Lake Tekapo

Wildfire Risk Management Analysis

Tony Teeling and Grant Pearce

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1. Introduction

This wildfire risk analysis has been undertaken by Fire and Emergency New Zealand (FENZ) to better understand the risk of wildfire to life, property, and the environment at Lake Tekapo Village (Village) and its environs, and to subsequently determine risk reduction treatments.

The analysis sets out to identify the impact a wildfire may have on the rural-urban interface (RUI) and wider Village, the Environment Canterbury (ECan) Regional Park, the Mackenzie District Council forests, and the Mt John recreation area and Observatory. These locations are the Area of Interest, with a wider scope area applied to enable capture of ignition risk that may result in wildfires threatening the area of interest. Refer Appendix 1.

2. Assumptions and Limitations

The Analysis is specific to the vegetation fire environment.

Wildfire ignitions occur from either natural causes such as lightning or are human-caused through many activities and their associated heat sources. It is not possible to have control over natural occurring ignitions or activities of those not directly related to the Scope Area, including deliberate ignitions with or without malicious intent.

There are numerous limitations and assumptions within the vegetation fire behaviour fuel models and systems. They are however based on sound science and best practice, and have been adjusted to represent the observed fuels in the Scope Area.

Weather data from remote automatic weather stations (RAWS) may have some data errors that affect averages and data for specific hours on specific days. It may also not be fully representative of all locations and elevation range. Lake Tekapo will influence local weather due to it being a major water body, and major terrain features such as Mt John also affect wind directions and speeds.

Fire behaviour modelling has been completed for likely, worse, and worst-case scenarios based on actual data from the long-term fire climate analysis. This translates to using Very High fire danger class for likely, Extreme for 'worse' and Very Extreme for worst-case. Because the fire danger classes are Very High to Very extreme it can be assumed that in the presence of continuous fuel a fire will spread (refer to New Zealand Fire Danger Class Criteria of Alexander 2008). Additionally, these fire danger classes do not prevail all year.

Damage potential is focussed on the direct impact from a wildfire on structures along the rural-urban interface (RUI), on utility infrastructure, on recreation areas and their visitors, and to the Mount John Observatory structures.

Determination of firebreak widths at the RUI and/or vegetation modifications have been based on estimation of radiant heat levels, and associated thresholds for piloted and non-piloted ignition of timber cladding and glass cracking and fallout.

Quantifying risk based on likelihood of ignition and spread uses wildfire occurrence return periods and assumes an ignition will spread, with consequence using a range of descriptive terms that identify damage levels. A final risk level is determined by combining likelihood and consequence. The

setting of the data ranges and descriptors is somewhat subjective and can be adjusted for organisational risk tolerance if necessary.

3. Definitions

Escape routes. Are routes that can be used to get to a safety zone if the primary route being used is cut off.

Entrapment. Are unexpected situations in which a wildfire poses an immediate threat to peoples' lives because the use of escape routes and safety zones is difficult or impossible. In such situations last resort sheltering may be required to increase survival probability.

Evacuation point. Is a specified assembly location accessible by helicopter or vehicle where people, trapped or otherwise, can be picked up and transported to safety. Evacuation points are not safety zones and do not provide protection from all levels of fire behaviour.

Impact Area. An area or location that has been risk assessed for possible damage potential from wildfire.

Peri-urban. Areas surrounding cities, towns and other urban areas that is neither urban nor rural and can extend well beyond the suburban edge. They are often contested spaces largely regarded as being in transition, can be wildfire prone and often their rapid growth puts added demands on public services. (La Trobe University, https://www.latrobe.edu.au/periurban/about/focus).

Risk ownership. A term used to define who owns a risk and how they own it.

Rural-urban interface (RUI). The area or zone where structures (houses) and other human development adjoin or overlap with flammable vegetation.

Safety zone. Safety zones are places of refuge, where a person can be assured of their safety. Safety zone size is dictated by the fuel, terrain, weather conditions, and worst-case fire behaviour. Escape routes would lead to safety zones.

Wildfire. Unplanned vegetation fire. A generic term which includes grass fires, forest fires and scrub fires, both with and without a suppression objective (https://knowledge.aidr.org.au/glossary/).

Wildfire risk. The combination of the likelihood and consequence of a wildfire at a specific location under specified conditions.

Wildfire management. All those activities directed to prevention, detection, damage mitigation, and suppression of wildfires (https://knowledge.aidr.org.au/glossary/).

4. Stakeholders

Fire and Emergency New Zealand (FENZ)

Mackenzie District Council (MDC)

Environment Canterbury (ECan)

Department of Conservation (DOC)

Alpine Energy

Land management and subdivision contractors

Communication supply service companies

Commercial business operators (including farming and farm forestry)

Private property owners

Community

5. Risk Context

Within the area of interest, the level of risk varies considerably from location to location. This variability includes ignition sources, values requiring protection (what is at risk), and the vegetation fire environment components of fuel, topography, and weather. For example, some locations have numerous ignition sources while others have few, some locations are at risk from wildfire when wind direction is from the northerly quarter while others from the southerly quarter. Fuel type and loads are extremely variable from dense conifer forest to depleted grassland, as is topography, especially slope steepness. Values requiring protection range from life and structural assets to environmental.

To enable analysis of these differences, the area of interest has been divided into risk areas which, in turn, have been sub-divided into zones. Refer Appendix 2. This approach allows risk treatments to be targeted at specific locations. The analysis presents a range of risk treatment options aimed at reducing the likelihood and consequence from a wildfire. However, it is important to understand that modification of risk (controls and treatments) must consider the concept of residual risk, as it is not possible to reduce risk completely to zero.

