08/2001 19:00	18.4	23	260	15	10	80	0	15

1.4 FDI 40 Selected Date and Weather Stream

Time (copy)	Temp (C)	Rh (%)	Wind Dir	Wind (km h)	Drought Factor	Curing	Cloud Cover	Generated FFDI
7/09/2003 11:00	23.8	28	320	18	10	80	0	16
7/09/2003 12:00	27	21	340	17	10	80	0	22
7/09/2003 13:00	29.4	13	310	13	10	80	0	29
7/09/2003 14:00	29.5	9	290	21	10	80	0	40
7/09/2003 15:00	30.1	9	290	17	10	80	0	37
7/09/2003 16:00	29.7	9	270	18	10	80	0	38
7/09/2003 17:00	28.2	14	240	13	10	80	0	27
7/09/2003 17:51	23	21	240	8	10	80	0	16
7/09/2003 18:43	18	32	350	2	10	80	0	8
7/09/2003 19:00	17.8	32	0	0	10	80	0	7

Sea Breeze From ~1845hr

1.5 FDI 50 Selected Date and Weather Stream

Time (copy)	Temp (C)	Rh (%)	Wind Dir	Wind (km h)	Drought Factor	Curing	Cloud	Generated FFDI
1/10/2000 11:30	31.9	31	280	13	10	80	0	17
1/10/2000 12:00	32.9	26	290	18	10	80	0	23
1/10/2000 12:30	33.3	27	290	13	10	80	0	20
1/10/2000 13:00	34	21	270	15	10	80	0	27
1/10/2000 13:30	34.8	12	260	18	10	80	0	40
1/10/2000 14:00	35.2	10	250	18	10	80	0	44
1/10/2000 14:30	35	10	260	21	10	80	0	47
1/10/2000 15:00	34.3	9	260	22	10	80	0	48
1/10/2000 15:30	34.1	9	270	24	10	80	0	50
1/10/2000 16:00	34	9	240	18	10	80	0	44
1/10/2000 16:30	33	10	270	21	10	80	0	44
1/10/2000 17:00	32.5	10	250	21	10	80	0	43
1/10/2000 17:30	31.7	11	260	18	10	80	0	38
1/10/2000 18:00	30.4	12	260	13	10	80	0	31
1/10/2000 18:30	29.4	13	250	11	10	80	0	28
1/10/2000 19:00	28.5	14	260	9	10	80	0	25

2 Appendix C – Vegetation Fuel Load Adjustments

Phoenix Fuels – QFES Standard Loading			Fuel Load (t/ha)			Total
No.	Description	WRF	Surface	Elevated	Bark	Load
3	Wet eucalypt tall open forest	3	24.1	2	1.5	27.6
5	Moist to dry eucalypt open forests on coastal lowlands and ranges	3.5	20.9	2.1	1	24
28	Melaleuca open forests on seasonally inundated lowland coastal swamps	3	7.9	3	2	12.9
41	Shrublands / Woodlands in coastal locations	2.5	2.8	2.5	1	6.2
45	Woodlands / Heathlands associated scrubs and shrublands	2.5	2.7	7.5	0	10.2
46	Grassland / Sedgeland communities associated with heathlands, scrubs and shrublands	2	1.3	3.5	0	4.7
55	Mangroves / Sedgeland dominated wetlands and tidal saltmarshes	2.5	1.7	0.2	0	1.9
59	Low to moderate tree cover in built-up areas	2	0.6	2	1	3.6

