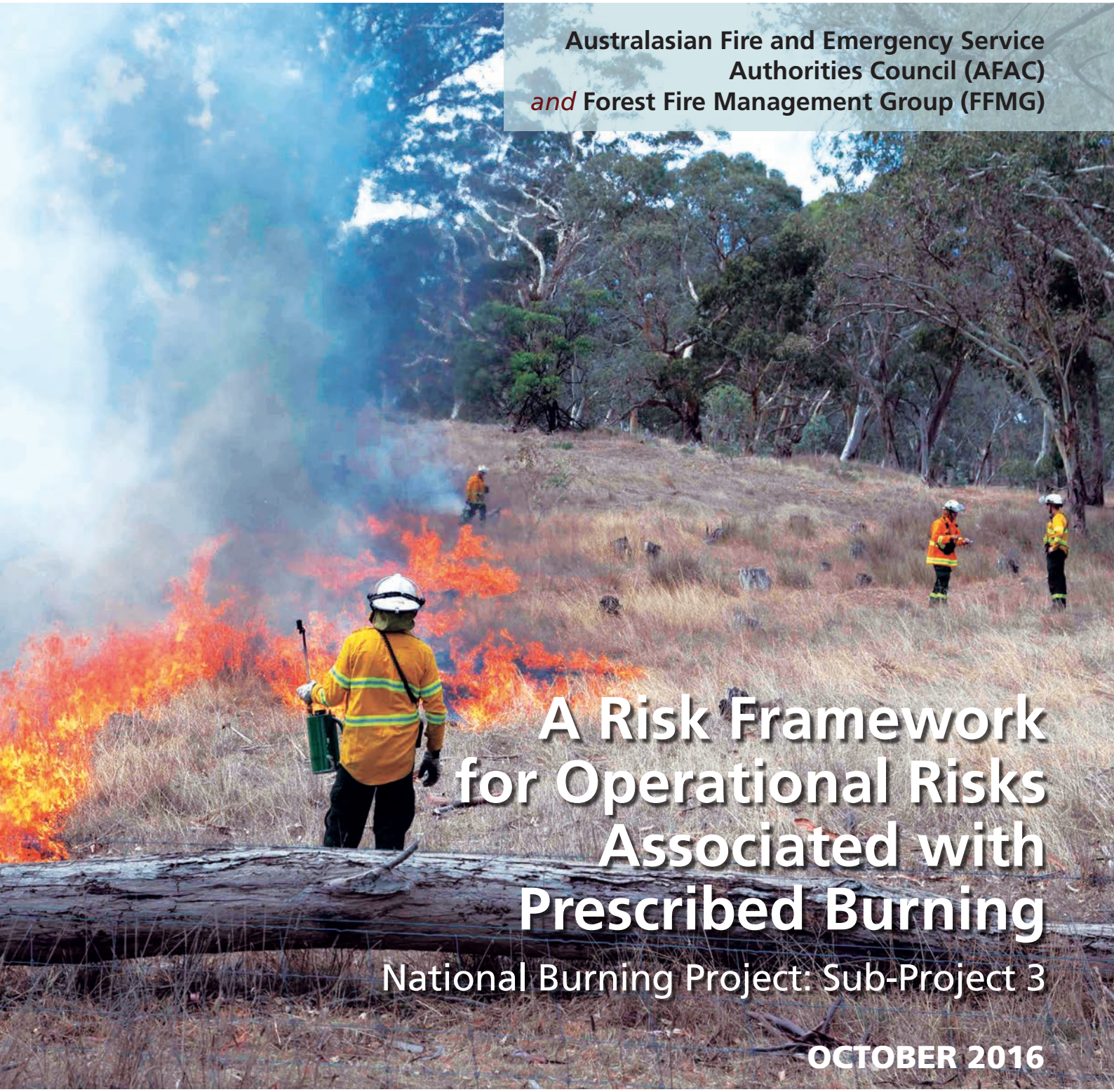
# NATIONAL BURNING PROJECT

Australasian Fire and Emergency Service Authorities Council (AFAC)
*and* Forest Fire Management Group (FFMG)



# A Risk Framework for Operational Risks Associated with Prescribed Burning

## National Burning Project: Sub-Project 3

**OCTOBER 2016**

afac

An Australian Government Initiative

FFMG

Australasian Fire and Emergency Service Authorities Council Limited (ABN 52 060 049 327)
Level 1, 340 Albert Street East Melbourne Victoria 3002
Telephone: 03 9419 2388 Facsimile: 03 9419 2389
Email: afac@afac.com.au Internet: http://www.afac.com.au
Author: AFAC Limited
ISBN: 978-0-9942589-1-5
Design: Fullpoint Media, +61 3 9376 5370, http://www.fullpointmedia.com.au
Avenue Press, 249 Wickham Rd, Moorabbin VIC, 3189.
Printer: Valiant Press, PO Box 3871, Nunawading VIC, 3131
To be cited as: AFAC (2016) A Risk Framework for Operational Risks Associated with Prescribed Burning – National Burning Project sub-project 3. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

# TABLE OF CONTENTS

# TABLE OF CONTENTS

# TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF FIGURES

*(Source: Department of Environment, Water and Natural Resources South Australia)*

# 1. INTRODUCTION

The National Burning Project (NBP) is a multi-year project jointly commissioned by the Australasian Fire and Emergency Service Authorities Council (AFAC) and Forest Fire Management Group (FFMG), with the overarching objective:

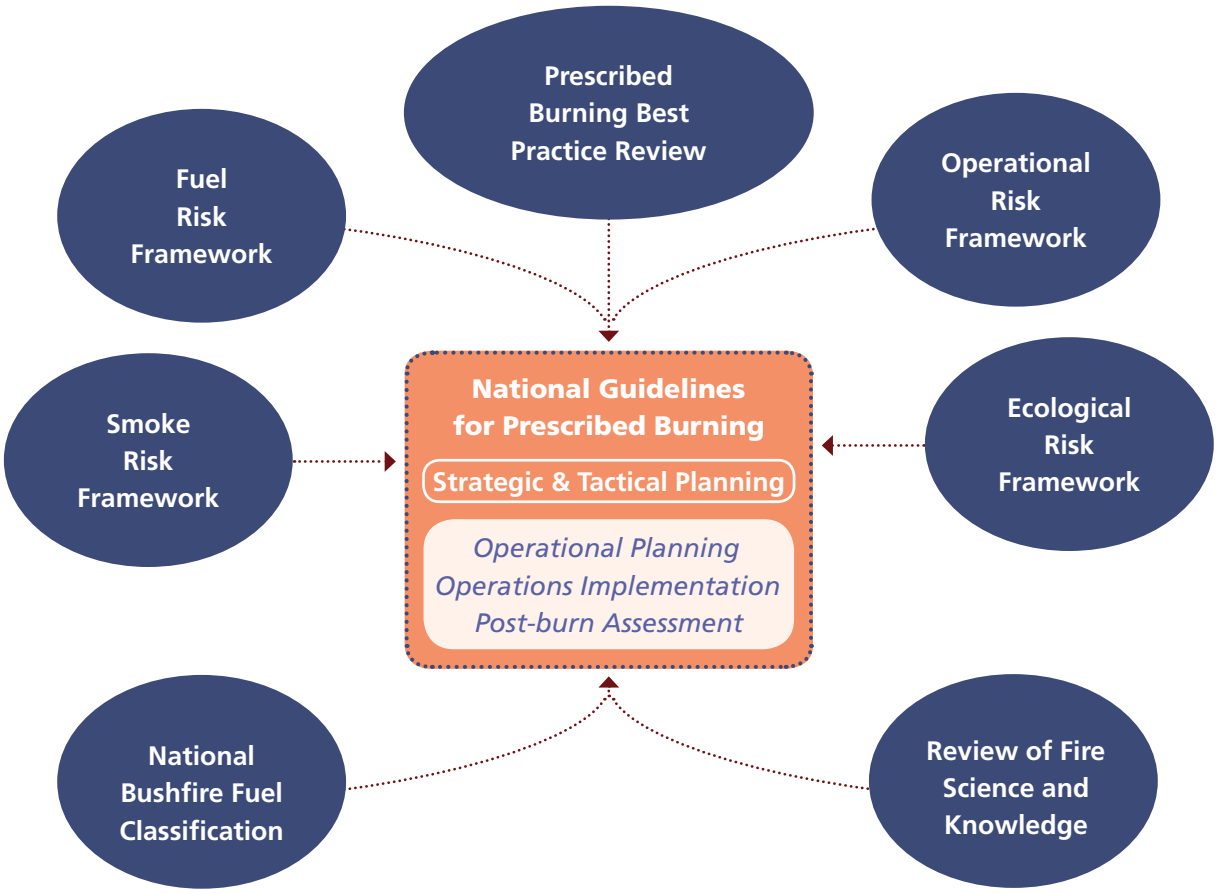
To use a national approach to reduce the bushfire risk to the Australian and New Zealand communities by the comprehensive management of prescribed burning at a landscape level that balances operational, ecological and community health risks.

A number of sub-projects are to be implemented under the NBP pursuant to developing national guidelines for:

- Best practice prescribed burning; and
- Ensuring greater interoperability between fire management agencies through developing common standards and approaches to prescribed burning.

This operational risk framework is one of the sub-projects that will contribute to a compilation of best practice national guidelines, as depicted in Figure 1 below.

***Figure 1*** *National Burning Project – related sub-projects*



# 1. INTRODUCTION

## 1.1 Operational risk framework overview

Prescribed burning is an important part of managing landscapes in many parts of Australia in order to achieve various objectives such as bushfire risk mitigation, ecological maintenance and restoration and land management.

The objective of this report is to design a nationally-agreed risk management framework for prescribed burning operations, for use by anyone involved in prescribed burning. It addresses risks associated with burn containment, crew safety, public safety and impacts on values.

A consistent national framework for managing and monitoring these and other prescribed burning risks can provide significant benefits to land and fire managers both in terms of minimising potential problems, and by providing a degree of risk management transparency.

Including this report, four risk frameworks have been developed under the National Burning Project. These are outlined in Figure 2.

*(Source: Bushfire CRC)*

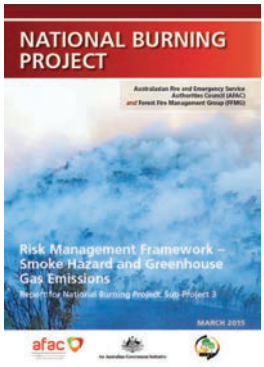
***Figure 2*** *National Burning Project risk frameworks*


### A Risk Framework for Operational Risks Associated with Prescribed Burning

This document reviews the approaches taken by land a fire management agencies with regard to prescribed burning risks associated with burn containment, crew safety, public safety and damage to assets and values. It offers a framework that addresses these dimensions of risk management across all phases of prescribed burn planning and implementation.


### A Risk Framework for Ecological Risks Associated with Prescribed Burning

This framework offers a synthesis of concerns, approaches and activities that organisations across Australia engage in to manage ecological risks across all phases of planning, implementation and evaluation of prescribed burns.




### Risk Management Framework – Smoke Hazards and Greenhouse Gas Emissions

This document reviews the approaches undertaken by various Australian and New Zealand land and fire management agencies with regard to management of risks associated with smoke and greenhouse gas emissions. From this starting point, it builds and presents frameworks that can be used in the context of prescribed burning, to manage smoke and emissions impacts on amenity, prosperity, health and safety.

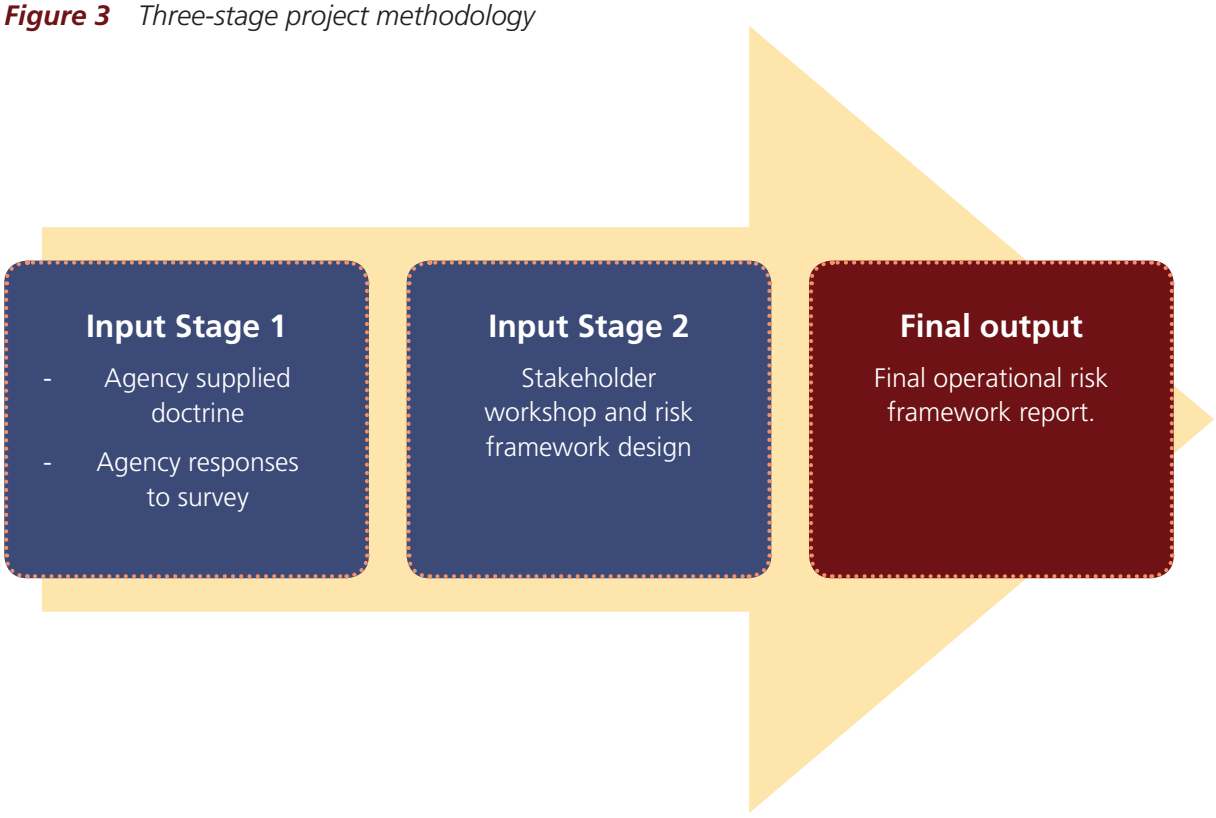

### Risk Management and Review Framework for Prescribed Burning Risk Associated with Fuel Hazards

This document reviews the approaches undertaken by various Australian and New Zealand land and fire management agencies with regard to management of risks associated with bushfire fuels. From this starting point, it builds and presents a framework that can be adopted by Australian and New Zealand agencies to facilitate an improved alignment of approaches and greater appreciation of fuel risks.

# 2. METHODOLOGY

The methodology for the operational risk framework was identified in AFAC and FFMG's request for proposals and was confirmed at the project inception meeting. The project consists of the following three stages:

***Figure 3*** *Three-stage project methodology*




## 2.1 Call for agency doctrine

The project considered the ways of measuring and managing operational risks to staff and the public by collating and analysing current risk frameworks used in each jurisdiction (Australian states and territories). To collect this information GHD prepared a survey (see Appendix B) which AFAC circulated for agencies to complete. AFAC also asked agencies if they could provide the relevant operational risk assessment material (copies of risk assessment templates, procedures, tools, checklists, prescribed burn plan template and doctrine for prescribed burning). This information was used to prepare preliminary frameworks for use in the stakeholder framework design workshops.

## 2.2 Framework design workshops

Workshops including participants from a wide range of agencies (see Appendix A) including land management agencies, fire management agencies, utilities, councils and defence providers were held at the following locations during July and August 2015:

- Darwin: to cover Northern Australia;
- Perth: to cover Western Australia;
- Gold Coast: to cover south-east Queensland, northern NSW and north Queensland; and
- Melbourne: to cover south-east Australia.

The workshops aimed to:

- Discuss the risk management frameworks which are already being used by individual fire agencies, tailored to meet their specific needs;
- Compare the uncertainties agencies have to address in preparing for and implementing a prescribed burn; and
- Review and confirm a single nationally-agreed framework, that sits above, but does not replace, pre-existing agency needs.