The Village is expanding with new subdivisions under development. This is increasing the exposure length of the RUI and will increase the number of residents and visitors in the village and recreation areas. The RUI comprises the boundary or overlap of residential and commercial structures with flammable vegetation, and where wildfire could have a direct impact. The village has approximately 6.5 kilometres of RUI which includes new development. Parts of the wider village are also considered for possible ember attack from either vegetation, structures or mobile property that may be burning upwind.

The main recreation areas are the ECan Regional Park northeast of the village which includes a campground, picnic area and walking/biking trails; the MDC forest on the south side of the village with walking and biking trails; and the slopes of Mount John with walking trails.

Other values include the wider township, power distribution assets, communication assets, the Mount John Observatory assets, plus ecological, environmental, historic and cultural assets.

Vegetation, including mature conifer forest (both planted and wilding), is being removed or modified in some locations. The analysis has endeavoured to capture these landscape changes and include them in the analysis. The Mackenzie District Council (MDC) have guidelines and requirements for vegetation modification and are presently preparing an exotic tree management plan. Landscape planners use the MDC guidance when preparing landscape plans for subdivisions.

To mitigate the impact of wildfire on the RUI, recreation areas and other assets, an understanding is required of how wildfire will behave and of the associated damage potential to values. To inform this understanding, likely, worse, and worst-case fire behaviour has been modelled for a range of scenarios based on what is at risk. Specifically of interest is a wildfire's energy release in radiant heat, flame length, rate of spread (ROS), likely smoke plume direction and ember transfer. Additionally for the RUI, fire intensity in kilowatts per metre (kW/m) for an approaching wildfire has been converted to a radiant heat flux output in kilowatts per square metre (kW/m^2) for determining impact on structural components.

The modelled fire behaviour informs decisions related to building survivability based on construction materials and vegetation setbacks, other vegetation treatments including fuel reduction or fuel modification such as specific amenity plantings, and activity controls linked to risk levels, fire danger classes and fire season status.

The tools and techniques employed in these calculations are the New Zealand Fire Danger Rating System (Anderson 2005, Alexander 2008), NZ Fire Behaviour Toolkit (Scion 2012) and Field Manual for Predicting Fire Behaviour in New Zealand Fuels (Pearce et al. 2012), representative remote automatic weather station data (https://fireweather.niwa.co.nz/), fuel flammability guidelines (e.g. Clifford et al. 2013; Scion 2018; Wyse et al. 2016), and information on international fuel models relevant to wilding conifer stands from Canada (Forestry Canada Fire Danger Group 1992) and the USA (Scott & Burgan 2005).

6. Scope

6.1. In scope

A risk management report that assesses wildfire risk for the areas identified in the overall objective (section 7), along with a range of risk treatment objectives and recommended treatment actions.

6.2. Out of scope

Implementation of risk treatment recommendations, including compilation of management processes and procedures.

Review and update of any existing risk plans.

7. Risk Criteria

The risk assessment process and determination of risk treatments will consider risk Reduction, Readiness, and Response in the context of wildfire.

The criteria for determining risk levels and risk rating uses generic statements and is not directly aligned with FENZ organisational risk management due to multiple risk owners. It is acknowledged that other organisations have their own specific risk management approaches including tolerance for certain risks, and that stakeholder communication will be required to ensure a collective understanding of wildfire risk and ownership of its components.

7.1. Overall objective

To identify wildfire damage potential and available risk mitigations (treatments) for the rural-urban interface (RUI) of Lake Tekapo Village, the surrounding recreation areas, and the Mount John Observatory.

7.2. Likelihood and consequence

The risk assessment process considers the vegetation fire environment and likely fire behaviour and damage potential. Ignition likelihood is based on the presence of ignition sources, fuel receptiveness, and history of fire occurrence.

7.2.1. Likelihood

Likelihood is concerned with whether a wildfire can ignite and spread within or adjacent to the areas stated in the overall objective. Ignitions that occur on land adjacent are only of interest if there is continuous vegetation that could spread fire to these areas.

To determine likelihood level the return period of fire from annually to 10 years is considered along with ignition sources. The return period ranges are assigned a descriptor from Almost Certain to Very Rare.

It is a given that an ignited fire will spread due to the fire behaviour modelling using the Very High, Extreme and Very Extreme fire danger classes for likely, worse, and worst-case scenarios respectively (refer to assumptions in section 2).

7.2.2. Consequence

Consequence is concerned with the impact on values, including people. A wildfire's intensity or energy release determines damage potential which includes injury to people. Radiant and convective heat as well as smoke and ember hazards will impact values. The consequence assessment requires an understanding of how a fire will behave once ignited, followed by its potential impact.

To determine the consequence level, the most likely location of ignitions and subsequent fire spread have been identified, with fire behaviour modelled to determine the potential impact of each wildfire run on values. Consequence levels range from insignificant to catastrophic, with each considering the effects to people, fixed assets and the environment.

7.3. Approach to evaluating risk

7.3.1. Risk level

The likelihood and consequence levels are combined using the risk level matrix to determine a risk level. The risk levels have designators of Low to Very High with each having a range based on multiplying the likelihood and consequence level scores. Refer Appendix 9.

The risk level outputs can be skewed if necessary to account for risk tolerance. Likelihood and consequence weightings could be adjusted or, rather than using a multiplier for risk levels, they could be assigned based on likelihood and consequence descriptors that in turn align with acceptable risk tolerance.

7.3.2. Risk tolerance and authority for continued tolerance of residual risk

For each risk level there would be an associated level of tolerance that informs risk treatment. Linked to risk treatments, a level of authority can decide to tolerate continued residual risk.