Phoenix Fuels – Russell Island – Adjusted			Fuel Load (t/ha)			Total
No.	Description	WRF	Surface	Elevated	Bark	Load
3	Wet eucalypt tall open forest	3	23	3	1.9	27.9
5	Moist to dry eucalypt open forests on coastal lowlands and ranges	3.5	11.6	2.4	2.2	16.2
28	Melaleuca open forests on seasonally inundated lowland coastal swamps	3	18.4	3.7	2.5	24.6
41	Shrublands / Woodlands in coastal locations	2.5	17	2.5	2	21.5
45	Woodlands / Heathlands associated scrubs and shrublands	2.5	24.1	2	2.1	28.2
46	Grassland / Sedgeland communities associated with heathlands, scrubs and shrublands	2	21.6	4.5	2	28.1
55	Mangroves / Sedgeland dominated wetlands and tidal saltmarshes	2.5	0.9	0.2	0	1.1
59	Low to moderate tree cover in built-up areas	2	21.5	3	1	25.5

Phoenix Fuels – Macleay Island – Adjusted			Fuel Load (t/ha)			Total
No.	Description	WRF	Surface	Elevated	Bark	Load

3	Wet eucalypt tall open forest	3	23	3	1.9	27.9
5	Moist to dry eucalypt open forests on coastal lowlands and ranges	3.5	23.8	2.1	1.2	27.1
28	Melaleuca open forests on seasonally inundated lowland coastal swamps	3	24.1	2.9	1	28
41	Shrublands / Woodlands in coastal locations	2.5	17	2.5	2	21.5
45	Woodlands / Heathlands associated scrubs and shrublands	2.5	24.1	2	2.1	28.2
46	Grassland / Sedgeland communities associated with heathlands, scrubs and shrublands	2	21.6	4.5	2	28.1
55	Mangroves / Sedgeland dominated wetlands and tidal saltmarshes	2.5	0.9	0.2	0	1.1
59	Low to moderate tree cover in built-up areas	2	21.5	3	1	25.5

Phoenix Fuels – Lamb Island - Adjusted			Fuel Load (t/ha)			Total
No.	**Description**	**WRF**	**Surface**	**Elevated**	**Bark**	**Load**
3	Wet eucalypt tall open forest	3	23	3	1.9	27.9
5	Moist to dry eucalypt open forests on coastal lowlands and ranges	3.5	15.5	3.3	1.2	20
28	Melaleuca open forests on seasonally inundated lowland coastal swamps	3	13.7	2	1	16.7
41	Shrublands / Woodlands in coastal locations	2.5	17	2.5	2	21.5
45	Woodlands / Heathlands associated scrubs and shrublands	2.5	24.1	2	2.1	28.2
46	Grassland / Sedgeland communities associated with heathlands, scrubs and shrublands	2	21.6	4.5	2	28.1
55	Mangroves / Sedgeland dominated wetlands and tidal saltmarshes	2.5	0.9	0.2	0	1.1
59	Low to moderate tree cover in built-up areas	2	21.5	3	1	25.5

Phoenix Fuels – Karragarra Island – Adjusted			Fuel Load (t/ha)			Total
No.	**Description**	**WRF**	**Surface**	**Elevated**	**Bark**	**Load**
3	Wet eucalypt tall open forest	3	23	3	1.9	27.9
5	Moist to dry eucalypt open forests on coastal lowlands and ranges	3.5	16.9	2.4	1.2	20.5
28	Melaleuca open forests on seasonally inundated lowland coastal swamps	3	19.5	2.8	1	23.3

41	Shrublands / Woodlands in coastal locations	2.5	17	2.5	2	21.5
45	Woodlands / Heathlands associated scrubs and shrublands	2.5	24.1	2	2.1	28.2
46	Grassland / Sedgeland communities associated with heathlands, scrubs and shrublands	2	21.6	4.5	2	28.1
55	Mangroves / Sedgeland dominated wetlands and tidal saltmarshes	2.5	0.9	0.2	0	1.1
59	Low to moderate tree cover in built-up areas	2	21.5	3	1	25.5

Appendix C – Phoenix House Loss Calculation method

http://www.bushfirecrc.com/sites/default/files/managed/resource/thu_p110a_1310_kevintolhurst.pdf

[i] These maps use data from 1950 – present, and have been made possible thanks to Dr Andrew Dowdy funded through the National Environmental Science Programme (NESP) working at BoM.