During the four project workshops:

- The issue of how to logically group the key operational risk groupings or dimensions was considered, for both the operational planning and burn implementation phases;
- The multi-layered control diagrams and the boxed text (in Section 7 – 10) were reviewed by participants; and
- The operational risk management framework (Figure 15) was reviewed and contributed to by participants.

## 2.3 Project report design

Pursuant to the project design agreed at the inception meeting, and further canvassed during the project workshops, GHD structured the input received from agencies and through the workshops according to the following defined phases of prescribed burn planning (described in Section 4.1):

- **Strategic planning;**
- **Program planning;**
- **Operational planning;** and
- **Burning implementation.**

Also, the following dimensions of risk management were addressed (described in Section 4.2):

- **Burn control and security;**
- **Burn crew safety;**
- **Public safety**; and
- **Impact on values.**

Section 3 discusses the nature of risk management frameworks. Specific consideration is given to the subtle changes introduced with the transition from AS 4360:2004 to ISO 31000:2009.

Sections 5 to 10 are the bulk of the report, and discuss in detail risk management controls for each phase and risk dimension outlined above.

Section 11 concludes the report by bringing together a risk management and review framework (based on the previous sections) for operational risks associated with prescribed burning.

# 3. PRESCRIBED BURNING RISKS – GENERAL CONCEPTS

Providing a frame of reference for subsequent sections, this section introduces risk management in accordance with international standards, and then contextualises risks in terms of prescribed burning.

## 3.1 Risk management frameworks

In 2009 the international *ISO 31000:2009 Risk Management – Principles and Guidelines* superseded *AS/NZS 4360:2004 Risk Management* as the primary standard on risk management in Australia and New Zealand. While the risk management process incorporated in ISO 31000 is virtually identical to the prior standard, there have been some subtle changes in the main points of emphasis between the two. Three in particular are worth highlighting, and are listed with some commentary on the implications for developing a national risk-based framework for managing operational risks from prescribed burns:

1. ***Risks are about uncertainties and relate to objectives.*** The definition of risk has changed from 'the chance of something happening that will have an impact on objectives' (old definition in AS 4360:2004) to 'the effect of uncertainty on objectives' (current definition in ISO 31000:2009). This subtle definitional change is intended to redefine the main focus of risk management to considering the effect that uncertainties can have on achieving objectives (understanding how risk arises), changing from the previous emphasis on considering the chance of an event occurring and its consequences. Further, risk management is "a coordinated set of activities and methods… used to direct an organisation and to control the many risks that can affect its ability to achieve objectives."

   Thus mitigating the risks associated with prescribed burning is achieved by explicitly attempting to identify and manage the uncertainties associated with the activity. Except perhaps in the very simplest of circumstances, prescribed burning risks cannot be eliminated. Thus prescribed burning risk management is about risk reduction to acceptable or tolerable levels.

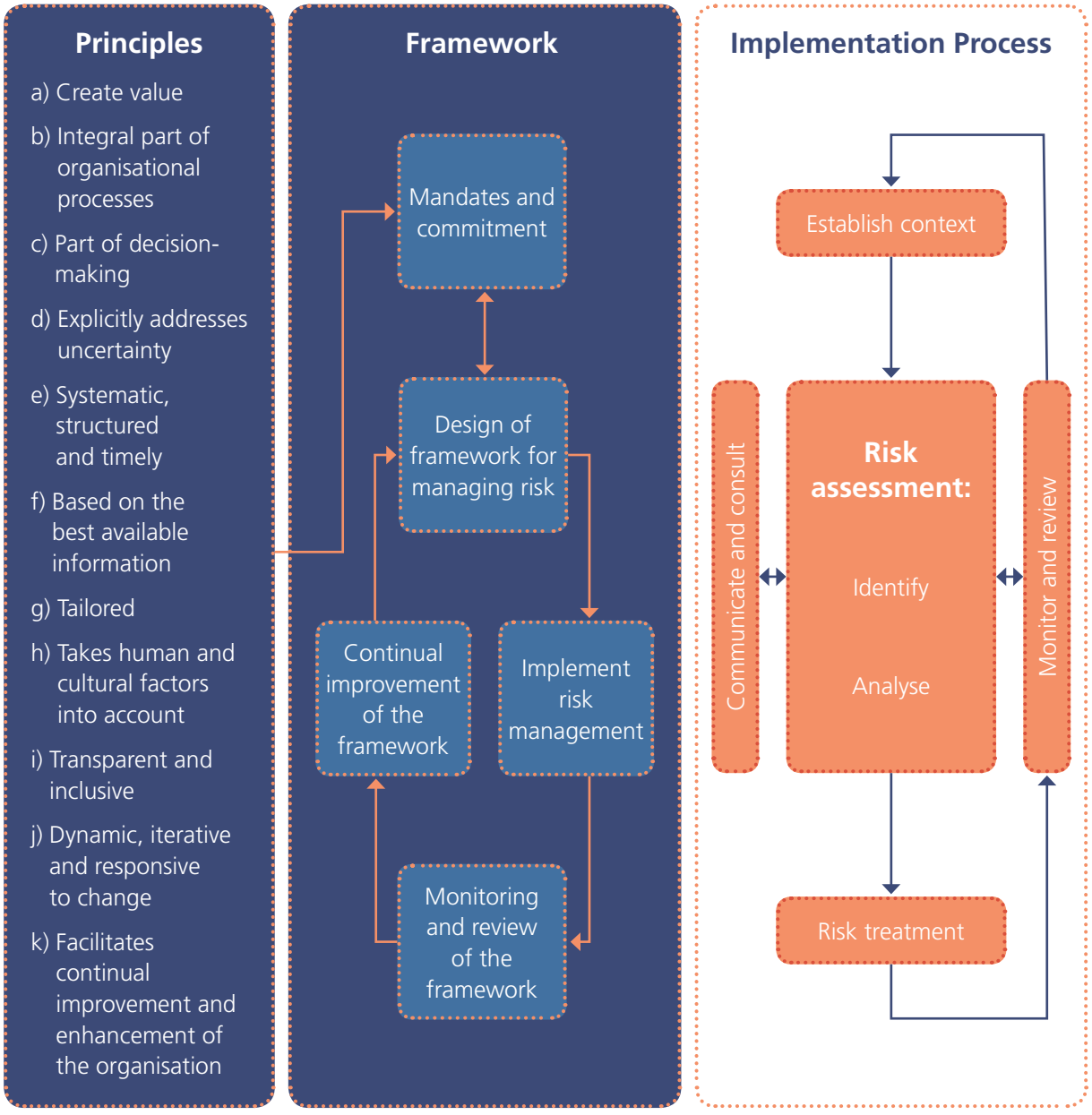
2. ***There are a variety of tools and methods available to perform risk assessments and inform management priorities.*** The AS/NZS 4360 standard included strong references to the use of risk assessment 'matrices' whereby qualitative descriptors of an event's 'likelihood' and 'consequences' of occurring were used to develop a risk rating of, typically, 'low', 'medium', 'high', 'very high', 'extreme' or some similar descriptors. In the bushfire risk management context, problems can arise trying to adopt the 'matrices' as an assessment tool, due to the complex and wide range of fire behaviour variability and uncertainty that can exist, and that is difficult to capture in such a way. While these types of matrices can be very useful in some situations to assist with risk assessment and recording, under AS/NZS 4360 it had become the mainstream standard approach for risk assessment, which was never the intention of the AS/NZS 4360 standard. To address this, reference to the risk matrices has been removed from the ISO 31000 standard and an accompanying document *ISO 31010:2009 Risk Assessment Techniques* has been created. While the risk matrices do appear in ISO 31010 as one type of tool that may be useful in risk assessment (among a list of over 30 techniques), it is emphasised that the appropriate risk assessment and communication tools should be developed with the specific context, in this case prescribed burning operational risk management, in mind.

# 3. PRESCRIBED BURNING RISKS – GENERAL CONCEPTS

*(Source: Bushfire CRC)*

3. ***ISO 31000 introduced 11 risk management principles to provide more explicit guidance as to how risk management is best implemented.*** The ISO 31000 generic framework for risk assessment and management is shown in Figure 4. It addresses a set of principles, a risk management framework, and a risk management implementation process, and how they inter-relate. The 'risk assessment' activities, sit within the overall risk management process. The addition of the 11 principles is an important enhancement of the superseded AS/NSZ 4360 risk management process model, and highly relevant to managing prescribed burning operational risks.

***Figure 4*** *The ISO 31000 risk management principles, process and framework*




Some further explanation of the risk management principles is provided below. The application of sound risk management should:

1. ***Create and protect value***

Good risk management contributes to the successful achievement of an agency's prescribed burning program and objectives (e.g. objectives relating to employee and public safety, operational effectiveness, financial efficiency and loss minimisation, agency reputation and social licence, environmental protection, legal compliance and meeting political imperatives) through the continuous review of its processes and systems.

2. ***Be an integral part of organisational processes***

Risk management needs to be integrated with an agency's governance framework and become an embedded part of its planning processes, through all phases of the prescribed burning process from strategic planning, through program and operational planning phases, to implementation.

3. ***Be part of decision making***

The process of risk management assists decision makers to make informed choices, identify priorities and select the most appropriate action. This applies through all the phases of prescribed burning.

4. ***Explicitly address uncertainty***

Identifying uncertainties is a necessary part of identifying potential risks – agencies can implement controls and treatments to optimising the chance of success while reducing (but not necessarily eliminating) the chance of failure or loss.

5. ***Be systematic, structured and timely***

The process of risk management should be consistent across an agency to ensure efficiency, consistency and the reliability of results. Well-formed and clear risk management procedures and systems enable staff to have a structured and timely response to risks.

6. ***Based on the best available information***

To effectively manage risk it is important to understand and consider all available information relevant to a prescribed burning activity and to be aware that there may be limitations on that information, potentially creating uncertainties. It is then important to understand how all this information informs the risk management process, and to adjust risk management as new and improved information becomes available (e.g. as commonly occurs during the burn implementation process).

7. ***Be tailored***

An agency's risk management framework needs to include its risk profile, as well as take into consideration its internal and external operating environment.

8. ***Take into account human and cultural factors***

Risk management needs to recognise the contribution that people and culture have on achieving an agency's objectives. Prescribed burning is implemented by people who are influenced by their organisational culture.

9. ***Be transparent and inclusive***

Engaging stakeholders, both internal and external, throughout the risk management process recognises that communication and consultation is key to identifying, analysing and monitoring risk. External stakeholders may have key information or insights relevant to managing prescribed burning risks, and in many cases may be able to contribute to controlling risks. Transparency in the form of clear and timely public information will enable the community to make any necessary preparations to mitigate impacts such as smoke.

10. ***Be dynamic, iterative and responsive to change***

The process of managing risk needs to be flexible. The challenging and dynamic environment of fire management requires agencies to consider the context for managing risk as well as continuing to identify new risks that emerge. Allowances should be made for those risks that no longer exist or which change.

11. ***Facilitate continual improvement***

Agencies with a mature risk management culture are those that have invested resources in review and evaluation processes over time, and are able to demonstrate the continual achievement of their objectives because they have developed sophisticated procedures and systems for addressing uncertainties.

## 3.2 Risk management objectives contextualised to prescribed burning

The National Bushfire Management Policy Statement for Forests and Rangelands (FFMG 2014) provides an agreed vision and principles for bushfire management. It also provides strategic objectives and national goals in order to achieve the vision. The strategic objectives (A, B, C and D) and national goals (1 – 14) are shown below.

***Figure 5*** *National Bushfire Management Policy Statement for Forests and Rangelands (FFMG 2014)*

# 3. PRESCRIBED BURNING RISKS – GENERAL CONCEPTS

In relation to Goal 8, reducing overall fuel hazard through prescribed burning can reduce the likelihood of harmful bushfires developing and reduce the consequences of such fires both to community and environmental values. Thus, treating hazards through prescribed burning is one of a suite of methods of controlling risks that can affect these objectives.

However prescribed burning to reduce fuel hazards and overall risk to nearby communities is an activity itself that can carry significant risk. A key consideration in determining whether prescribed burning as a risk management option is appropriate is to determine: will the anticipated benefits (e.g. proposed hazard reduction and proposed ecological or economic benefits) offset the risks caused by the prescribed burning activity (e.g. possibility of escape into surrounding areas) and from potentially adverse impacts on other values (e.g. economic or ecological impact)? Conversely where prescribed burning in an area with elevated fuels is deferred to the following year, this is in itself not risk-free. Such decisions are made with the knowledge that an area already identified as being in a high hazard condition will continue to contribute an elevated threat to the community during the next bushfire season.

When a decision has been made to implement a prescribed burning activity, there are some key principles that will help to contain fire spread to within the prescribed burn boundaries (whether natural and formed) or desired burn extent (for unbounded burns) and hence minimise the potential for adverse impacts from the burn, such as:

- Burning within prescriptions to ensure fire behaviour during the burn meets the burn objectives (i.e. fuel reduction and environmental requirements);
- Understanding how fuel attributes, topography, aspect, lighting patterns and weather will contribute to fire behaviour and adjusting plans accordingly; and
- Determining appropriate containment strategies, contingency plans and resourcing requirements.

These key strategies are core risk management considerations for prescribed burning. This report will explore these and a range of additional risk management strategies that are designed to address burn containment, crew safety, public safety and reduction of risk to values.

*(Source: Queensland Parks and Wildlife Service)*

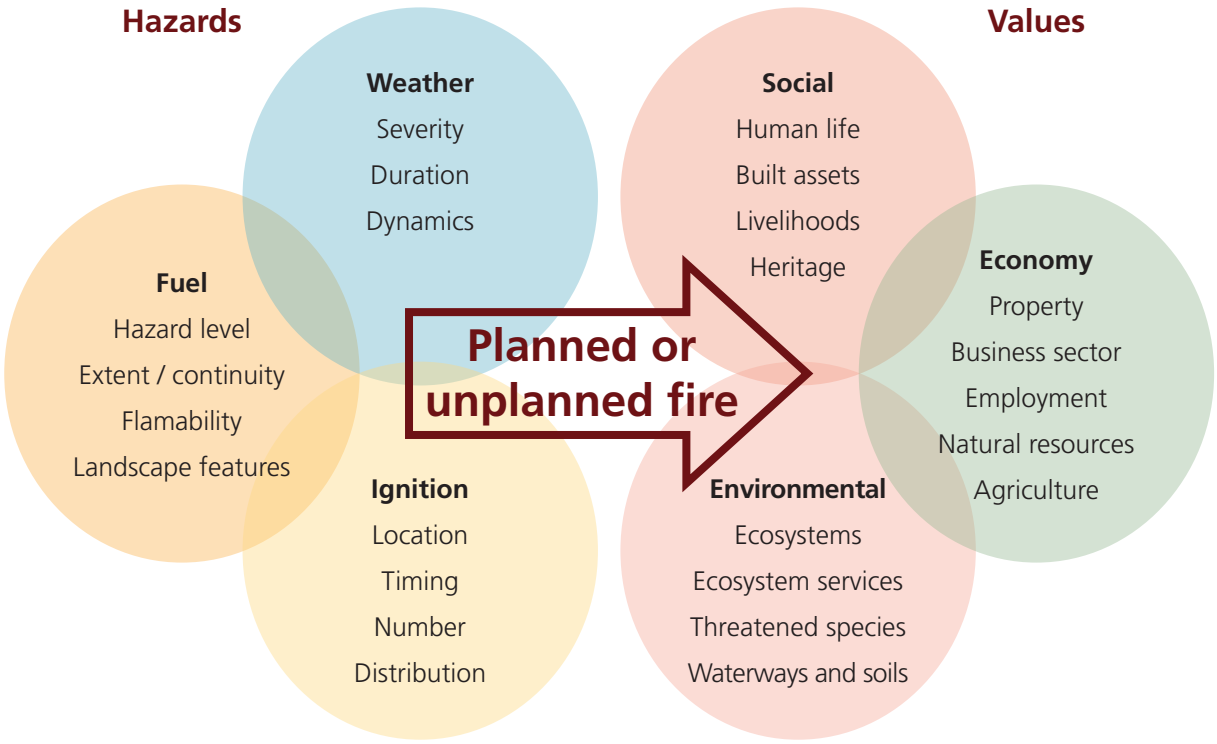
## 3.3 Inter-relationships among hazards, values and risks

Fuel, weather and ignition hazards individually do not constitute a fire risk. Each hazard has dependencies on the others to create a bushfire with behaviour attributes sufficient to adversely impact those values which are vulnerable and exposed to fire elements (flame contact, radiant heat, ember attack and smoke).