Because wildfire risk can have multiple risk owners, either for whole of risk or components of it, no risk tolerance and authority for accepting residual risk has been included. It would be up to the risk owners to determine their own position and collaborate with others to agree risk level and appropriate treatment options.

7.4. Risk treatment planning

7.4.1. Specific treatment objectives

Risk treatments can be considered under one or more specific objectives and where applicable assigned a function of reduction, readiness, and response. The combination of treatments from across these objectives would aim to reduce risk to a tolerable level.

1) To reduce the likelihood of ignitions.
2) To reduce the consequence on values.
3) To share the risk with other parties.
4) To transfer the risk to another party.
5) To retain or accept the risk.
6) To avoid the risk.

8. Risk identification

Wildfires are a threat in areas of vegetation and develop based on the environment in which they are burning. The fire environment consists of three components that interact to determine how a fire will behave. The three components are the fuel available to burn, the topography (terrain) the fire is burning in, and the prevailing weather with its cumulative effect on the underlying level of

dryness that can lead to drought. The ability of a fire to ignite, develop, spread and do damage is dependent on the environmental conditions at any one time and place. These conditions vary in time and space, with weather (air temperature, relative humidity, wind speed and direction, and rainfall) the most dynamic, and fuel condition (moisture content) close behind. Fuel is the one component that can be easily manipulated to reduce relative fire behaviour.

A heat source of enough temperature is required before a wildfire can ignite and develop. Once again, the likelihood of ignition is dynamic in regards fuel condition and weather. To have a wildfire there must be a capable heat source, a receptive fuel bed, and a mechanism that brings these two things together.

In New Zealand, more than 98% of wildfires are caused by human activity, whether through careless use or poor maintenance of machinery or cooking equipment, discarding of lighted material, accidental circumstances, or malicious activities. Because of the human factor there is an excellent opportunity available to control activities that are sources of heat, sparks or flame that could cause a wildfire.

8.1. Risk Area 1 – Lake Tekapo Regional Park

The Park covers approximately 205 hectares between Lake Tekapo, State Highway 8 and farmland to the north and east. A section of the lakebed and margin is managed in conjunction with the Regional Park. Park use is predominantly recreational, with the forest also providing protection against soil erosion.

Due to the varied forest structure and types of use, the area has been divided into two zones.

8.1.1. Zone A: Camping and picnicking (between Lake Tekapo and Lilybank Road)

This area includes approximately 40 hectares between Lake Tekapo, Lilybank Road and State Highway 8. There is a New Zealand Motor Caravan Association (NZMCA) campground in the centre with a large picnic area to the north, and a disc golf operation in the south that uses the length of the area, and a dog park.

The zone scenario looks to determine damage impact on the campground and recreation areas.

Vegetation fuel

Vegetation is mixed mature pine that is pruned and reasonably open. The plantation fuel type is predominantly Corsican Pine (*Pinus nigra*) with lesser amounts of Ponderosa Pine (*Pinus ponderosa*) and European Larch (*Larix decidua*). Forest structure is variable, being more open at the north end and tighter/denser surrounding the campground itself, with grass areas near the lake and within and around the campground. There are variable levels of loose organic and surface litter including cones. Areas of unmanaged grass have a level of accumulated dead thatch.

The powerline corridor is mainly grass with heavy thatch, with patches of old forest slash or is broken with unvegetated areas of sand and shingle.

Modelled fuels for the zone:

Fuel #1: Open and limbed/pruned areas.

Fuel #2: Tight canopy with ladders to the ground.

Fuel #3: Grazed pasture

Topography

The land rises from the lake surface at 710m to Lilybank Road at 720m over an estimated distance of 450m. The zone is undulating by a few degrees, with associated flat areas and some steeper banks where there have been earthworks.

There are numerous tracks and metal roads dissecting the fuels as well as shingle areas near the lake shore. Lilybank Road is a 10m sealed barrier (wider in places) essentially dissecting the park in two.

People and pursuits

Visitors are daily recreationalists, picnickers, maintenance personnel, or are associated with the campground which caters for self-contained motorhomes and caravans. The campground had an occupancy of approximately 6,000 in 2019, and 9000 in 2020.

Visitor activities include walking, mountain biking, horse riding, disc golf, camping and picnicking, along with access to the lake for boating and kayaking.

Power company staff and contractors undertake power infrastructure maintenance, the Tekapo Recreational Society undertakes forest management work on behalf of ECan, with ECan staff and their contractors accessing as required.

Environmental, cultural and historic

There are several urupä (resting places of Ngäi Tahu tupuna) associated with Lake Tekapo and often protected by undisclosed locations.

An 1884 report noted the presence of Moa bones in the park area.

The vascular plant *Chenopodium detestans* is found on the foreshore area and is classified as threatened – nationally critical. There are several other indigenous species in the park including flora of Matagouri, Sphagnum moss, tussock, Purei (*Carex* spp.) and marram grass along the foreshore, with native bird species of tomtit and grey warbler.

Recent revegetation species include *Brachyglottis bennetii, Carmichaelia ciliate, Coprosma propinqua, C. taylorii, C. rugosa, Corokia cotoneaster, Hebe cuppressoides, H. odora, H. pinguifolia, H. subalpine, M. alpinus, Olearia virgata, Ozothamnus leptophylla, Pittosporum patalum and Sophora prostrata.*

Built environment (including mobile property)

There is a toilet block and picnic tables at the picnic ground, with transient mobile property in the campground and picnic area carpark.

Infrastructure

Powerlines run from Lilybank Road in two directions. One follows the campground access road into a specific fuel-reduced corridor heading north through the plantation and re-crossing Lilybank Road into zone B east of the picnic area carpark. The other powerline runs from the Lilybank Road near the junction with SH8 across the southern end of the zone A west- northwest towards the village.

The forest area has internal, and external (boundary) fences.

Access/egress

The zone is accessible from several points off either SH8, the Lilybank Road or the lake front.

There is one public road access point off SH8 to the eastern shore of the lake. Motor vehicles have a single locked access point to the campground from Lilybank Road and users must be members of the NZMCA for access. From the campground, campers can utilise the recreation track network to get to the lake, or go north to the picnic area or south to SH8. The picnic area and northern area of the zone can be accessed from a couple of points along the Lilybank Road.

Refer Appendix 7 for roads and track locations.

8.1.2. Zone B: Forest recreational pursuit area (above Lilybank Road)

This area covers approximately 165 hectares between Lilybank Road, State Highway 8, and farmland to the north and east. There are three public access points, one to the park residential house and buildings, one is the main park access point, and the last is a legal road to Mt Hay Station. Forest roads/tracks, as well as recreation tracks, crisscross the park creating a network for recreational use.

There are two scenarios for the zone:

1) To protect the forest and recreation users from wildfire.
2) To protect structural and utility assets - house and buildings plus powerline infrastructure from wildfire.

Vegetation fuel

Vegetation is predominantly forest and varies considerably in structure from the Lilybank Road to farmland in the east. The forest structure along the Lilybank Road and at the top of the slope leading to farmland is quite open and limbed up. This is especially evident around the main access point off Lilybank Road and the southern half of the upper slope where there are grassland openings. The lower/middle or mid-slope section of the forest is a lot tighter spacing with ladder fuels to the ground in many places. The loose organic and litter layers are variable, including many cones.

On the eastern boundary with Sawdon Station the forest gives way to depleted grassland. On the Mt Hay Station boundary there is a non-fuel break along parts before a cover of depleted grassland with groups of felled pine laying on the ground.

Modelled fuels for the zone:

<u>Fuel #1:</u> Open and limbed/pruned areas.

<u>Fuel #2:</u> Tight canopy with ladders to the ground.

<u>Topography</u>
The zone rises from Lilybank Road at 720m to approximately 760m where it gives way to farmland. The slope angles range from undulating to 15 degrees, with some landforms and earthwork areas steeper.

<u>People and pursuits</u>
The forest and tracks provide recreation opportunity to visitors for walking, running, mountain biking and horse riding. The Tekapo Recreational Society undertakes forest management work on behalf of ECan with ECan staff and their contractors accessing as required.

<u>Environmental, cultural and historic</u>
Refer to zone A, plus there is the historic hut remnant.

<u>Built environment</u>
There is a residential dwelling and numerous service structures at the lower south end of the zone which are accessible from Lilybank Road.

There is a remnant historic hut near the eastern boundary in the northern half of the zone.

<u>Infrastructure</u>
Powerlines extend through three locations and include a set of transformer poles.

The first powerline enters the zone mid-way along the southern end where it crosses SH8 and runs down a corridor towards Lilybank Road to a set of five transformer poles behind the dwelling and other structures.

From the transformers the line goes in two directions, one crossing Liliybank Road to the campground access point, and the other cutting between the dwelling and other structures to cross Lilybank Road and carrying on to the village.

The powerline that heads generally north through zone A re-crosses Lilybank Road east of the picnic area and enters zone B. It runs through a 30m – 40m fuel-reduced corridor before exiting at the north end and re-crossing the road.

There are three sets of three water supply tanks, each set having 90,000 litres available. They are located at different elevations across the zone. In some locations there is irrigation piping to service revegetated areas.

There are fences surrounding the forest area.

Access/egress

The track and forest road system dissect the park in both north/south and east/west directions and at a range of elevations. The Te Araroa trail passes through from the north to the south.

The main park entrance is off Lilybank Road about 600m from SH8, with an arterial forest road and recreation tracks accessed at this point. There are several other access/egress points terminating at either SH8 or Lilybank Road. Additionally, tracks run near the boundary with farmland allowing easy egress from the forest if needed.

Refer Appendix 7 for roads and track locations.

8.2. Risk Area 2 – Rural-urban interface (RUI)

This risk area is approximately 400 hectares in size and is divided into 3 zones to account for separation of the Lake Tekapo Village dwellings and their associated RUI locations. There is an approximate total of 6.9km of interface which has been divided by zone in the coming sections. Village areas that are in the wider village are included in the zones as they are likely to be impacted by embers and smoke.

8.2.1. Zone C: Southeast Village and forest pursuits

This zone is approximately 180 hectares comprising the southeast village and its RUI, as well as the MDC forest and other land to the south and southeast.

The RUI for the southeast village has been divided into 7 sections to allow for clear description of the varied vegetation, determination of damage impacts, and determination of risk treatments aimed at reducing the risk. Refer Appendix 3.

The predominant scenario is to protect the urban structures and associated outdoor fixtures from wildfire, as well as look at forest recreation use.

Vegetation fuel

Beginning at SH8 at RUI sections 1 and 2, vegetation is to property boundaries and is predominantly depleted grass extending south to include public conservation land; and is bordered by SH8 and the MDC forest area.

Along the RUI section 3 there is a 4x4 track between the property boundaries and continuous vegetation, with a second vehicle track between 40 to 80 metres away that essentially divides RUI sections 2 and 3. The vegetation between the two tracks is scattered mature conifer forest with some eucalyptus, depleted grassland, and heavy thatched grass sometimes with scrub included. Surface and subsurface forest fuel loads are minor.