All attributes of the hazards and values contribute to the degree of risk. The higher the hazard, and the higher the exposure and vulnerability of the values at risk, the higher the risk. The 'hazard' elements listed in Figure 6 are factors influencing the ability of a bushfire to ignite, spread and increase size and intensity, the 'values' listings broadly describe the things that can be at risk.

Commonly, 'risk' is considered as a combination of the likelihood of an event arising together with the consequences of the event. In this sense, values attributes may sometimes be equivalent to 'consequence' risk factors because they are factors influencing the severity of impacts arising from a fire. Hazard attributes may sometimes be referred to as 'likelihood' risk factors because they are factors influencing the likelihood of a fire starting and propagating. However, they are not exclusively 'likelihood' risk factors as they also influence the size, speed and intensity of the fire which has a major bearing on fire impact or consequences. Hence, the uses of the terms hazards and values to describe the primary drivers of risk achieves the same as considering 'likelihood' and 'consequence' but is more attuned to the focus on fuel and bushfire management.

***Figure 6*** *Fire risk arises from the intersection of hazards with values (through fire)*



# 4. PRESCRIBED BURNING PHASES AND RISK DIMENSIONS OVERVIEW

This report culminates in an operational risk framework presented as a matrix of prescribed burning phases against operational risk dimensions (see Figure 15). This section briefly introduces these prescribed burning phases and risk dimensions.

## 4.1 Planning and implementation phases

Risk assessment processes need to be appropriately tailored to the spatial and temporal scales being considered in planning or operations, and the resolution of outputs required. It may not be productive or efficient to conduct fine scale analysis using high resolution data if the outputs produced are on a landscape scale and grouped into broad risk categories. Equally, it is sub-optimal to use coarse resolution data and analytical methods designed to deliver broad category outputs, when the decision-making involves fine spatial and temporal scale. Risk assessment processes need to be appropriate to the scale of decision making.

***Figure 7*** *Phases of prescribed burning planning and implementation*

**Communication and consultation**

| Strategic Planning | Program Planning | Operational Planning | Burning Implementation |
|---|---|---|---|
| Long-term planning driving the scale and nature of an agency's prescribed burning program and the agency capability and organisation needed to deliver risk management outcomes. | Programming the scheduling of burns one to five years ahead. Refined as burning season approaches. | Advance planning for individual burns. Refined in the weeks before the burn, up until the day before the burn. | Mobilisation, briefings, test burn, light up, mitigation measures, control strategies, mop-up, patrol and reporting. |
| => 5 years | 1 – 5 years | Months/year | Days |
| Jurisdiction, region, property | Jurisdiction, region, property | Individual burn | Individual burn |

**Monitoring and evaluation**

# 4. PRESCRIBED BURNING PHASES AND RISK DIMENSIONS OVERVIEW

As identified in Figure 7, this operational risk framework is structured around the four sequential prescribed burning phases most commonly used. This allows individual agencies and burn planners to cross-reference their more specific operational procedures and practices against each phase. The four planning and implementation phases are joined by two whole-process activities (communication and monitoring) that occur throughout. Note that planning phases may be termed differently in different jurisdictions, or in some cases, combined into a single phase (such as in northern Australia where program planning and operational planning are combined into a single process in response to a highly dynamic fire environment).

### 4.1.1 Strategic planning

Strategic planning addresses the establishment of jurisdiction wide prescribed burning policy and supporting systems, standards, guidelines, procedures, competencies and training that support risk management through all subsequent phases of planning and implementation. It also addresses the establishment of strategic prescribed burning objectives often expressed in plans or strategies created at a jurisdiction, regional or local level.

### 4.1.2 Program planning

Program planning processes typically take the outputs of the strategic planning phase and develop works programs over a year or several years (depending on jurisdictional planning processes), identifying the locations and extents of different work types, their objectives, proposed sequence and timing. These plans schedule where and when the component activities of a burn program will nominally take place, understanding that weather, unplanned fires and other circumstances can necessitate changes to planned schedules.

### 4.1.3 Operational planning

Strategic and program planning address the broad-scale where, why and when of the planning process. At the operational planning level, planning processes need to operationalise how the burning will be delivered, under what conditions and with what resources. It is at this stage that specific risk treatments are required. Accordingly, the operational planning phase is usually the first stage in the prescribed burn planning process at which the site-specific and seasonal timing-specific operational measures or prescriptions are required to manage the uncertainties associated with the burn. This process typically involves desktop assessment activities, followed by a more detailed site assessment and internal and external communication and consultation; and usually results in the development of a documented burn plan for individual burns.

### 4.1.4 Burn implementation

Operational risk appraisal before light-up, during burn operations, and after the burn is a continual process of identifying and monitoring the conditions and situation as the fire behaviour and environmental conditions change, asking ‘what ifs?’, communicating and consulting with those participating in the burn and adapting tactics to address uncertainties and to meet burn objectives.

Because the operational level planning phase may be completed weeks or months ahead of when a prescribed burn takes place, such things as fire behaviour predictions and nominated lighting method, stages and patterns may be based on assumptions about fuel attributes (often averaged across whole sites or sections of sites), and weather conditions (typically the desired weather conditions) to achieve the burn objectives. Forecast and actual conditions on the day(s) a burn is conducted may vary from the conditions assumed in planning, and uncertainties can arise from the differences between actual and assumed conditions. Therefore a degree of flexibility and vigilance by those conducting the burn must be maintained, to tailor planned burning approaches to the real conditions at the site on the day(s) of burning. This is an important aspect of prescribed burning risk management.

## 4.2 Dimensions of risk management for operational risks

This report considers operational risks across four risk dimensions as outlined below. It should be noted that although each risk dimension is presented separately, they overlap and reinforce one another. For example, burn containment and security is discussed as its own risk dimension, but significantly re-enforces all the other risk dimensions.

### 4.2.1 Burn control and security

Burn control and security involves being able to contain the burn within planned boundaries and within planned fire behaviour prescriptions. It is a key risk dimension for consideration in prescribed burn planning and delivery, that if successfully controlled, also substantially reduces the exposure to other risk dimensions (burn crew safety, public safety and impacts on values).

### 4.2.2 Burn crew safety

Operational risks associated with burn crew safety include risks to personnel undertaking the burn and addresses matters such as identifying site safety hazards, ensuring crews are appropriately trained and experienced and ensuring the suitability of equipment, communications and PPE.

### 4.2.3 Public safety

Operational risks associated with public safety include risks to members of the public who may be at the burn site, near to the burn site or further away but affected by smoke. It addresses issues such as identifying public safety hazards and mitigation strategies at, or near, the site of burning, ensuring the public is clear of the site and maintaining safety awareness throughout and after burning operations.

### 4.2.4 Impact on values

Most burn sites will include either built assets, infrastructure, private property, cultural or natural values that require protection. Many of these values will be protected by burns undertaken within appropriately prescribed conditions, other values will require planned mitigation strategies to reduce their exposure risks to tolerable levels.

## 4.3 Operational risk controls overview

This section presents an overview of the operational risk controls that are presented in the subsequent sections. Strategic and program planning phases can be considered as a common foundation of planning work, upon which each risk dimension sits. These background planning phases are discussed in Section 5 and 6. Following this, operational planning and implementation phases are considered in detail for each of the four risk dimensions (Section 7, 8, 9 and 10).

Each of these operational risk dimensions is introduced by a stacked risk diagram (Figure 8) showing multi-layered control measures for preventing or mitigating impacts on that risk dimension. The diagrams cross all phases of prescribed burn planning with strategic and program planning phases presented as a podium on which the more detailed operational planning and burn implementation phases sit. The diagrams should be read from bottom to top.

***Figure 8*** *Stacked risk diagram overview*


Each section also includes boxed summaries that outline principal points and are accompanied by subsequent paragraphs of explanatory text.

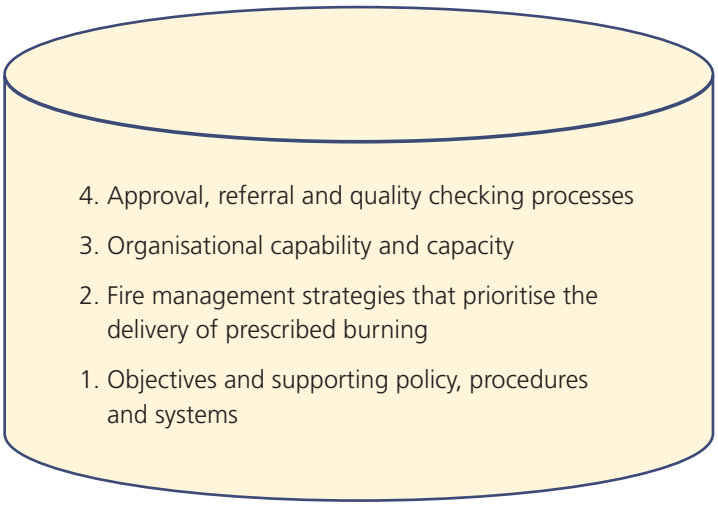
Finally, the stacked risk diagrams and boxed summaries discussed in the following sections contribute to the content that forms the risk management framework presented at the end of this document in Figure 15.

# 5. STRATEGIC PLANNING PHASE – ALL OPERATIONAL RISK DIMENSIONS


*(Source: Department of Parks and Wildlife Western Australia)*

Decisions made at the strategic planning phase have an important impact on later planning and implementation phases. Strategic planning decisions and considerations affect the scale, complexity and tempo of burn planning and delivery processes and the organisational capability requirements for implementation. The scale and complexity of prescribed burning set at the strategic level, needs to be commensurate to the organisational capacity to deliver, otherwise significant risks can manifest in the subsequent planning and implementation phases. The matters addressed at strategic planning phase are summarised in Figure 9 below and described in the subsequent paragraphs.

***Figure 9*** *Strategic planning phase risk controls*



# 5. STRATEGIC PLANNING PHASE – ALL OPERATIONAL RISK DIMENSIONS

## 1. Objectives and supporting policy, procedures and systems

Ensure strategic level objectives are clearly articulated and supported by policies, procedures, standards, guidelines and systems suitable to support the type, quantity and complexity of prescribed burning required.

Operational risk control measures relevant at the strategic planning levels are typically agency-wide controls including:

- A clear statement of strategic objectives and statements regarding what is an acceptable level of risk to those objectives;
- Supporting doctrine and decision support systems to facilitate effective planning and implementation across the agency, for example:
  - Policy addressing crew safety, public safety, smoke management and environmental protection;
  - Procedures, standards and guidelines addressing prescribed burning operations, use of equipment, environmental assessment, smoke management and community engagement. Examples include standards for control lines, procedures for handling spot overs or escapes and procedures for contingency planning. It also includes procedures or guidelines for unbounded burning, site safety checks, public safety management, use of personal protection equipment (PPE), ecosystem management and technical work instructions for safe use of equipment.
  - Fuel assessment and fire behaviour prediction and decision support systems;
  - Risk management systems and procedures; and
  - GIS, asset management, human resource management and other information management systems;
- Community engagement procedures and systems to foster efficient and effective engagement;
- Cooperative agreements and workforce arrangements with support agencies and collaborators; and
- Continuous improvement processes and a culture willing to adopt lessons learnt.

## 2. Fire management strategies that prioritise the delivery of prescribed burning

Strategic level planning documents are available that guide the quantity, type and complexity of prescribed burning required.

Agencies are required to analyse the amount and type of prescribed burning required to achieve strategic level objectives across the landscape. These strategies attempt to describe (at least broadly), the quantity, location and type of prescribed burning required. This can be achieved in various ways, e.g. through fire management zoning plans, through modelling using fire growth simulators and risk landscape profiling, through assessments of ecosystem fire regimes or through a combination of these.

These strategic level documents guide subsequent planning phases and in particular, dictate burn program requirements which in turn dictate organisational capability requirements. These need to be in good alignment for optimal risk management.

## 3. Organisational capability

Maintain resources, equipment, financial allocation and a skilled workforce commensurate to the scale and complexity of prescribed burns undertaken.

Deciding the technical capability and staff/contractor competency requirements for the range of roles undertaken at all phases and identifying the workforce development required is essential to ensuring delivery of stated agency objectives with regard to prescribed burning. These may include:

- Recruitment and retention strategies;
- Training competencies, training material, trainers and training systems;
- Contractor standards and requirements; and
- Mentoring and professional development opportunities.

Consideration should be given to putting in place consistent organisational or team structures to deliver strategic objectives across all phases of planning and delivery to ensure the right mix of technical and other skills are in place for coordination of the planning, implementation and review process.

Fire and land management agencies typically have competency frameworks and structured training systems in place specific to prescribed burning roles, with differentiation between supervisory level and crew level requirements.

Prescribed burning firefighting and communication equipment needs to be appropriate for the quantity, type and complexity of prescribed burning required. Financial resource allocations and arrangements need to be adequate for staffing, equipment and burn program needs.

## 4. Approval, referral and quality checking processes

Ensure there are appropriate requirements to have prescribe burn plans quality checked, peer reviewed and approved. Also, approval processes around scheduling burns and permission to ignite burns are required.

Quality control of burns is a major risk management consideration and therefore policy or procedures governing this is required. These often take the form of requirements for internal review by suitably qualified staff so that containment, operational safety issues and potential impacts on assets, cultural and natural values can be considered. It also includes formal approval processes by those in appointed positions with authority to approve burn plans, reject burn plans or require review of burn plans. These are often done in accordance with checklists or procedures.

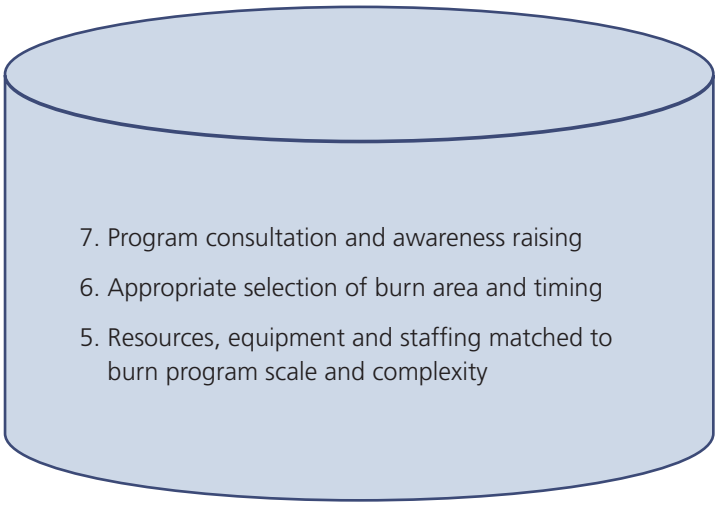
In addition to burn plans, there are often procedures and requirements around approving scheduling of burns and permission to ignite a test burn/prescribed burn. These usually take into consideration the quantity of burning current within a jurisdictions, smoke issues, resourcing capability and weather forecast scenarios and the ability to safely meet prescriptions.

Many agencies also apply decision support system approaches to determining the level of risk and/or complexity associated with a burn, linking this to the level of review and approval required. Ensuring that adequately experienced staff review burn plans and give final approval is a key risk control strategy.

# 6. PROGRAM PLANNING PHASE – ALL OPERATIONAL RISK DIMENSIONS

Through defining the quantity, location and timing of prescribed burning activities, the program planning phase can have significant impacts on operational risk dimensions at the planning and implementation phases as summarised in Figure 10 below and discussed in the subsequent paragraphs.

***Figure 10*** *Program planning phase risk controls*




## 5. Resources, equipment and staffing matched to burn program scale and complexity

Assess burn program quantity, complexity and technical difficulty in relation to internal capacity and capability. Decide appropriate technical skill and experience levels and resources required for assigning burn delivery responsibility.

Although the strategic planning phase sets the general scale and complexity of prescribed burning, the program planning phase specifies which burns will be undertaken where and when, often in an annual or multi-year burn program.

Adequate planning of resources is required to ensure that staff allocations are commensurate to the complexity and size of the burn. This may involve engaging more qualified or extra staff from outside the local region to where the burn is being carried out. The quantity of burning at any one time should generally not exceed a local region's ability to deliver the specified program of burns, unless other resources are available to bring in.

When assigning burns to officers in charge of the burn and burn crews, decide appropriate technical skill and experience levels required.

## 6. Appropriate selection of burn area and timing

Avoid where possible prescribed burn area, location, boundary, timing and sequence selections that are too difficult or risky to treat operationally, posing unnecessary safety risks to crews or to the public, or that generate undue smoke impacts or impacts on assets or values.