RUI section 4 has a foot track behind the property boundaries, but essentially there is vegetation to and inside the property boundaries. The vegetation is heavy thatched grass with some exotic trees on or near the boundaries. The grassland generally extends 50 – 60 metres south to an open and at times scattered mature conifer plantation. Plantation surface fuels are grassland, weed species, and old windrowed harvest slash. There is a 4x4 vehicle track dividing the grassland area from the forest area.

RUI section 5 has a well-formed metal roadway between the property boundaries and continuous vegetation. The properties themselves vary with what flammable fuels could potentially spread fire to structures; some have well-maintained defensive areas and others are poor. The vegetation south of the metal road is heavy thatched grassland with some mature conifer trees at the west end, an area of flammable native planting including toetoe (native pampas grass), and dumped tree trimmings. As for RUI section 4, the grassland generally extends 50 – 60 metres south to an open and at times scattered mature conifer plantation. Plantation surface fuels are grassland, weed species, and old windrowed harvest slash. There is a 4x4 vehicle track dividing the grassland area from the forest area.

RUI section 6 has the remnants of a fuel break between the property boundaries and the mature conifer forest. The conifer trees overhang the break to touch fuels within the property boundaries. The mature conifers run south for approximately 40 metres giving way to young 10-year-old plantings that are around 2 metres tall. The mature forest surface has a large build-up of cones, with the immature forest having grass, weeds, and windrowed harvest slash.

RUI section 7 runs along the top of the eastern bank of the Tekapo River. There is a foot track separating the properties from vegetation. The vegetation is highly modified and a mix of heavy thatched grass and weeds with some exotic deciduous trees. Vegetation on the track sides is managed low.

The MDC Forest runs south from behind the RUI sections 4, 5 and 6, from approximately 700 to 1000 metres before giving way to depleted grassland. The forest is somewhat compartmentalised running west to east. Starting behind the RUI and moving south there is a compartment of generally open mature Corsican pine 40 – 130 metres wide, followed by immature Corsican pine 140 – 200 metres wide with a large amount of aged windrow and piled harvest slash. The forest is then highly variable for some 500 to 800 metres with open grassland and scrub areas, open and scattered mature conifer areas, as well as tighter compartments of Corsican and Radiata pine. The mature forest surface fuels are varied, but generally light surface with some cones and ladder fuels to the ground in places with little subsurface organic material.

Modelled fuels for the zone:

Fuel #1: Plantation fuel type (Corsican pine) – area south of grass and road/track behind RUI. There is a large variation in this fuel from one end to the other. Select highest load.

Fuel #2 Further to the south is immature Corsican Pine planting (estimated 10 y.o.) which is still predominantly grass with windrows and bird nests of slash.

Fuel #3: Plantation forest, clean understory – east end of RUI.

Fuel #4: High load grass between RUI and forest fuel #1.

Fuel #5: Depleted grass at eastern end of RUI.

Topography

The southeast of the village is sited on a series of terraces above Lake Tekapo and the Tekapo River that give way to very large wide open flat terrain further south. South of the immature conifer compartment the ground rises in a part bowl shape to meet the highest terrace edge.

The terrace edges are moderate steepness ranging from 10 to 30 degrees, and much steeper where they face the Tekapo River.

The elevation from the lake to the conservation land in the south is 710m to near 800m, rising 90m with a general aspect range between northeast through north to southwest.

Aside from the village road network there are a couple of formed metal roads and numerous forest and recreation tracks that provide breaks in the vegetation cover. Forest access roads are generally 3 – 4 m wide with cycle and foot track 1 – 2 m wide. The oxidation ponds and rubbish transfer station areas provide a non-fuel area within the zone.

People and pursuits

There are many people living along the RUI with the forest and many more in the urbanised area. South of the RUI is used for recreational mountain biking, walking, and running. There is public access to the rubbish transfer station with contractors accessing the high point above the oxidation ponds to service communication towers. Forestry contractors undertake forest management and Council staff access the area as required.

Built environment (including mobile property)

There is approximately 2.8km of RUI comprising of 67 properties with dwellings and other structures, and 7 vacant sections. The rest of the residential area has numerous properties numbering in the hundreds with dwellings and other structures located on them.

There is one building at the rubbish transfer station and two at the communication towers to the southeast.

Infrastructure

There are two sets of communication towers on the high point to the southeast of the rubbish transfer station and numerous fences in and near the forest.

There is a rubbish transfer station and oxidation ponds in the southwest on the upper banks of the Tekapo River.

Access/egress

The MDC Forest can be accessed from properties along the RUI. There is access from Murray Place along the metal road leading to the rubbish transfer station and oxidation ponds with a series of 4x4 tracks and recreation tracks linking to it.

There are two 4x4 tracks off Hamilton Drive that link to a central arterial 4x4 track running east west through the forest. At either end of this arterial a 4x4 track links in leading to the communication towers.

Recreation tracks extend from SH8 east of the village passing through the forest and immature conifers to Murray Place. There is another track extending along the eastern upper bank of the Tekapo River from Moyes Lane to the rubbish transfer station road.

Refer Appendix 7 for roads and track locations.

8.2.2. Zone D: Southwest Village

This zone is approximately 137 hectares in size, comprising the southwest portion of the village including the RUI, residential area, the commercial centre, and the forest area and other land to the south and southwest including the west bank of the Tekapo River. It does not include the golf course.

The RUI for the southwest village has been divided into 3 sections to allow for clear description of the vegetation, determination of damage impacts, and determination of risk treatments aimed at reducing risk. Refer Appendix 3.