Operational risks can be partly addressed by selecting burn locations, dimensions and sequencing that avoids unnecessary complexity and delivery issues. This not only includes internal delivery considerations but also external issues such as minimising, to the extent practicable, impacts on local communities, business and assets.

When choosing burn units to add to the burn program, be conscious of the timing and season of burns so as not to plan burns in high escape-risk periods, or if they are programmed at higher risk periods ensure that approval, planning and implementation levels are commensurate to the higher risk level. Be wary when planning burns in periods of worsening fire weather, these require a higher level of containment consideration.

Be aware of impacts on smoke sensitive receptors, both through the placement of burns and through the quantity of burns scheduled and associated cumulative impacts of smoke. Nursing homes, hospitals, schools and major transport infrastructure are examples of sensitive smoke receptors. Inevitably burns will need to be scheduled near these locations; however, programming too many burns at the same time in these areas is avoidable. Timing of burns should be conscious of impacts on peak tourist periods, major community events, major transport corridors and timing considerations for vulnerable agricultural enterprises (e.g. grape growers, apiculturists).

The cumulative impact of smoke on particular airsheds or regional areas needs to be considered when programming burns. Many environmental protection agencies have introduced pollution standards with regard to smoke, and in many jurisdictions, fire and land management agencies are required to program prescribed burns in a way that comply with these.

There may be circumstances where ambient smoke and particulate pollution levels in or near a proposed burn area are already high, and conducting the burn could further add to an already undesirable situation potentially triggering an adverse community response. There may be occasions when it is not desirable to delay such burns, and therefore additional community warnings, and political risk management measures may be necessary, but where possible, postponement may be the more prudent option for reducing risk. To the extent possible, selection of burn timing to avoid maximum sensitivity or impact periods can reduce the off-site risks. For example, crops that are sensitive to smoke at particular developmental stages (e.g. wine grape crops are sensitive during their ripening period), and businesses that have heightened sensitivity at particular times (e.g. tourism-based business during peak holiday periods).

Refer to *Risk Management Framework – smoke hazard and greenhouse gas emissions* (AFAC 2015b) for a detailed discussion regarding smoke risk management.

A number of native species have timing considerations with regard to prescribed burning in order to avoid times when they or their young are vulnerable to fire or smoke. Such timing considerations, especially for rare or threatened species, may form part of scheduling of prescribed burns. In some jurisdictions these timing considerations and relevant mitigation measures are legislated.

# 6. PROGRAM PLANNING PHASE – ALL OPERATIONAL RISK DIMENSIONS

To provide increased operational flexibility, planning more burns than required in a particular program enables wider choice of pre-planned 'ready-to-go' burns, should conditions in other parts of the planning area be too wet or dry or otherwise unsuitable. Decisions to defer burns are not risk-free. There may be considerable residual risk if deferred burns are held over the summer months (in a high fuel condition), particularly where a number of burns are deferred. By at least treating burns that are better suited to the burn conditions, the overall residual risk from the sum of areas requiring treatment is reduced, and the extent of future burning work backlogs is lessened. However, the impacts of altered scheduling on burn programs that rely on a particular sequence for reducing implementation risks needs to be considered.

## 7. Program consultation and awareness raising

Consulting stakeholders can raise issues that are relevant for consideration at later planning stages.

Raising the level of public awareness of burn programs well in advance of prescribed burning activity increases community acceptance of burn programs and allows community members to be prepared.

In some jurisdictions (but not all) stakeholder consultation processes are applied at the program planning phase, and community group and/or individual concerns about the potential operational risks of proposed burns may arise at this stage. Feedback and concerns raised can be documented and provide inputs requiring consideration during the operational planning phase.

Newspapers, the internet and increasingly, social media are used to notify the community of scheduled burning activities. Ensuring the community is well informed helps agencies gain acceptance for their scheduled burn programs. Community acceptance and support allows agencies continued license to undertake prescribed burning activities.

Early notification of burn programs can serve to remind adjoining community members to undertake their own preparatory actions such as clearing debris from yards and gutters.

Burn program impacts on certain industries, economic values and infrastructure need to be assessed. These may require extensive liaison with managers or technical staff managing businesses or utilities in order to optimise or develop standard mitigation approaches.

# 7. BURN CONTROL AND SECURITY

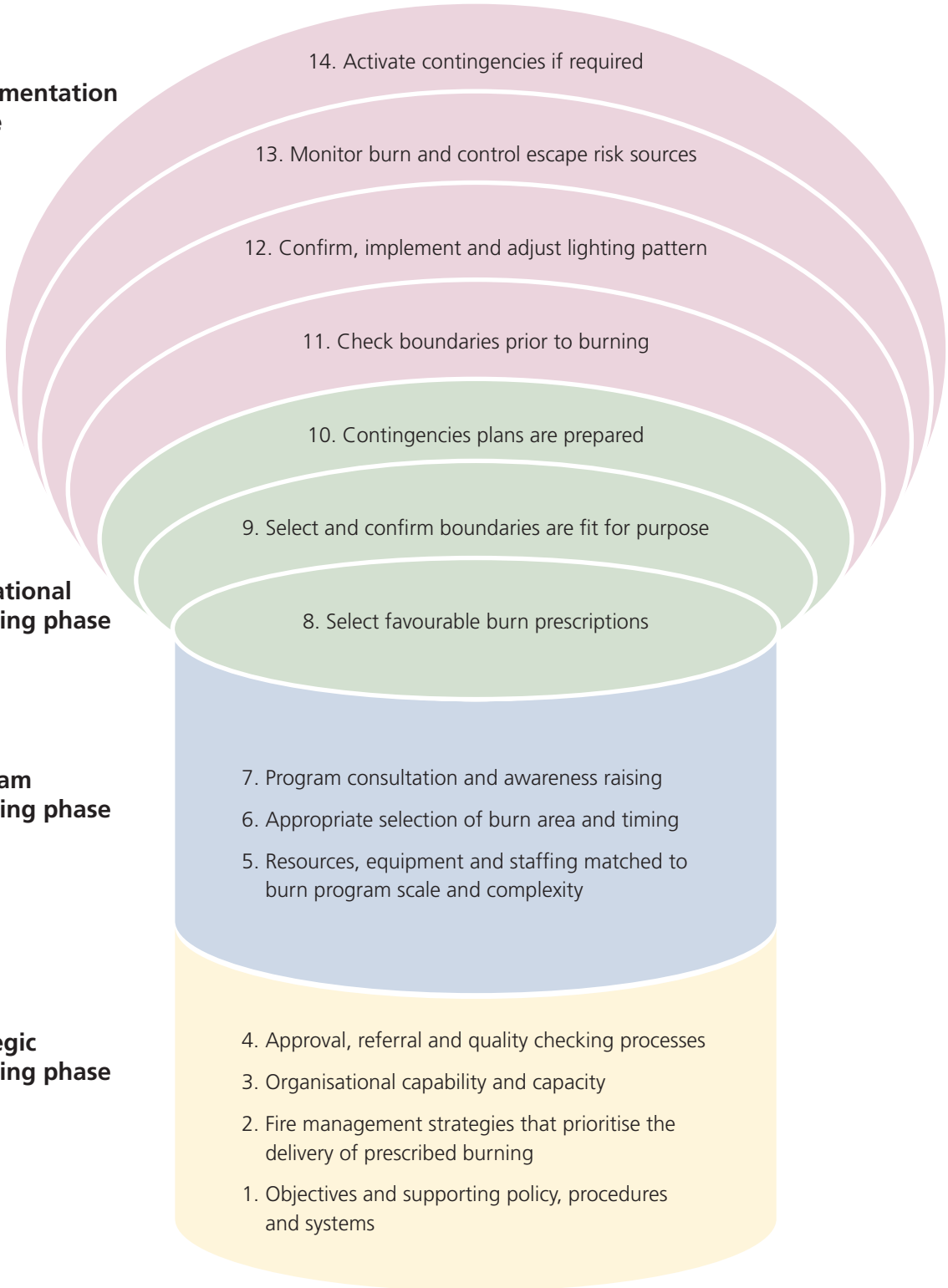
In the operational planning and burn implementation phases, multiple layers of risk control (see Figure 11) are applied to achieve successful burn control and security. In Australia, these controls are effective in the overwhelming majority of cases[1]. Loss of control and security is typically due to absence, weaknesses or failures in one or more of the risk control layers discussed in this section, noting that in some cases, circumstances beyond those reasonably foreseeable may still defeat well-planned control measures.

*(Source: Paul de Mar GHD)*

1 For example, the November 2015 independent investigation of the Lancefield-Cobaw fire in Victoria identied that over the ten year period up to and including 2014/15, of 6,427 prescribed burns undertaken on public land in Victoria, a total of 71 burns (1.1%) were deemed to have breached containment.

# 7. BURN CONTROL AND SECURITY

***Figure 11*** *Burn control and security risk control measures*



## 7.1 Burn control and security – operational planning

### 8. Select favourable burn prescriptions

Use prescriptions that are suitable to achieve prescribed burn objectives while safely containing the burn. Be aware of conditions that may produce unexpected fire behaviour such as certain fuel types, drought effects and thresholds (e.g. wind speed, fuel moisture content) beyond which fire behaviour suddenly escalates.

When monitoring windows of opportunity for burning, select a day, or sequence of days when forecast weather conditions are predicted to generate controllable fire behaviour within acceptable prescriptions to achieve objectives, and in which the burn can be completed and securely mopped-up.

The weather conditions during which a burn may spot, spread and smoulder, are a critical prescribed burning risk driver. In many fuel types, a relatively modest escalation in weather conditions may result in a disproportionately large escalation in fire behaviour, from desirable and controllable levels, to problematic fire behaviour with substantially increased potential to breach planned containment. Hence, fire and land management agencies understand the critical importance of selecting appropriate weather conditions for maintaining burn control and security and have in place various systems to achieve this[2].

All burn practitioners implementing burn prescriptions appreciate that weather forecasting is not an exact science, and weather forecasts are always best-estimates with inherent uncertainty. Weather conditions which were 'not normal', or were 'unexpected' are often cited in lessons learnt and after action reviews as a reason for loss of burn control. Such conditions may include 'unexpected' drought effects, lower humidity than expected, stronger winds, erratic winds or the burn time extending beyond what was anticipated, effectively extending the burn into a different set of weather conditions than those for which it was planned. Local weather variances also need consideration as these may be significantly different from the generic forecast conditions. Altitude of the burn needs to be accounted for, as winds at altitude can be higher than at forecast locations.

When considering 'what ifs' scenarios and contingency planning when decisions to ignite burns are being made, weather forecast uncertainty and variance need to be taken into account.

For example, in Western Australia allowances are made for the following potential variance in weather forecasts. These variance parameters reflect the understanding used by fire and land management agencies in Western Australia as to what level of forecast variance would trigger a forecast revision by the Bureau of Meteorology – after a forecast is issued, any forecast variance that may become apparent in subsequent model outputs (during the forecast period) would not constitute grounds for issuing a 'revised forecast' unless one or more of these parameters are exceeded:

- Temperature – up to <± 3 degrees[3];
- Relative humidity – up to ± 7 – 15%;
- Wind speed – up to ± 15%[4]; and
- Wind direction – up to 45 degrees either side of the forecast direction.

2 Typically this is done through the development of standard 'prescriptions' expressing constraints on weather parameters which are applied on a vegetation type basis (e.g. as done in Tasmania, Victoria and South Australia) and/or through a blend of fuel, weather and fire behaviour parameters detailed in agency burning guides (e.g. as done in Queensland and NSW)

3 The Bureau of Meteorology's Annual Report 2014/15 (page 15) identifies that maximum and minimum temperature forecasts (one day ahead) are considered to be 'accurate' if they are within 3 degrees of observed conditions (BoM 2015)

4 CSIRO research during Project Vesta identified that the minimum error in estimating wind speed at a fire front is ±15% (Gould *et al.* 2007)

# 7. BURN CONTROL AND SECURITY

Fire behaviour is sensitive to slight variation in some of these parameters. Wind speed is among the most important of these factors as fire behaviour is particularly sensitive to wind speed. Slight increases in wind speed can dramatically increase fire behaviour, particularly where the change in wind speed results in fire spread escalation thresholds being crossed (fire spread escalation thresholds represent a point beyond which fire spread suddenly escalates. For example in dry eucalypt forests either side of the 12 – 15 km/hr threshold, at 10 metres above ground).

Recent rainfall is also important, with soil dryness index (SDI) or drought factor (DF) a means to estimate its influence on fire behaviour by influencing how much dead fuel will be available for burning. High soil dryness indices typically indicate low bark moisture levels, increasing the potential for escapes through spot-overs from burning bark (particularly thick fibrous bark types). They also indicate that more of the fuel bed is available, which increases fire intensity as well as the potential for fire to continue smouldering in heavy fuels, extending the burn control and security risk period. Fire and land management agencies use various Bureau of Meteorology products as well as their own locally collected data, including maps depicting SDI, Keetch Byram Drought Index (KBDI), McArthur Drought Factor, and rainfall deficiency maps to obtain a coarse scale indication of fuel dryness. These can provide indicators of whether potential fuel dryness issues may arise during light up, patrol and mop-up. However these are at relatively coarse spatial scales and more finely scaled consideration and field validation techniques, in accordance with agency procedures, will generally be prudent, particularly for larger burns with topographic and aspect variation within and outside the burn area.

When the approaching suitable weather windows are shorter than desirable and/or burning objectives or execution method assumptions are overly optimistic, control problems may result. Such situations may occur where a complex burn is scheduled to be completed in a single day, as operational flexibility is reduced, and time available to adjust to unforeseen events is shortened, potentially amplifying small issues or resulting in burn objectives not being met. For example, prescribed burn conditions may be too mild, with only a very short window when conditions are in the desirable range and therefore the burn may not meet its objectives (e.g. for reducing fuel levels, or reducing bark hazard). Alternatively the burning conditions may be too severe, potentially generating an undesirable degree of crown scorch and fuel removal, increasing the risk of escape, and potentially producing secondary impacts such as erosion and tree mortality. The extent to which these issues manifest is driven by fine-scaled fuels and fire behaviour considerations including local subtle diurnal weather pattern effects, in some cases with vegetation structure, condition or fuel type-specific nuances. Accordingly, agency guidance in relation to these local knowledge matters is typically incorporated in their prescribed burn training and/or on-the-job mentoring.

In many cases, agencies undertaking prescribed burning across complex burn sites or fuel types apply a multi-staged approach, scheduling a sequence of ignition events over multiple days, months or years. In the case of karri/marri/jarrah and heath burning in the south-west of WA, burning may be staged over many months leading up to and within summer as different fuel types become available (see http://www.afac.com.au/initiative/burning for a detailed case study). Staging burns in this way allows treatment of more volatile fuel types or critical boundaries in conditions optimal for burning those particular fuels. Multi-stage burns allow greater time to take advantage of suitable weather conditions required to burn different fuel types and maintain control. It also allows more time to adjust tactics and implement contingency plans if required. However, multi-stage burning also comes with significant residual risk periods to be managed in between ignition events due to the potential for live fire activity to continue combustion within the partially burnt area, potentially at or near the margins of substantial unburnt fuel expanses which can serve as a wick or area of increased fuel hazard for fire escalation in subsequent adverse weather conditions. Hence robust risk monitoring and management systems are required.

Climate change is also a consideration, such as in parts of south-west Australia where the onset of favourable autumn burning conditions is occurring later than it did twenty years ago, with the effect that the burning window has been shortened. Maintaining control of spring burns is also becoming more difficult due to drier fuels and bark than was typically the case in past decades.

Operational risk is likely to be increased where burning is undertaken outside of prescriptions. Sometimes this may be necessary such as when additional ignition to improve burn security on an incomplete burn is considered a lower risk than not burning an area out before the onset of adverse weather. In such situations there is effectively a much-reduced margin of error – particularly if forecasting errors arise, elevating conditions even further above upper prescription thresholds, or conditions at the fire-ground are worse than those predicted for the forecast location. Decisions to operate outside prescribed parameters are typically subject to rigorous peer-review and include contingency planning specifically tailored to the higher level of potential risk.

Other than for some simple short duration burns, selection of favourable burn conditions is not always straightforward. For these reasons, selection and confirmation of favourable burning conditions is a key component of prescribed burn training and mentoring and typically a key matter reviewed in peer-review and burn approval processes.

## 9. Select and confirm boundaries are fit for purpose

Confirm burn boundary features are appropriately located and are suitable to contain predicted fire behaviour. Be aware of boundary weak spots, adjacent fuel condition, spotting risks and the effect of planned lighting patterns on boundary stability. For unbounded burns, it is important to understand where the burn is likely to extinguish and how.

Selection of burn boundary features to contain a burn to the prescribed area is a critical part of risk management. The risk of a burn boundary being breached is dependent on a range of interacting factors including:

- The type of boundary feature:
  - Whether it is suitable for control purposes;
  - Whether it has weak spots; and
  - Whether or not it contains fuel which can sustain surface fire spread under certain conditions.
- The type and condition of fuel adjacent to the boundary feature;
- The presence of spotting and escape problem sources such as trees with flammable bark-type fuels, hollow trees and chimneys or damaged trees that may fall and spread fire across containment features;
- The direction the fire is travelling when it reaches the boundary feature;
- The weather and topography influencing fire behaviour;
- The lighting pattern and intensity used to ignite the burn;
- The amount and type of resources, and the skill and experience levels of those managing the residual risk associated with the selected boundary features;
- The extent to which the boundary features are trafficable or accessible by ground crews; and
- For unbounded burns, a good knowledge of how and where fire is expected to extinguish.

# 7. BURN CONTROL AND SECURITY

With so many highly variable interacting factors affecting the ability of a selected burn boundary feature to successfully contain fire, this particular aspect of burn planning and implementation has many uncertainties. Therefore, this component of the burn control and security risk assessment relies heavily on local knowledge, experience of how the various factors interact and what has worked historically, noting that historical conditions may not be reflective of current or future conditions.

In terms of burn boundaries, some of the questions to consider in assessing the uncertainties associated with maintaining the security of the burn in the planning and/or implementation process are:

- What are the characteristics of fuels within the burn area and in the adjoining areas, and how available are the adjacent fuel areas if a spot-over were to occur, how difficult would it be to access and extinguish any spot-overs and what is the likelihood that escapes can be contained within fall-back control lines?
- Have similar boundaries successfully held prescribed burns in the past, if so in what conditions and with what resources, and if not why not?
- Have the planned boundaries been changed or adjusted since the previous prescribed burn and if so have the changes been subject to appropriate level of field verification and review?
- Has the planned season of the burn changed such that the fuel and weather may be different from those assumed in previous planning?
- Can the burn boundary edging and core burning be done in one continuous operation (if that is proposed) or are conditions such that edging should be put in place in a first-stage preparation for a second, subsequent phase of burning the internal area later in the prescribed burning season?
- Is there a particular fuel type or fuel age present that is not familiar, or is known to be problematic, which may behave unexpectedly, potentially resulting in a loss of control or a breach of boundary (e.g. by creeping through duff layers)? What measures are proposed to address any such risks?
- Has local knowledge been sought where there is uncertainty about how fire in certain fuel types behaves or how well boundaries have contained prescribed burns historically?
- Has opinion from an experienced practitioner been sought?
- Are there large hollow trees or trees with high bark loads present which, once alight, may spot over the control lines, or representing a risk to crew safety, and have they been identified for raking around, candling or removal?
- Are control lines and fall-back control lines identified as fit-for-purpose and have any weak or problematic control lines been clearly marked on maps and plans for additional preparatory work or other risk control measures been made?
- If using natural breaks, are these in a condition that will successfully contain prescribed burning in the selected and contingency areas planned. Will the fire burn to the desired extent in the particular burn phase as planned?
- Is the specific burn and ignition pattern appropriate to ensure boundaries are not impacted by head fires and are ignition strategies appropriate (e.g. burning away from these boundaries).
- For unbounded burns, are spot ignitions of sufficient spacing to enable spot fires to join up (if desirable) prior to burns self-extinguishing overnight with increasing nocturnal fuel moisture?
- Are lighting crews experienced in unbounded burning? and
- Are edge burns of sufficient depth to meet the treatment objectives of subsequent burn phases in multi-stage burns?

As is evident from the foregoing discussion, selection and confirmation of fit-for-purpose burn boundary features is mostly a process involving interaction of many variables, and therefore many uncertainties (although it may be relatively straightforward for some simple fuel and terrain types). For these reasons, selection and confirmation that burn boundary features are fit-for-purpose (and identification of what, if any, boundary preparations might be required) is a key component of prescribed burn training and agency mentoring, and generally requires assessment by an experienced burn practitioner with sound local knowledge. It is typically a key matter reviewed in burn plan peer-review checking processes as part of burn supervision and approval processes.

## 10. Contingencies plans are prepared

Have in place ready to activate fall-back and consequence management contingencies to address the potential for significant increased fire behaviour within the burn area, or escapes across containment lines.

Contingency plans are increasingly being recognised as an important component of burn plans, especially for complex burns or burns with a higher level or risk. Contingency plans address pre-planned actions that can be enacted where fire behaviour exceeds expectations, or where the burn escapes control boundaries. Among other matters, they may address:

- Identification of fall-back control lines;
- Safety zones and escape routes for crews;
- Potential points of weakness around the planned burn perimeter (e.g. higher fuel loads, narrower fire control lines on top of hills);
- Potential weather changes that may impact on forecast burn spread;
- Additional resources that are on standby and can be called upon;
- Actions to be taken in the event of accidents;
- Additional crew and public safety considerations in the event of an escape; and
- New command structures that may be enacted.

Fire and land management agencies will typically conduct planning of such arrangements similar to the LACES (Lookouts, Awareness, Communications, Escape Routes and Safety Zones) safety system applied in fire response operations.

## 7.2 Burn control and security – burn implementation

### 11. Check boundaries prior to burning

Fire control lines may have been selected and prepared weeks or months in advance, and therefore there is a need to check boundaries close to the day of burning.

An often-cited cause of loss of burn security is that containment lines or the extent the burn was intended to burn to did not hold as expected and/or were not checked close to light-up. Conditions may have changed due to storms bringing down trees, branches or litter which may create fuel corridors across boundaries or disrupt trafficability during burning operations. Also, boundary preparations may have left fuel piles by roadsides which may cause localised increases in fire intensity and potentially a spotting risk. Boundaries need to be checked on the day or day before burning and any final preparations made to ensure they are suitable.

It is important to implement any planned mitigation actions for hollow trees or trees with high bark accumulations as part of ensuring boundaries are prepared and secure.

### 12. Confirm, implement and adjust lighting pattern

Confirm the ignition method and lighting sequence, pattern and timing are suitable for site conditions (e.g. fuels, slope, weather, resources) and will keep containment lines manageable, and meet burn objectives and fire behaviour prescriptions. Ensure crews are appropriately skilled for lighting and containing the burn in their sector(s).

Use of suitably experienced aerial and ground ignition crews with experience of the fuel type being burnt is critical as the light-up operators set the tempo for the entire prescribed burn. They are able to observe, if lighting up at a measured pace, subtle changes in fire behaviour in different vegetation types, and adjust lighting spacing or pattern, suspend lighting, seek additional resources and communicate actions and situation reports to the officer in charge of the burn. This monitoring and evaluation of fire behaviour occurs throughout the prescribed burn, with the lighting pattern adjusted in response to changing weather conditions or fire behaviour.

The identification of the ignition method and how long it will take to implement and burn may to some extent occur during planning phases, but will be developed and refined during operational implementation. It is important to consider what pressure lighting patterns will place on fire control lines, especially if lighting patterns must be adjusted on the day of burning. In confirming the lighting sequence, pattern and timing, the fuel moisture measurements or estimations referenced need to adequately indicate conditions in the target burning area, as well as areas outside the target area, so informed consideration can be given to escape risks. Fire and land management agencies will typically conduct a test fire (although in very simple situations this may not be required), at a location representative of the target fuels, as a key initial indicator of fire behaviour, noting that allowance needs to be made for how fire behaviour can be expected to change as conditions change through the course of the day, and following days.

Fire and land management agencies will routinely conduct crew briefings, which in some cases may be before the test-burn is conducted. In such situations it is necessary to communicate any anomalies, issues or noteworthy observations from the test-burn to all lighting crews so all have the same understanding of fire behaviour and requirements to meet the burn objectives and execution specifications.

## 13. Monitor burn and control escape risk sources

Monitor fire behaviour and containment security, and apply control measures to any fire events and circumstances which pose unacceptable threats to burn security (such as flare-ups, increased fire behaviour or spot-overs). Be aware of condition creep.

Maintaining awareness of fire behaviour, providing situation reports and communicating changes across the fireground, no matter how subtle, is essential to maintain burn security. Communication should be regular and should at minimum adhere to the Sitrep reporting schedule specified in the burn plan and/or confirmed at the briefing. Fire and land management agencies typically have in place a communications plan or fire supervision and reporting protocols addressing when and what changes need to be reported.

Human factors such as complacency in relation to condition creep are key risks in monitoring burn security. Condition creep may occur where a fire is under patrol for an extended period during which there is a gradual, incremental escalation in fire behaviour that goes unnoticed and/or unremarked by crews. Such a gradual increase may not present obvious signals to patrol crews of deteriorating conditions. Continual monitoring, noting subtle changes, and being conscious of condition creep or complacency in assumptions of fire behaviour can avoid slow-onset 'surprises'. This awareness and ongoing monitoring should extend through all stages until the burn is declared safe.

Changes in vegetation hazard are also noted by lighting crews, as pockets of unfamiliar or problem fuels might be overlooked in the planning or initial appraisal. Smouldering organic matter (such as dry peat beds) or areas of heavy fuels well within a burn area have been factors in a number of burn escapes. Aerial observation may be used to monitor internal fuels and reduce uncertainty of internal fire behaviour.

Where flare-ups, increased fire behaviour or spot-overs threaten burn security, appropriate actions need to be taken which may include changing lighting patterns, suppressing spot-overs or strengthening containment crews.

## 14. Activate contingencies if required

It is important to brief crews about contingency arrangements and ensure they understand triggers that may activate planned contingencies. Enacting contingencies may require changing command structure, revising objectives and issuing information.

All crews need to understand where the pre-planned fall-back control lines and escape routes are, and maintain awareness of potential triggers for which a contingency plan is enacted. Contingency planning may also consider options to tie-in a burn earlier (for example, by containing it to intermediate internal control lines) than anticipated due to slow progress or other factors which require a burn to be put on hold.

Enacting pre-planned contingencies may require:

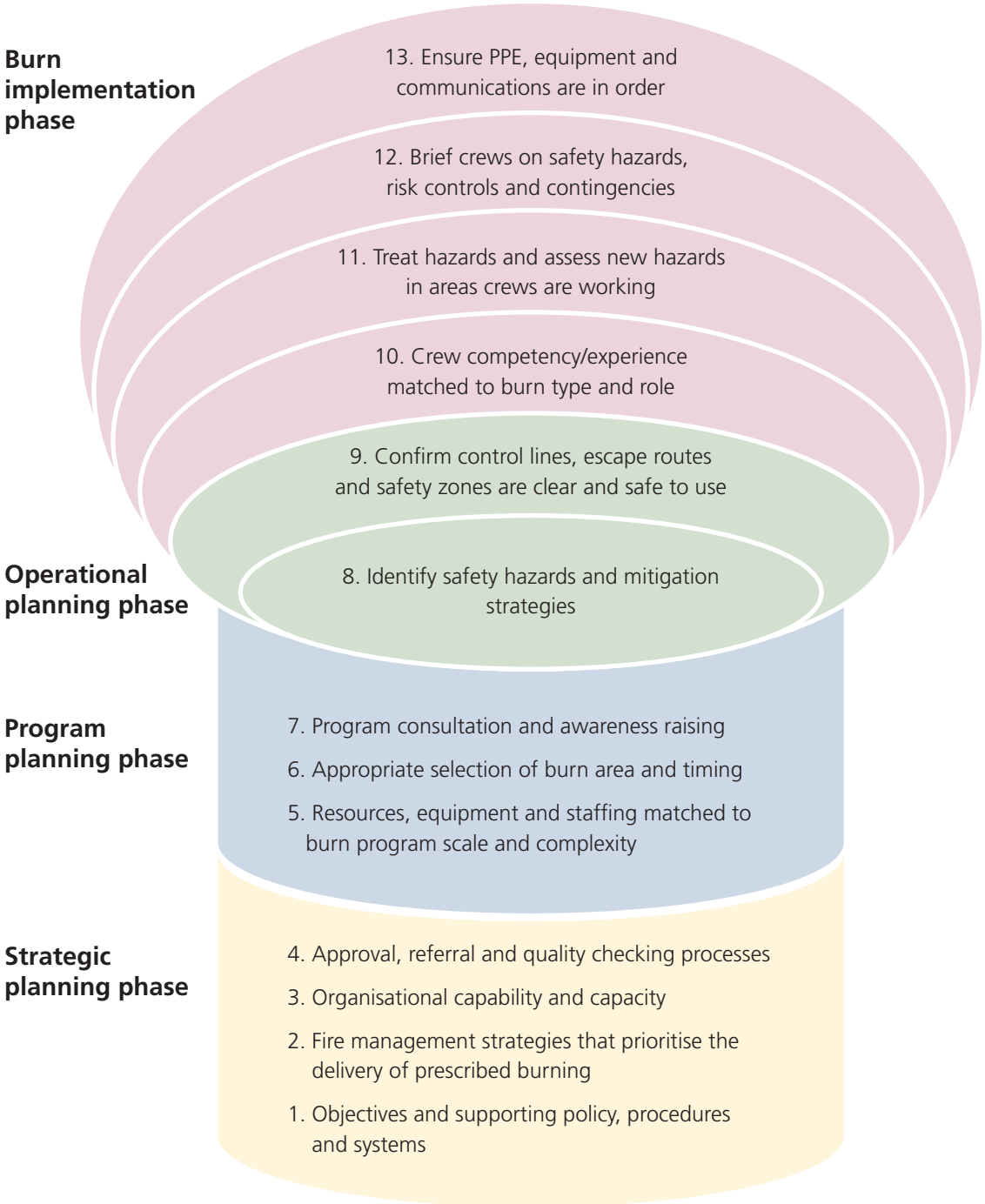
- Setting revised containment objectives;
- Scaling up or down resources;
- Adjusting incident management capability; and
- Issuing communication to neighbours and other stakeholders.

This may include a change in the officer in charge of the burn to account for a greater level of experience required during contingency conditions. For long duration burns or more complex high risk burns, contingency resources may have to be available for multiple days.

# 8. BURN CREW SAFETY

Figure 12 outlines the multi-layered risk control strategies typically undertaken for burn crew safety, which are discussed in detail in the following section. Although the focus is at the level of prescribed burn operational planning and implementation, all phases of prescribed burn planning are important to ensure crew safety. Burn control and security (see Section 7) also contributes significantly to crew safety.

***Figure 12*** *Burn crew safety risk control measures*



## 8.1 Burn crew safety – operational planning

### 8. Identify safety hazards and mitigation strategies

Scope out risks to crew safety and identify any planned mitigation strategies required to reduce risk to tolerable levels.

Vehicle movement on narrow, sometimes freshly formed boundary tracks increases the risk of accidents, particularly when crews may be responding with some urgency to an escape. For certain complex burns where this could become a concern a traffic management plan may be required identifying:

- Direction of traffic movement, if one-way only;
- Location of passing-bays and turning points;
- Dead-end tracks; and
- Safety zones and escape routes.

Other safety issues that may require consideration during formation of burn plans include:

- Particular ignition patterns that are required and that might, under certain circumstances place lighting personnel at risk. If such ignition patterns are required, appropriate strategies to safely undertake such burning should be identified;
- Localised areas of steep slopes or rocky ground may pose safety risks and require an altered approach to ignition strategies, or may need to be highlighted in the burn plan;
- Some locations may produce particular localised weather phenomena that may need to be considered during burn planning;
- Vegetation types with high elevated fuels or that may flare up unexpectedly should be highlighted in burn planning and taken into consideration when forming ignition strategies;
- Changes in aspect, slope or vegetation that may result in sudden changes in fire intensity may require their own fire behaviour predictions so that crew are aware of expected fire behaviour;
- Mine shafts, cliffs, powerlines, gas pipelines and other utilities may pose particular risks to crew safety and these should be highlighted in burn plans together with any mitigation strategies required; and
- Known hazardous trees can be highlighted in the burn plan so that they are brought to the attention of those conducting the burn and appropriate actions can be taken if required.

### 9. Confirm control lines, escape routes and safety zones are clear and safe to use

Confirm burn access routes and boundaries for lighting and burn management activities are identified and safely accessible, ensure escape routes for each burn sector are identified, appropriately mapped and confirmed as clear to use in the event that they are required.