The predominant scenario is to protect the urban structures and associated outdoor fixtures from wildfire.

Vegetation fuel

Starting at SH8, the west bank of the Tekapo River starts as grassland with thatch and transitions to mature forest that becomes denser the further south until reaching a more open area where forest harvesting has taken place.

At the south end of the zone there are pockets of mature and immature conifer trees, areas that have been recently harvested, and open areas of depleted grassland.

The western side of the zone predominately boundaries with the golf course with its low managed grass and managed grass between SH8 and the lake.

Modelled fuels for the zone:

> *Fuel #1: Plantation fuel type (mixed conifer) – from 4 x 4 track along the true right of the Tekapo River to the top of the terrace where the houses are. Very steep short run to the terrace and then grass at 30cm tall.*
>
> *Fuel #2: Ungrazed pasture 30cm tall.*
>
> *Fuel #3: Depleted grass.*

Topography

The southwestern part of the village is located within the zone above the lake front at 710m, rising south to 740m on to broad low-angled ground before dropping steeply to the Tekapo River. The east boundary of the zone is the Tekapo River with very steep banks and some bluffs leading to the RUI; here the ground slowly rises to a high point at 800m before dropping to the Tekapo Powerhouse Road. At the southern end, the ground drops down a series of low angled terraces with steep faces to the Tekapo River.

Slope steepness varies from 2 – 10 degrees from SH8 to the broad ground further south at 2 – 5 degrees. The southern terrace faces are greater than 30 degrees, with parts of the western bank of the Tekapo River steeper than 40 degrees.

The aspect ranges from northeast through north to west, with most of the zone northeast through north. Potential barriers to fire spread are the lake, the Tekapo River, sealed and metalled roads, some commercial areas of bare ground, and recreation tracks.

People and pursuits

There are many people living along the RUI and many more in the urbanised area. This part of the village is under active development with many sections yet to be built on. Once the area is fully built, the number of people on the RUI and within the wider urban area will increase further. The banks of the Tekapo River are used for general recreation including fishing and kayaking, and there is a commercial golf course to the west.

There are areas of forest that are accessed for maintenance purposes, and a commercial area south and below the village.

Built environment (including mobile property)

There is approximately 2km of RUI comprising of 25 properties with dwellings and other structures and an estimated 17 vacant sections. The rest of the area has numerous residential and commercial buildings.

On SH8 there is one structure associated with road maintenance. To the south of the urban area there is one dwelling and a commercial area with several structures and containers.

Access/egress

The zone can be accessed by road or 4x4 track from several points along SH8, with a metal road and a 4x4 track on the south side. There is a recreation track (Lake George Scott Track) from SH8 along the western bank of the Tekapo River linking to the southern end of Andrew Don Drive.

Refer Appendix 7 for roads and track locations.

8.2.3. Zone E: Northwest Village

The zone is approximately 120 hectares in size, comprising the lake's western waterfront to just south of SH8, with the most western boundary at Godley Peaks Road cutting back to the lake a little north of Tekapo Springs. The area includes the holiday park and hot pools, ice-skating rink and snow park complex, and is subject to active residential and commercial development that will in time significantly change the risk. Already an area of mature conifer forest including larch has been felled, with slash-waste piled ready for removal for subdivision development.

The scenario is to protect urban structures and commercial assets from wildfire.

Vegetation fuel

The eastern edge of the zone at the western side of the campground is predominantly thatched grass both sides of SH8, with some scattered mature conifers here and there and

revegetation in and around the campground. Beyond the campground boundary is the new subdivision area that has been cleared of mature trees with slash heaped into piles. This area closely links to the commercial operation of Tekapo Springs that is well developed and has native plantings on its boundary and a very flammable fence. Further west the vegetation gives way of grazed grassland at the horse trekking operation out to Godley Peaks Road.

Southwest of the subdivision to the Godley Peaks Road is a block of mature mixed conifer forest with mainly open canopy but with some closed areas. From the power distribution substation on SH8 there is a wide grass corridor heading northwest and splitting in two before crossing the Godley Peaks Road. The corridors are thatched grassland but with old windrowed slash along the edges and here and there in the middle.

Modelled fuels for the zone:

Fuel #1: Plantation fuel type (mixed mature conifer) – SE of new subdivision.

Fuel #2: Mature Larch forest.

Fuel #3: Grazed pasture 30 cm tall.

Fuel #4: Native ground cover (new subdivision plantings).

Topography

From the lake at 710m ASL, the ground rises north and west before flattening out at 760m toward the Godley Peaks Road and gently rising to 780m at the base of Mount John. Residential and commercial development is mainly situated on the sloping ground facing the lake.

Slope angles are relatively flat near the lake increasing to 10 to 20 degrees as the ground rises to the flatter area above and toward Godley Peaks Road. The slopes on the north side of the Tekapo Springs complex are up to 40 degrees.

Aspect is generally east through north to west facing, with an area of south facing slope at Tekapo Springs. Potential barriers to fire spread are SH8 and the Godley Peaks Road, the lake and a metalled road just above it, the subdivision area except the piled slash, and a 4x4 track leading from the western end of the subdivision to the Godley Peaks Road via the horse trekking operation.

People and pursuits

The zone is presently commercial and industrial operations including a campground, ice-skating rink and pools, and power distribution infrastructure. The subdivision development will in time add residential people to the mix and create a new RUI.

Other recreation activities include horse trekking off the Godley Peaks Road, walking on the slopes of Mount John and lake access.

Environmental

The vascular plant *Chenopodium detestans* is found on the foreshore area in front of Tekapo Springs and is classified as threatened – nationally critical.