It is important that control lines, water points, safety zones and escape routes and contingency control lines identified in plans as fit-for-purpose have been checked to ensure they are in a suitable condition and correspond with those marked on maps and plans. Where crews are operating in areas they are not familiar with, field marking of control lines and escape routes with directional arrows, tape or other means can be helpful, particularly where there may be uncertainty about which route to take.

For night burns, escape routes are normally checked during the day and additional options for signage and directional arrows appropriate to night operations should be considered.

## 8.2 Burn crew safety – burn implementation

### 10. Crew competency/experience matched to burn type and role

Ensure all burn personnel have appropriate competencies, experience and skills for the burning operation and their role. Ensure crews are supervised and are following correct procedure.

When selecting an officer in charge of the burn, ensure they are matched to the type and complexity of the burn they are asked to implement. When tasking burn crews, ensure they are matched to the particular tasks they are asked to implement.

While qualifications are important, the experience and local knowledge of crew leaders and crews is essential to be able to consider the range of uncertainties associated with an operation, and mitigate the potential impact of these.

Mentoring by experienced practitioners and personnel with local knowledge provides a key means to address experience and local knowledge gaps and can facilitate knowledge transfer. The presence of experienced personnel where occasionally there may be pressure to proceed with a burn in marginal conditions can greatly assist in the decision to proceed or not.

Effective communication and coordination within and between crews is an essential element of mitigating risk. Ongoing monitoring of how the fire is progressing and how the crews are holding up is important. Burning personnel should feel comfortable raising their concerns if something does not look right, and not assume that because more experienced persons are present that they will step in, that they have already observed something or they are ready to respond.

Fire behaviour needs to be monitored for changes (however small) and those changes communicated. Adjustments to objectives or resourcing may need to be made, with these changes communicated back to crews.

## 11. Treat hazards and assess new hazards in areas crews are working

Implement risk reduction strategies identified in the burn plan. Ensure all areas where crews will be working are assessed for site and operation-specific crew safety hazards not yet identified, with appropriate control actions identified and incorporated into safety briefings.

Prescribed burning, like many field-based activities, includes a range of operation-specific hazards. The most common hazards which present safety risks to crews include the following:

- Tree or limb fall;
- Vehicle movement (e.g. contact, fatigue, motor vehicle accidents);
- Heat stress and medical (e.g. fatigue, heart attack);
- Equipment use (e.g. manual handling, chainsaw, fuel);
- Environmental (e.g. falls, cliffs, bites, trips, vegetation-eye impact injury);
- Built (e.g. mineshafts, gas pipelines, powerlines)
- Flame; and
- Smoke.

Fire and land management agencies typically have job safety assessment systems to meet their responsibilities under occupational health and safety legislation and regulations. These require some sort of site safety check in which the presence of hazards are checked prior to prescribed burn operations on the day or day prior to the burn. Many hazards will have been identified in burn plans and the burn plan may include site safety risk reduction strategies that can now be undertaken. However, some hazards may not have been identified in the burn plan, or may have arisen since the time the burn plan was written.

Tree or limb fall is one of the most significant risks in forests, therefore the assessments of dangerous or potentially dangerous trees is a key consideration in the planning of a prescribed burn and during prescribed burn site preparation, light-up, mop-up, patrol and re-opening of the site. Fire and land management agencies typically have dangerous tree recognition methods and checklists tailored to the nature of forests and woodland in their operating environments. Training in dangerous tree recognition is part of firefighting training. Preventative treatment of obviously defective trees (those which have readily observable characteristics that render them susceptible to catching alight and being further weakened by fire within a tree length of boundaries) may be safer and more efficient than having to monitor and deal with burning trees during the duration of the burn and patrols. Trees with a lean toward containment lines and/or in relatively open positions exposed to wind, have an amplified risk. Treatments may include raking or creating an earth break around the base or grove, candling in advance of the prescribed burn, felling dangerous trees, or excluding particularly dangerous sections from the burn area. Potentially dangerous trees identified both before and during the burn, should be clearly marked in the field.

Traffic management plans, smoke hazard warning signage on roads, and stop/go control measures are a key mitigation measure to address vehicle accidents.

# 8. BURN CREW SAFETY

In the delivery of remote burning operations, additional considerations include:

- Fatigue, particularly if crews are working long days, have long travel times and/or are sleeping in tents or swags where sleep may be disturbed. Recreational opportunities and catering arrangements need consideration;
- Logistics such as camping arrangements, food, water, fuel and spare parts;
- Crew replacement for contingencies or extension of the planned burning operations;
- Team composition, competencies and medical conditions; and
- Emergency planning and natural hazards including dangerous fauna such as snakes and crocodiles at water access points.

Night burns add an additional dimension to operational risk due to:

- Reduced awareness of hazards as vision is more restricted;
- Site unfamiliarity which may require scoping of the site and marking potential hazards (including problem trees) during daylight hours;
- Colder overnight conditions with implications for the adequacy of PPE;
- People may not be aware of how weather varies during the night at the locality, unless they live locally;
- Due to more residents being home, there may be increased risks associated with smoke or escaped burns. There may also be increased traffic due to more onlookers. Street meetings and/or traffic management plans may be required; and
- A more detailed communications plan might be required to ensure that communications can be maintained.

Some jurisdictions require a further site safety check after lighting operations prior to crews re-entering burnt areas (e.g. for mopping up and patrol).

## 12. Brief crews on safety hazards, risk controls and contingencies

Ensure an operational briefing covering hazards and safety management for both ground and air operations is provided to all burn crew members, and that safety hazards, risk control measures and emergency and contingency arrangements are understood.

Operational briefings are a mandatory requirement of most prescribed burns and are usually structured around the SMEACS (Situation, Mission, Execution, Administration, Command/ Communications and Safety) format. Briefings clearly define the objectives for both air and ground operations, the uncertainties and hazards associated with the activities, the risk control measures and contingency plans.

Briefings also provide an opportunity to challenge and confirm the understanding that people involved in the burning operations have of the objectives, hazards, controls and contingencies. The person delivering the briefing can explicitly ask:

- What are the things that we have forgotten?
- What are the uncertainties with the approach? and,
- Are there any things flagged as medium or low risk that shouldn't be?

When crew briefings are conducted, it is important to confirm that each crew and each crew member has a clear understanding of burn boundaries, safety hazards, escape routes and contingencies.

Formal briefings are not the only means of communicating safety hazards and emphasising particular exposures. Informal briefings, Sitrep processes and ongoing supervision provide additional means of safety hazard identification, risk appraisal and control.

## 13. Ensure PPE, equipment and communications are in order

Crews should be appropriately equipped, dressed in approved PPE and have effective means of communication.

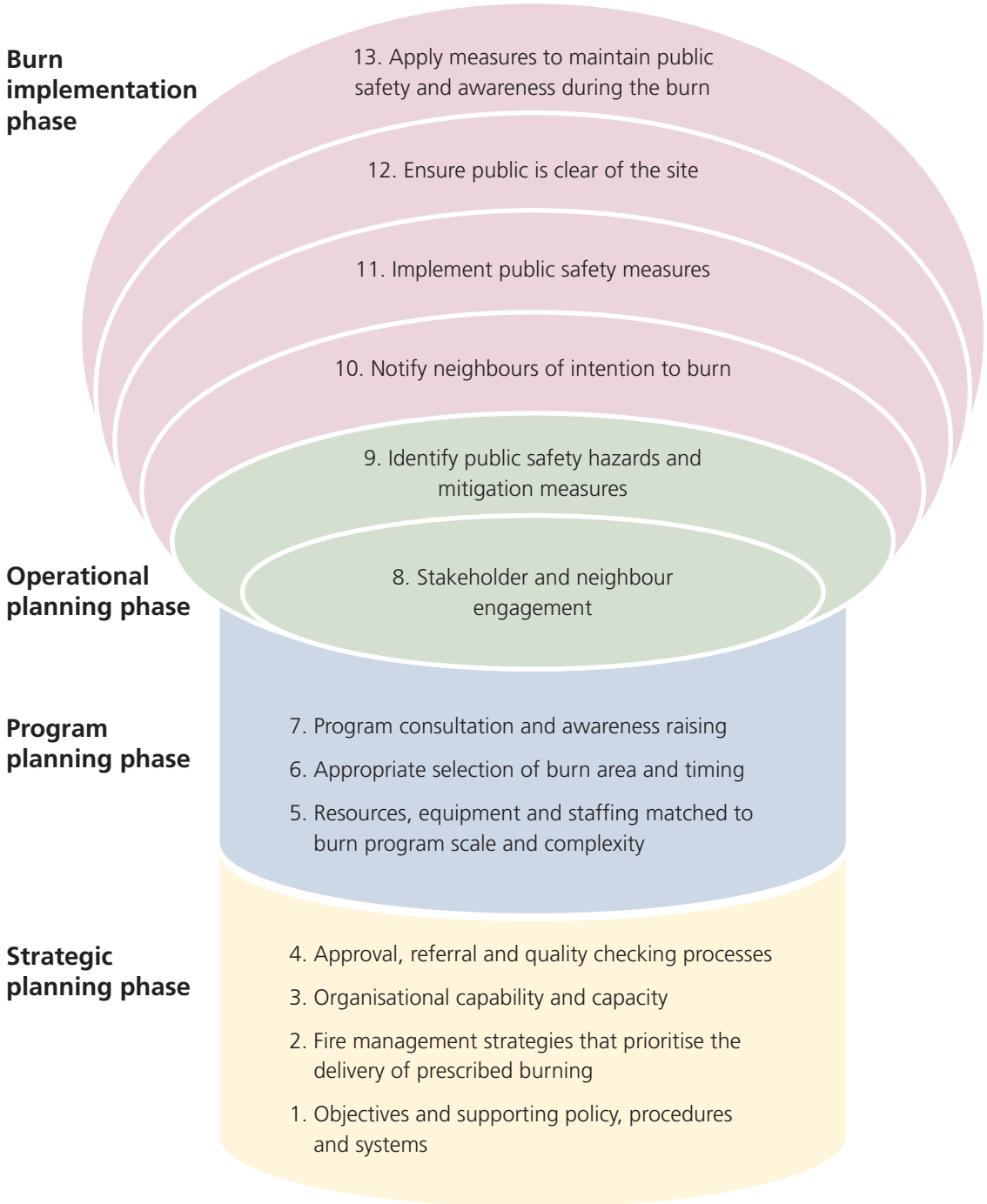
Prior to ignition, ensure burn crews are suitable equipped and are attired in approved PPE. Ensure firefighting equipment is appropriate for the job, in working order and safe to use. Ensure crews have suitable communication equipment that is working. Strategies to overcome communication blackspots may be required.


*(Source: Department of Environment, Water and Natural Resources South Australia)*

# 9. PUBLIC SAFETY

Figure 13 outlines the multi-layered risk control strategies typically undertaken for public safety, which are discussed in detail in the following section. Although the focus is at the level of prescribed burn operational planning and implementation, all phases of prescribed burn planning are important. Burn control and security (see Section 7) also contributes significantly to public safety.

***Figure 13*** *Public safety risk control measures*



## 9.1 Public safety – operational planning

### 8. Stakeholder and neighbour engagement

Consulting neighbours and stakeholders prior to the burn enables them to raise issues that may be pertinent to burn planning and take any actions required to ensure their property or assets are prepared.

Consulting with neighbours and stakeholders during the planning of individual burns should specifically target those persons directly adjoining the burn area, including contingency areas. Collaboration and cooperation with potentially affected neighbours is important as there may be a fall-back option on neighbouring properties to hold the fire if it escapes, they may have assets requiring protection within or adjoining a burn area, or there may be a need to quickly advise them when contingency plans are enacted in response to changing conditions. Neighbours or local stakeholders may be able to contribute local knowledge or experience of previous burns in the area, and may raise potential safety hazards.

For certain burns, the preparation of a ready to implement communications plan is an important tool that can save staff resources, assist in smoother burn delivery, and allow personnel to focus on essential burn implementation tasks during the burn delivery phase without being distracted by unexpected issues. Key elements of such a plan may include letter box drops, media releases, door knocking, text messages, email, variable message boards on roadsides, static signs and other mechanisms. Each communication strategy will need to be tailored to specific burn conditions and be of a scale appropriate to the number of stakeholders that would like to be kept informed.

Opportunity may also need to be provided for neighbours to identify if they need special assistance to make appropriate preparations. Fire and land management agencies typically have brochures and guides describing the measures individuals can take in preparing their house or business for potential fire impacts. Some materials may require tailoring to address language issues in areas with migrant populations, or different delivery methods may be required, such as when targeting Traditional Owner groups.

### 9. Identify public safety hazards and mitigation measures

Scope out any public safety hazards particular to the burn site and contingency area and plan any mitigation measures required to reduce risks to acceptable levels.

During planning for individual burns, risks to the public need to be identified, and any risk-mitigation treatments required documented. Risks to the public may arise due to:

- The public unexpectedly being present in the burn area;
- Smoke impacting sensitive receptors such as nursing homes, hospitals, schools or transport infrastructure such as roads or airports; and
- Traffic risks associated with smoke affecting visibility or through trees falling onto the road, or due to the presence of slow moving or parked fire vehicles along the edge of the road.

Agencies often require the preparation of a traffic management plan as part of or attached to the burn plan. Smoke management planning of some sort often forms part of burn plans, and may influence the choice of wind direction and ignition pattern.

Asking 'what-ifs?' during the planning phase, in relation to members of the public entering the burn area can assist in identifying mitigation measures, e.g. placement of signage to inform the public not to enter the burn area. However, there may be a need to consider the access needs of adjoining land users such as neighbours, farmers, and livestock haulers when planning any access restrictions.

## 9.2 Public safety – burn implementation

### 10. Notify neighbours of intention to burn

Ensure that neighbours and other potentially affected stakeholders are notified that the burn is taking place and reminded of their opportunity to complete preparations to avoid any impacts or minimise smoke effects.

Notifications should provide basic information on the burn about to be implemented and remind neighbours to take risk mitigation actions, including preparing backyards and verandas, and removing items vulnerable to embers and fine fuel adjacent to the house. Other actions may include moving livestock to a paddock away from the fire boundary, or keeping horses in stables.

Closing reserves or forests to the general community through websites, signage and media platforms including radio, and where applicable also via social media, is also commonly undertaken by agencies to provide an additional layer of notification to the public that they should not be accessing the site.

### 11. Implement public safety measures

Ensure public information signage, smoke warning hazard signage, traffic control and any other planned public safety measures are in place in potential impact zones for the burning operation.

Public safety measures at and near the burn site may include:

- Smoke hazard warning message boards with simple messages such as burn coming up, burn in progress, reduce speed, turn on headlights, and burn patrols in progress;
- Signs, flags, tape or barriers on major walking tracks;
- Signs at information areas, trail heads or on roads that provide entry points;
- Road closures;
- Stop/go measures on major routes; or
- Warning signs on major road approaches.

Access barriers and signage advising of potential hazards should be erected at the entry points to the burning area. It should be noted that it is impossible to completely limit or physically block access to a burn area and the public may not see signage. However, hazard warning signage and traffic management measures are key physical measures, complementing communication tools, to assist in letting the public know that a prescribed burn is coming up or underway and that there are public safety hazards associated with the activity requiring them to remain clear of the area or take precautions to maintain their own safety and potentially that of others (e.g. reduce driving speed in smoke-impacted areas).

The burn plan may have identified other measures to improve public safety beyond those mentioned above. These should be implemented.

## 12. Ensure public is clear of the site

Confirm members of the public are clear of the designated burn area and areas immediately adjoining the burn site. This may include checking for campers, itinerants, unapproved media or persons undertaking recreational activities.

An on-ground or aerial assessment for people within the burn area, and areas that may form part of contingency plans should be implemented along the main access routes prior to light-up. It may be prudent to liaise with appropriate local information sources to check on whether any people are known or thought to be in the area.

## 13. Apply measures to maintain public safety and awareness during the burn

Ensure operational measures are implemented to maintain public awareness and safety throughout prescribed burning operations, and enact contingency measures if required.

The range of potential public safety risks (including smoke-related risks) specific to a burn site are mostly identified during burn planning, with necessary control measures specified in the burn plan for implementation during burning. However, not all risks can be foreseen in the planning phase, and it is prudent to expect that some unforeseen risks may arise during operations. Therefore, in addition to continually monitoring burn control and security risks and burn crew safety risks, throughout burn operations, crews also must monitor for new or changing public safety risks.