Built environment (including mobile property)

Between Lakeside Drive and SH8 there is approximately 2.1km of RUI comprising 53 structures related to the commercial operations of the campground and Tekapo Springs complexes. The campground caters for transient mobile property, cars, vans, and campervans, etc. with a large carpark associated with Tekapo Springs.

On the north side of SH8 there is one structure associated with the electricity substation.

An RUI has been pre-emptively identified to account for subdivision and campground development and will need to be adjusted when it is clear where structures meet continuous vegetation. The RUI is in two sections to account for proposed residential development near forest and the commercial boundary with grassland.

Infrastructure

There is an electrical power substation located on SH8 west of the village. There are five overhead distribution lines associated with the substation, with two crossing the Godley Peaks Road near its intersection with SH8 and going west toward Lake Pukaki and one following along the east side of Godley Peaks Road before splitting in two with one crossing to the west side of the road and the other going uphill to the Mount John Observatory. Of the remaining two, one links to the village and the other runs south to the power station. Refer Appendix 8 for a map of powerline locations.

There are numerous farm fences as well as horse yards associated with horse trekking.

Access/egress

Access to the zone is from Lakeside Drive, one way in and one way out unless the subdivision development road can be used to access Godley Peaks Road via the horse trekking operation. The powerline corridors are 4x4 accessible but not formed tracks.

The Mount John walking track is accessed from beside Tekapo Springs and passes through zone F of Risk Area 3 to the Mount John Observatory, and then continues north to the base of Mount John and the lake or Godley Peaks Road.

Refer Appendix 7 for roads and track locations.

8.3. Risk Area 3 – Mount John

This risk area is approximately 450 hectares in area, with a single zone including the Mount John Observatory and access road, and general recreation on the slopes of Mount John.

8.3.1. Zone F: Mt John

The zone is approximately 450 hectares comprising the slopes of Mount John, the Mount John Observatory access road and structures, and recreation tracks. The eastern slopes of Mt John are subject to a Conservation Covenant.

The scenario is to protect people accessing and using the Mount John Observatory via the sealed road, to protect the Observatory's structural assets, and to protect people using the Mount John recreation tracks.

Vegetation fuel

The southern slopes of Mt John have a cover of mature Larch forest with varied structure giving way to grassland at around 940m. The eastern side of the forest has larger older trees 15m to 20m tall, with relatively deep duff and dead-down medium and heavy fuel. Tree limbs are to the ground in many places. The surface litter is made up of a good cover of needle and small cones.

Further west where the Mount John access track is located the forest is more open in structure, especially on the lower angle bench and old moraine areas on the initial slopes above Tekapo Springs. There are denser forest pockets in places with tree height reducing with elevation. Stem diameters vary considerably from a few centimetres to greater than 30cm for the older seed source trees. Branches in a lot of places reach the ground where there is a relatively light litter layer of needles and small cones, except where there is accumulation in swales and gullies.

On the western and eastern slopes there is varied grassland cover with interspersed wilding Larch and some native scrub. The grassland ranges from grazed pasture with a tussock component, to depleted grassland and very depleted grassland on the higher slopes. There is a sparse scrub component of rosehip and matagouri on the lower and parts of the upper eastern slopes above the lake.

The northern slopes are like the western and eastern slopes but without the wilding trees.

Modelled fuels for the zone:

Fuel #1: Larch mature, dead down, relatively open, with ladders to ground in places.

Fuel #2: As for #1 without the dead down component.

Fuel #3: Grazed pasture 30cm tall.

Fuel #4: Depleted grass.

Fuel#5: Grazed pasture/tussock mix 20cm tall.

Topography

Mount John is a very old moraine located on the southwestern shore of Lake Tekapo. It is a prominent tear drop mound with two high points rising from the lake at 710m to 1031m, then dropping to the Godley Peaks Road at around 760m.

On the south side, a bowl rises from the lake at a slope of around 30° to a terrace at approximately 890m. Past the terrace, the land rises steeply at a slope greater than 35°with some bluffs to 920m, before easing back to around 10° for a short distance. Above this the land steepens to a boulder moraine and bluffs before easing back to 5° - 10° leading to the high point at the Observatory.

The greater than 35° slope is a band ranging between 890m and 990m that generally sweeps around the western through southern and eastern faces. On the eastern slopes, the band elevation is 900m to 990m.

The eastern slopes are low-angled from the lake for a very short distance before steepening up as they rise to the steep bluffy band mentioned above, and finally easing back towards the Observatory. The eastern slopes decrease in elevation toward the north as they meet the terraced northern slopes. The western slopes are also low-angled for a short distance before rising through the steep band to the lower angle top area. Both the western and eastern slopes have narrow and very shallow gullies running top to bottom.

The northern slopes, starting from a small stream at the base, are a series of terrace steps rising to the top of Mount John. The slope from the stream rises from 730m to 780m at greater than 35° and flattens out on a small terrace. From this terrace the land rises to around 850m at a slope angle of 25° - 30° to the second terrace. The second terrace rises in an undulating manner for 1800m, from an elevation of 850m to 950m and slope angles of near flat to 15°. From here the land steepens again to 20° - 30° before the lower angle top section of Mount John.

Aspect range encompasses all directions, with the Observatory access road facing mainly west to northwest. Recreation tracks are predominantly located on slopes facing south through east to north.

Potential barriers to fire spread are the lake, Godley Peaks Road and the Observatory access road, boulder moraines on the mid-southern and parts of the upper eastern slopes, recreation tracks managed free of fuel, as well as non-fuel areas at the Observatory complex such as carparks and other bare areas.