Public safety risks from prescribed burning operations can be many and varied. A key risk group are motorists, due to increased potential for motor vehicle accidents. These can arise from drivers not reducing their driving speed in reduced visibility due to smoke, and from driver distraction where roadside operations are occurring.

Tree-fall risks are a significant issue at many forest and woodland burns, particularly those where significant numbers of trees have exposed stem deadwood or butt hollows that can be ignited during the burn.

# 9. PUBLIC SAFETY

Public safety risks do not end when a burn reaches mop-up and patrol stage. Many trees that catch alight during the burn can take a considerable time to burn internally and eventually have their structural integrity reduced to the point of failure. This often peaks in the patrol phase. Other issues in areas popular with walkers and other recreational groups can arise where people deviate from formed tracks into recently burnt areas where concealed hazards such as underground combustion sources (such as old stumps, roots or peat beds) may still be actively burning, or where visitor infrastructure has been damaged (e.g. wooden boardwalks or bridges). Also, smoke that is taken aloft with convection during the active burning phase can cool and descend during the patrol phase. In some situations and environmental conditions it can pond and concentrate in low-lying areas and become considerably denser at ground level than during the active burning period. Therefore, continued attention to public safety risk management is required throughout the mop up and patrol phase.

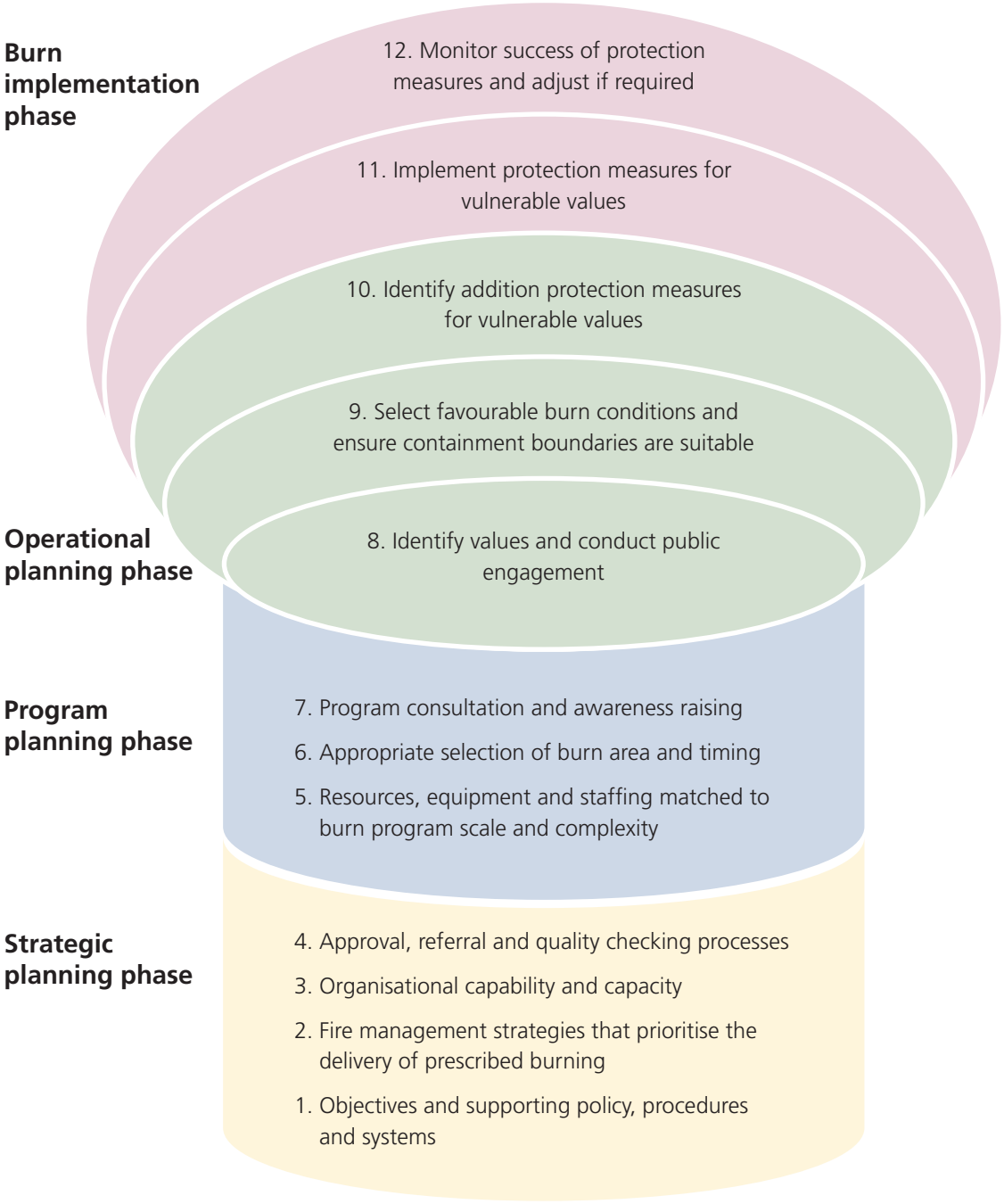
Once the patrol phase of a burn is nearing completion and decisions to re-open burn areas to public access and use are being contemplated, a final post-burn public safety assessment should be conducted to determine that the area is again safe for the public to access. Fire and land management agencies typically have post burn safety assessment protocols, procedures or checklists in place which are risk-based, prioritising areas of greatest potential exposure to hazards (e.g. walking routes, picnic areas, and trees on boundaries, camping grounds, near roads and parking areas).

*(Source: Bushfire CRC)*

# 10. IMPACT ON VALUES

Figure 14 outlines the multi-layered risk control strategies typically undertaken to manage risks to vulnerable built assets, infrastructure, natural or cultural heritage values. These risk controls are discussed in detail in the following section. Although the focus is at the level of prescribed burn operational planning and implementation, all phases of prescribed burn planning are important. Burn control and security (see Section 7) also contributes.

***Figure 14*** *Impact on values risk control measures*



# 10. IMPACT ON VALUES

## 10.1 Impact on values – operational planning

### 8. Identify values and conduct public engagement

Undertake desktop and field assessment to identify potentially vulnerable values. Also engagement with neighbours can elucidate values or mitigation measures that the burn planner was previously unaware of, but which can be included in the burn plan.

When planning a prescribed burn, it is essential to gain familiarity with the built, natural and cultural values that are on or near the burn site. Strategic-level planning documents are a good place to start, and most agencies will have GIS resources that will greatly assist. However, to properly identify values, it is necessary to visit the site of the burn and nearby areas. Local knowledge of values within or near the prescribed burn area is indispensable, as GIS, data systems, maps and drive-by appraisal may not facilitate discovery of all issues. Vulnerable values may include, but are not limited to:

- Residential structures and outbuildings;
- Transport corridors including smoke impacts on highways, shipping channels, rail-lines and airports;
- Utilities supply infrastructure;
- Communication towers, cables or conduits;
- Health and childcare facilities;
- Livelihood and commercial assets (including grazing infrastructure and fences, hives, smoke vineyards, livestock and crops);
- Buildings, machinery, houses, aquaculture enterprises;
- Ecosystems or species with particular fire management needs;
- Planned community or seasonal events;
- Water catchments; and
- Cultural heritage values.

Some of these values may be directly within the designated burn area, and others may be closely adjacent or within a contingency area. Some burns, for example large burns in peri-urban areas, can have a large number of exposed vulnerable built assets, with their protection amounting to a significant component of burn planning.

Engagement with stakeholders is implemented via a range of means including letters, door knocking, community and stakeholder group meetings or an on-site walk throughs. In terms of protecting values, such consultation has two major benefits:

- Allows opportunity to raise the awareness of stakeholders and neighbours with regard to actions they may take to protect their own values during prescribed burning operations; and
- Allows opportunity for stakeholders and neighbours to identify values or mitigation strategies that burn planners may have been previously unaware of but which may be included in the burn plan.

In some prescribed burn situations, particularly burns in peri-urban areas, or where smoke can potentially impact major commuter routes, mass public transport infrastructure, or major community events, the stakeholder consultation aspects of burn planning can be a major component of planning.

## 9. Select favourable burn conditions and ensure containment boundaries are suitable

Plan and implement the burn at a time and in conditions that are within acceptable limits of impact potential and damage to values. Ensure containment boundaries are suitable.

Not all values on or near the burn area will be vulnerable to prescribe fire. For them to be vulnerable they need to be potentially damaged by flames, radiant heat or embers, or else impacted by smoke. Values that are assessed to be vulnerable should be included in the burn plan. Consult the opinions of experienced practitioners, if necessary, to determine whether values are vulnerable. Irrespective of their vulnerability or not, all built assets should be identified on the prescribed burning map.

Two key aspects of ensuring values are protected include:

- Selecting favourable conditions under which to burn when planning burn prescriptions. Burning under suitably mild conditions will mitigate many risks to values and such conditions can be prescribed in the burn plan; and
- Ensuring the burn can be contained within planned boundaries. For more information, see Section 7.

For those values where it is assessed that there is an unacceptably high level or risk, appropriate risk reduction measures need to be devised and included in the burn plan as discussed below.

## 10. Identify addition protection measures for vulnerable values

Consult asset owners or technical specialists if required to help form mitigation measures.
Have contingencies planned in the event of unexpected fire behaviour or circumstances.

Fire and smoke vulnerable values within and near the burning area may require preparation and protection works on the value itself or within the area surrounding the value to reduce the potential for impacts from the prescribed burn (e.g. from flame, radiant heat, embers, smoke or vehicle/plant movement associated with the burn). Such measures are discussed in Section 10.2.

For certain assets, infrastructure (such as utilities) and natural values (e.g. endangered species), liaison with the asset owners/managers or technical specialist may be required to confirm the appropriateness of planned mitigation measures, and to confirm any action necessary on the part of the stakeholders. For cultural heritage values, consultation with Traditional Owners is advised.

## 10.2 Impact on values – burn implementation

### 11. Implement protection measures for vulnerable values

Implement mitigation strategies identified in the burn plan and any other mitigation measures required to protect values.

Many values may require particular mitigation strategies in order to reduce their risk to acceptable levels. These should have been documented in the burn plan, but additional values or a requirement for altered mitigation measures may be identified on the day of burning. Mitigation measures may include:

- Establishing temporary control lines which may include slashed lines, rake-hoe lines, wet lines or areas cleared of all fuel;
- Using appropriate ignition strategies to back fire away from values;
- Burning with appropriate winds so that embers, smoke and flames are directed away from values;
- Preliminary burns in areas adjacent to values under very mild conditions to establish a burnt buffer prior to conducting the main prescribed burn;
- Notification of owners of the built assets so that they are aware and may potentially assist by preparing their property;
- Planned contingencies; and
- Notification of additional resources (and local brigades) so that they can be ready to respond, or so that they can be in attendance with suitable appliances to assist in protecting values.

Protective measures need to be in place prior to light up and their readiness confirmed as part of the ignition approval process. Some protective measures will require preparation well in advance of the prescribed burn.

Briefings should ensure that lighting crews are aware of the location of infrastructure, assets, natural and cultural heritage values as shown on the map. Sometimes heritage values are not shown on maps to protect cultural integrity, in which case the general location of values can be indicated during briefings.

### 12. Monitor success of protection measures and adjust if required

Monitor fire behaviour and containment security, and apply control measures to any fire events and circumstances which pose unacceptable threats to values (e.g. flare-ups, increased fire behaviour or spot-overs).

Not all risks can be foreseen in the planning phase, and it is prudent to expect that some unforeseen risks may arise during operations. Therefore, in addition to continually monitoring burn control and security risks and safety risks throughout a burn, crews also must monitor risks to values.

During the burn, adjustment to strategies to protect values may be required for various reasons such as changes in weather, unexpected fire behaviour, spot overs or escapes or changed ignition patterns. Crews should be aware of circumstances that would trigger planned contingencies.

# 11. OPERATIONAL RISK MANAGEMENT FRAMEWORK

From the analysis in the preceding sections, a framework for considering the operational (control and impact) risks for prescribed burning has been developed. The framework is depicted on the following pages (Figure 15).

The framework identifies the following:

- The prescribed burn planning and operations sequence from strategic planning through the program planning phase, operation planning phase to burning implementation phase (see also Section 5 and 6); and
- The four[5] operational risk dimensions associated with prescribed burning as follows:
  - **Burn Control and Security** (Section 7);
  - **Burn Crew Safety** (Section 8);
  - **Public Safety** (Section 9); and
  - **Impact on values** (Section 10).

Operational risk factors are considered for each risk dimension numbered sequentially across each phase of the prescribed burn planning and operations process, getting progressively finer in resolution as the phases of planning and operations progress to the implementation phase.

The value of the operational risk framework is chiefly:

- To set out and define the key phases of the prescribed burn planning and implementation process;
- To identify the purpose and scale of operational risk assessment based on the key operational risk dimensions at each phase; and
- Identify the key operational hazard attributes for assessment.

It is a high-level, non-prescriptive framework. It can be readily adopted in Australian jurisdictions, providing for improved alignment of approaches whilst still accommodating locally developed methodologies tailored to the different statutory and policy frameworks, institutional arrangements, agency capabilities, and operating environments in each jurisdiction.

Knowledge and systems exchange between jurisdictions, as has been conducted to various extents in the past, can promote practice improvement in different parts of the framework, particularly if considered as part of a structured review and improvement processes.

Combined with other prescribed burning risk management frameworks that have been developed (AFAC 2015a, 2015b, 2016) it may be possible to develop national, but locally customisable tools for prescribed burning risk assessment.

5 Note that this list does not include environmental risk, smoke / greenhouse gas risk or fuel hazard risk which is dealt with under separate National Burning Project risk frameworks.

# 11. OPERATIONAL RISK MANAGEMENT FRAMEWORK

***Figure 15*** *Operational risk management framework*

| Strategic | Program Planning | Phase/ Dimension |
|---|---|---|
| **1. Objectives and supporting policy, procedures and systems**<br>– Strategic level objectives are clearly articulated and supported by policies, procedures, standards, guidelines and systems.<br>– Systems and procedural frameworks are matched to the scale of complexity of prescribed burning required including:<br>  – Prescribed burning, safety, risk management, impact assessment and community engagement procedures.<br>  – Technical guidelines and decision support systems for fuel assessment, fire behaviour, fire spread, smoke management, ecological fire regimes etc.<br>  – Public engagement information systems, portals and procedures (e.g. internet portals, social media, text messaging systems).<br>  – GIS, asset management, human resource and other data systems.<br>– Cooperative agreements and workforce arrangements with supporting agencies and interoperability of systems, procedures and communications.<br>– Continuous improvement culture facilitated.<br><br>**2. Fire management strategies**<br>– Strategic level planning documents are available that guide how much, where in the landscape, types, complexity and range of burns. This dictates burn program requirements which in turn dictates organisational capability requirements. These need to be in good alignment for optimal risk management. Risk landscapes and fire management zoning plans are examples of fire management strategies.<br>– Community engagement strategies, and guidelines to support or restrict burning by private landholders.<br>– Strategies that address protection of built, natural and cultural values.<br><br>**3. Organisational capability and capacity**<br>– Technical capability, resources, equipment, staffing and financial allocation commensurate to quantity, type and complexity of prescribed burning activities required.<br>  – Recruitment and retention strategies.<br>  – Training competencies, training material, trainers and training systems.<br>  – A means to guide, restrict, facilitate and support independent contractors.<br>  – Mentoring and professional development opportunities.<br>  – Training on crew safety aspects of burning operations (e.g. site safety surveys, hazardous tree identification).<br>  – Capacity to undertake public safety aspects of burning operations (e.g. public warning issues, stakeholder engagement, traffic management).<br><br>**4. Approval, referral and quality checking processes**<br>– Ensure there are appropriate requirements to have prescribe burn plans quality checked, peer reviewed and approved. Also, approval processes around scheduling burns and permission to ignite burns are required.<br>– Peer review includes review by those with suitable expertise in different aspects of prescribed burning.<br>– Approval by suitably experienced people. | **5. Resources, equipment and staffing matched to burn program scale and complexity**<br>– Assess burn program quantity, complexity and technical difficulty in relation to internal capacity and capability.<br>– Decide appropriate technical skill and experience levels required for assigning burn delivery responsibility.<br>– Avoid as far as possible, nominating burns into programs that are beyond the technical capability of local resources to deliver, or be aware of the need to bring in external resources.<br>– Generally, the type and quantity of burning should not exceed the local region's ability to deliver the specified program in terms of equipment and staffing.<br><br>**6. Appropriate selection of burn area and timing**<br>– Prescribed burn area, location, boundary, timing and sequence selection are not avoidably difficult or risky to treat operationally, will not pose unnecessary safety risks to crews or to the public, and will not generate undue smoke impacts or impacts on assets or values.<br>– Assess the extent to which prudent program design (timing, sequencing and placement of burns) can reduce operational risks in later phases. Decide program design and fire control line investment that could reduce operational delivery risks.<br>– Avoid programming burns during periods with conditions that pose high risks of escapes or during periods of escalating bushfire risk. This needs to be weighed against risks of delaying burns.<br>– Burn area selection and timing will not generate undue smoke impacts or unnecessary cumulative smoke impacts. Be particularly aware of sensitive smoke receptors, transport corridors, business/ industry impacts and major community events.<br>– Burn area dimension, location and timing do not generate collateral impacts to built assets, cultural and natural values that are outside of tolerable limits.<br>– Be aware of burns that have particular sequencing requirements to build protective buffers of lower fuel for subsequent burns.<br>– Program more burns where possible (including plans for forward years and varying in complexity), so that in the event of inclement weather in one location, burns in other locations can be brought forward to keep the program stable.<br><br>**7. Program consultation and awareness raising**<br>– Raising the level of public awareness of burn programs (newspapers, internet) well in advance of prescribed burning activity increases community acceptance of burn programs and allows community members to be prepared.<br>– Assess potential burn program impacts to external assets and economic values and decide industry sector engagement and standard mitigation approaches. | Burn control and security<br><br>Burn crew safety<br><br>Public safety<br><br>Impact on values |

# 11. OPERATIONAL RISK MANAGEMENT FRAMEWORK

| | Operational Planning | Burn Implementation |
|---|---|---|
| Burn control and security | **8. Select favourable burn prescriptions**<br>– Use prescriptions that are suitable to achieve prescribed burn objectives while safely containing the burn. Be aware of conditions that may produce unexpected fire behaviour such as certain fuel types, drought effects and thresholds (e.g. wind speed, FMC) beyond which fire behaviour suddenly escalates.<br>– When monitoring windows of opportunity for burning, select a day, or sequence of days when forecast weather conditions are predicted to generate controllable fire behaviour within acceptable prescriptions to achieve objectives, and in which the burn can be completed and securely mopped-up.<br>– Apply higher level of rigour/approval when it is determined that it is necessary to burn outside of prescription.<br>**9. Select and confirm boundaries are fit for purpose**<br>– Confirm burn boundary features are appropriately located and are suitable to contain predicted fire behaviour. Be aware of boundary weak spots, adjacent fuel condition, spotting risks and the effect of planned lighting patterns on boundary stability. For unbounded burns, it is important to understand where the burn is likely to stop/extinguish and how.<br>– Seek local knowledge when determining suitability of boundaries.<br>**10. Contingencies plans are prepared**<br>– Have in place ready to activate fall-back containment and consequence management contingencies to address the potential for significantly increased fire behaviour within the burn area or escapes across containment lines. | **11. Check boundaries prior to burning**<br>– Boundaries may have been prepared weeks or months in advance, and therefore there is a need to check boundaries close to the day of burning.<br>**12. Confirm, implement and adjust lighting pattern**<br>– Confirm the ignition method and lighting sequence, pattern and timing are suitable for site conditions (e.g. fuels, slope, weather, resources) and will keep containment lines manageable, and meet burn objectives and fire behaviour prescriptions.<br>– Ensure crews are appropriately skilled for lighting and containing the burn in their sector(s) and maintain leadership over lighting crews.<br>**13. Monitor burn and control escape risk sources**<br>– Monitor fire behaviour and containment security, and apply control measures to any fire events and circumstances which pose unacceptable threats to burn security (such as flare-ups, increased fire behaviour or spot-overs). Be aware of condition creep. Implement sit-rep reporting protocols.<br>**14. Activate contingencies if required**<br>– It is important to brief crews about contingency arrangements and ensure they understand triggers that may activate planned contingencies.<br>– Enacting contingencies may require changing command structure, revising objectives and issuing information. |
| Burn crew safety | **8. Identify safety hazards and mitigation strategies**<br>– Scope out risks to crew safety and identify any planned mitigation strategies required to reduce risk to a tolerable levels.<br>– Consider hazardous trees, vehicle movement, heat stress/medical, equipment use, environmental, built obstructions, flame and smoke.<br>– Consider additional requirements for remote or night burns.<br>**9. Confirm control lines, escape routes and safety zones are clear and safe to use**<br>– Confirm burn access routes and boundaries for lighting and burn management activities are identified and safely accessible, ensure escape routes for each burn sector are identified, appropriately mapped and confirmed as clear to use in the event that they are required. | **10. Crew competency/experience matched to burn type and role**<br>– Ensure all burn personnel have competencies, experience and skills appropriate for the burning operation and their role. Ensure crews are supervised and are following correct procedure.<br>**11. Treat hazards and assess new hazards in areas crews are working**<br>– Treat hazards identified in the burn plan and ensure all areas where crews will be working are assessed for site and operation-specific crew safety hazards and mitigation strategies identified.<br>**12. Brief crews on safety hazards, risk controls and contingencies**<br>– Ensure an operational briefing covering hazards and safety management for both ground and air operations is provided to all burn crew members, and that safety hazards, risk control measures and emergency and contingency arrangements are understood.<br>**13. Ensure PPE, equipment and communications are in order**<br>– Crews should be appropriately equipped, dressed in approved PPE and have effective means of communication. |
| Public safety | **8. Stakeholder and neighbour engagement**<br>– Consult neighbours and stakeholders prior to the burn to enable them to raise issues that may be pertinent to burn planning and take any actions required to ensure their property or assets are prepared.<br>– Consider the need for a communications plan.<br>**9. Identify public safety hazards and mitigation measures**<br>– Scope out any public safety hazards particular to the burn site and contingency area and plan any mitigation measures required to reduce risks to acceptable levels.<br>– Examples of public safety hazards include the public unexpectedly present in the burn area, smoke impacting on sensitive receptors (e.g. nursing homes) and transport infrastructure, traffic risks and hazardous trees during and after burning operations are complete.<br>– After ignition phase, site safety checks are often conducted prior to re-opening the site to crews or the public. | **10. Notify neighbours of intention to burn**<br>– Ensure that neighbours and other potentially affected stakeholders are notified that the burn is taking place and reminded of their opportunity to complete preparations for impact avoidance or minimisation of smoke effects.<br>**11. Implement public safety measures**<br>– Ensure public information signage, smoke warning hazard signage, traffic control and any other planned public safety measures are in place in potential impact zones for the burning operation.<br>**12. Ensure public is clear of the site**<br>– Confirm members of the public are clear of the designated burn area and areas immediately adjoining the burn site. This may include checking for campers, itinerants, unapproved media or persons undertaking recreational activities.<br>**13. Apply measures to maintain public safety**<br>– Ensure operational measures are implemented to maintain public awareness and safety throughout prescribed burning operations, and enact contingency measures if required. |
| Impact on values | **8. Identify values and conduct public engagement**<br>– Identify values using desktop and field assessment. Ensure potentially affected stakeholders are consulted and have an opportunity to raise issues.<br>**9. Select favourable burn conditions and ensure boundaries are suitable**<br>– Plan and implement the burn at a time and in conditions that are within acceptable limits of impact potential and damage to values. Ensure containment boundaries are suitable.<br>**10. Identify additional protection measures for vulnerable values**<br>– Identify fire-vulnerable values. Record their location in the burn plan and consult asset owners/ specialists to confirm avoidance or protection measures. Have contingency measures planned. | **11. Implement protection measures for vulnerable values**<br>– Implement mitigation strategies identified in the burn plan and any other mitigation measures required to protect values. A wide range of measures are possible such as burning away from the values, using particular wind directions and raking fuel away from values.<br>**12. Monitor success of protection measures and adjust if required**<br>– Monitor fire behaviour and containment security, and apply control measures to any fire events and circumstances which pose unacceptable threats to values (e.g. flare-ups, increased fire behaviour or spot-overs). |

# 12. ACKNOWLEDGEMENTS

The project to produce this report was made possible through funding from the Attorney-General's Department.

The report was prepared by Paul de Mar and Dominic Adshead (of GHD) and revised by Wayne Kington (of AFAC) for AFAC, AGD and the Forest Fire Management Group (FFMG). The report was edited by Deb Sparkes of AFAC.

The content was generated from input by AFAC member agency staff and key stakeholders and their contributions are highly appreciated. Other valuable contributions, including photographs, were received from other agency staff and their contributions are also recognised.

Front cover photograph was provided by Ian Tanner of the Department of Environment, Water and Natural Resources South Australia.

The National Burning Project Steering Committee has worked consistently to ensure the project attracted funding, stayed on track and achieved desired outcomes. Their contributions are also acknowledged. The National Burning Project is managed and supported through the considerable efforts of Greg Esnouf and Deb Sparkes.

*(Source: Country Fire Authority Victoria)*

# REFERENCES


AFAC (2015a) Risk Management and Review Framework for Prescribed Burning Risks Associated With Fuel Hazards. Report for National Burning Project – Subproject 3. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

AFAC (2015b) Risk Management Framework – smoke hazard and greenhouse gas emissions – Subproject 3. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

AFAC (2015c) National Guidelines for Prescribed Burning Operations – Subproject 4. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

AFAC (2016) A Risk Framework for Ecological Risks Associated with Prescribed Burning. Report for National Burning Project – Subproject 3. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

Bureau of Meteorology (2015) Annual Report (Canberra: ACT)

FFMG (2014) National Bushfire Management Policy Statement for Forests and Rangelands. Prepared by the Forest Fire Management Group for the Council of Australian Governments. (O'Connor: ACT)

Gould JS, McCaw WL, Cheney NP, Ellis PF and Mathews S (2007) 'Project Vesta. Fire in dry eucalypt forest: fuel structure, fuel dynamics, and fire behaviour' Ensis-CSIRO (Canberra: ACT) and Department of Environment and Conservation (Perth: Western Australia)

Standards Australia (2009) Risk management: Principles and Guidelines (AS/NZS ISO 31000:2009). http://standards.org.au/ [Verified 15 September 2016]

Standards Australia (2004) Risk management (AS/NZS 4360:2004). http://standards.org.au/ [Verified 15 September 2016]

# APPENDIX A: LIST OF PARTICIPATING ORGANISATIONS

ACT Rural Fire Service

Brisbane City Council

Bunya Mountains Murri Rangers

Bureau of Meteorology, Darwin

Bushfires, Northern Territory

Department Of Defence

Department of Environment Land Water and Planning, Victoria

Department of Environment, Water and Natural Resources, South Australia

Department of Fire and Emergency Services, Western Australia

Department of Land and Resource Management, Northern Territory

Department of Parks and Wildlife, Western Australia

Department of Transport and Main Roads, Queensland

Energex

Fire and Landscape Strategies

Gold Coast Council

HQ Plantations

NSW Fire and Rescue Service

NSW National Parks and Wildlife

NSW Rural Fire Service

Office of Bushfire Risk Management, Western Australia

Parks Victoria

Parks and Wildlife, Northern Territory

Quandamooka Yoolooburrabee Aboriginal Corporation

Queensland Fire and Emergency Services

Queensland Parks and Wildlife Service

Savanna Solutions

South East Queensland Fire and Biodiversity Consortium

Tasmania Fire Service

Ten Rivers

Toowoomba City Council

Wildlife Conservancy

# APPENDIX B: PROJECT SURVEY QUESTIONS

**AGENCY AND ORGANISATION SURVEY ON OPERATIONAL RISKS OF PRESCRIBED BURNING**

**AFAC NATIONAL BURNING PROJECT**

**Agency/Organisation name:**

**Completed by (name and email address):**

**Survey Questions**

**1 What Operational Risk Categories (or Factors) does your agency use in assessing the operational risks of prescribed burning?**

**2 Are Risks to Burn Crew Safety assessed?**

2.1 Is Burn Crew Safety Risk documented?

2.2 Are specific Burn Crew Safety Risk Factors assessed:

2.2.1 Burn injury?

2.2.2 Smoke inhalation?

2.2.3 Injury by hazardous (burning) trees/limbs?

2.2.4 Entrapment within burn area?

2.2.5 Trips/falls?

2.2.6 Vehicle accident or rollover?

2.2.7 Heat stress/dehydration?

2.2.8 Clear access/egress?

2.2.9 Electrical/live powerline associated injury?

2.2.10 Injury by rolling rocks/logs on slopes?

2.2.11 Wind change associated fire escalation?

2.2.12 Chemical/fuel handling risks?

2.2.13 Unexploded Ordnance risk?

2.2.14 Other burn crew safety risks?

2.2.15 Please list agency procedures for assessing and managing the above burn crew safety risks

**3 Are burn security risks (risk of escape) assessed?**

3.1 Are burn security risk assessments documented?

3.2 Are specific burn security risk factors assessed:

3.2.1 Adequacy of constructed containment lines?

3.2.2 Adequacy of natural containment features?

3.2.3 Adequacy of contingency containment?

3.2.4 Predicted fire behaviour within the burn area?

3.2.5 Fire behaviour potential adjacent to the burn area?

# APPENDIX B: PROJECT SURVEY QUESTIONS

3.2.6 Heavy or problem fuel types/areas posing elevated escape risk?

3.2.7 Misjudged lighting pattern related escape risk?

3.2.8 Same day weather change related escape risk?

3.2.9 Next day or subsequent weather change related escape risk?

3.2.10 Containment resourcing adequacy risks?

3.2.11 Other burn security risks?

3.2.12 Please list agency procedures for assessing and managing the above burn security risks

**4 Are Public Safety Risks assessed?**

4.1 Are Public Safety Risk assessments documented?

4.2 Are specific Public Safety Risk Factors assessed:

4.2.1 Visitors/tourists/public within the planned burn area?

4.2.2 Traditional Owners on the land?

4.2.3 Tourist operators or event operators?

4.2.4 Road users/motorists on adjacent/nearby roads potentially impacted by fire or smoke?

4.2.5 Smoke-sensitive facility users/communities/land users?

4.2.6 People on neighbouring properties?

4.2.7 Other public safety risks?

4.2.8 Please list agency procedures for assessing and managing the above public safety risks

**5 Are stakeholder notification and warning risks assessed?**

5.1 Are stakeholder notification and warning risk assessments documented?

**6 Are Aircraft Operations/Aerial Burning Operations-specific risks assessed?**

6.1 Are Air Ops Risk assessments documented?

6.2 What Air Ops risk factors are assessed?

**7 Are Asset Damage and other Operational Objectives failure risks assessed?**

7.1 Are these Asset Damage and other Operational Objectives Risk assessments documented?

7.2 Asset damage (within or adjacent to the burn) risks assessed?

7.3 What are the other Operational Objectives Risks that are assessed?

**8 What decision support tools are used for assessing and evaluating operational risks?**

**9 What Agency 'checklists' relating to risk management actions are used?**

**10 Are any night operations specific risk assessed?**

10.1 What additional night operations specific risk factors are assessed?

# NOTES

# NOTES


These reports are available at the AFAC shop www.afac.com.au.

Information about the National Burning Project is available at www.afac.com.au/initiative/burning

# A Risk Framework for Operational Risks Associated with Prescribed Burning

***National Burning Project: Sub-Project 3***


***Authors***

Paul de Mar, Dominic Adshead (GHD) and Wayne Kington (AFAC)

***Editor***

Deb Sparkes (AFAC)

*Prescribed burning is one of the most essential, effective and efficient fuel management operations undertaken by land and fire managers. At the same time it is among the most risky. Variability in fuels and topography across the burn site, coupled with the vagaries of weather predictions make delivery of prescribed burns challenging. The consequences of getting it wrong can be extensive with real possibilities of loss of life or property – all in an environment of high political and community expectations.*

*This document looks at operational risks to life and property surrounding the delivery of prescribed burns. It analyses the risk controls in a structured manner to help ensure prescribed burns are implemented effectively and safely.*

*The risks around prescribed burning can never be eliminated, however they can be managed to acceptable levels. This document is a great leap forward in achieving that goal.*

***– Neil Cooper,***
***Manager of Fire,***
***ACT Parks and Conservation Service***

**AFAC Limited (ABN 52 060 049 327)**
**Level 1, 340 Albert Street,**
**East Melbourne, Victoria, 3002**
**Phone: 03 9419 2388**
**Email: afac@afac.com.au**
**Web: www.afac.com.au**