<u>People and pursuits</u>
During the day in the warmer summer months there can be many walkers and hikers of all ages using the recreational tracks. The visitor profile ranges from fit individuals to families with young children, and for many the destination is the Mount John Observatory complex.

The Observatory is also accessed by road off the Godley Peaks Road. The access road is gated, and numbers are controlled.

The Mount John Observatory houses day and night staff and researchers and is available at times for night sky viewing experiences.

<u>Built environment (including mobile property)</u>
The Mount John Observatory has 12 structural facilities, each well separated and located near or at the top of Mount John.

<u>Infrastructure</u>
There is a pole-mounted powerline running northeast from zone E uphill to terminate at the Mount John carpark. The line has a few poles that take it to the most southern structure.

There is a communication pole on the top of Mount John and above-ground water storage at the hard-surface area of the south-eastern most structure.

Access/egress

Mount John is accessed from either Lakeside Drive, Godley Peaks Road, or the lake itself. From Lakeside Drive there is a 4x4 track that runs north along the lakeshore for about 1km. A foot track begins from this track and follows north just above the lake before climbing to the first northern terrace where it meets the track coming down the backbone of Mount John. At this junction the track drops off the terrace to the west and follows a small stream to Godley Peaks Road.

There is a foot track that passes to the west of the Tekapo Springs complex and zigzags up the steep southern face and along to the top of Mount John. Another track comes off this near the top and sidles to the east of Mount John and heads on down the northern backbone.

The sealed road to the top of Mount John is gated and leaves the Godley Peaks Road around 4km from SH8. The access road is narrow and climbs the slope at the north-western end to then follow the western edge of Mount John's long backbone south to the top carpark and facilities.

8.4.Weather – all risk areas

8.4.1. Weather

The Met Service climate zone (NZMS 1983) for the area of interest is F2 but the area of interest is on the boundary for F3. Climate Zone F2 is characterised by cooler and wetter climate than F1, with rainfall in the range of 800 to 1,500mm. Northwesterlies predominate with occasional very strong gales, especially along river valleys. Snow may lie for weeks in winter. Climate Zone F3 is characterised by semi-arid areas with annual rainfall 300 to 500mm, and very hot summers and cold winters.

The Lake Tekapo area is also affected by two weather phenomena. The first is the hot and dry Fohn wind coming from the west to northwest over the Main Divide. This is created by the orographic effect as air is lifted over the mountains. The second is the Canterbury Wind which is caused by strong land heating that draws air inland from the east coast creating unstable atmospheric conditions with up and down drafts. This thermally driven condition is why the Mackenzie Basin is renowned for gliding. The thermal heating causes easterly winds to increase on hot afternoons as cooler coastal air comes in to replace the rising warmer air.

Two remote automatic weather stations (RAWS) are located nearby – the Tekapo (TEK) fire weather station located on the Defence training area west of Lake Alexandrina; and the NIWA Tekapo Ews located at the Tekapo Airport. The long-term climate data using daily recordings from the NIWA RAWS located at the airport has been used for the fire behaviour analysis in this report (refer to Appendices 4 and 5). This RAWS is considered more representative of the area of interest and has eighteen years of continuous data.

Using the monthly rainfall averages, the annual rainfall is around 540mm, and for the months of the fire season (October through to the end of April) is 293mm. For the fire season months, the maximum monthly rainfall recorded was 172mm in the month of February and a minimum of 2.4mm in the month of January.

For the fire season months, the average noon temperature was 16.1° Celsius, with a maximum of 31.2° in the month of January and a minimum of 0.1° in the month of October. Minimum relative humidity recorded was 4% in the month of January, and at some time in the 18-year record, relative humidity was recorded below 25% for every month in a year.

Tekapo can be a windy location as winds are funnelled down major river valleys and lakes. The strongest winds predominantly come from the west through northwest direction, but from time-to-time strong winds do come from the northeast and south (Refer Appendix 5). Generally, wind speeds from the southerly quarters are lighter. For fire season months, the average noon daily windspeed was 16.1km/h, with a maximum of 89km/h from the north-northwest in the month of October and a minimum of 0.9km/h from the west in the month of November.

8.5.Ignition sources and causes – all risk areas

Heat sources are those with enough temperature to ignite vegetation fuel, with around 300˚C required. Heat sources have been categorised below and include those that may be present in the scope area.

8.5.1. Maintenance and construction equipment, heavy machinery, and motor vehicles

1) Chainsaws, mowers and cutters/slashers striking solid material such as rocks, wire or cables.
2) Welding, heating, steel cutting (gas and manual) and other spark hazardous operations.
3) Engine exhaust emission of hot carbon.
4) Exhaust system failures resulting in very hot parts that can break away (catalytic converters).
5) Liquid fuel and hydraulic fluid igniting on hot exhausts.
6) Direct vegetation contact with hot exhaust parts.
7) Friction on accumulated vegetation within vehicle systems.
8) Electrical failures resulting in fire.
9) Vehicle and machinery accidents.
10) Motorhome/caravan fires

8.5.2. Open air burning or cooking

1) Use of outdoor barbeques, braziers, and other oven types.
2) Private dwellings in the vicinity burning rubbish or tree trimmings, etc.
3) Escaped burn-off (e.g., of forestry slash or scrub).
4) Spontaneous combustion.

8.5.3. Powerline infrastructure

1) Line breakages and line strike.
2) Line disconnects from insulators and arcs on poles and cross arms.
3) Transformer and fuse failures.

8.5.4. Careless discarding of hot material

1) Lighted cigarettes discarded.
2) Home fire ashes discarded.

8.5.5. Deliberate lighting of fire

1) Malicious lighting of fire.
2) Escaped burn-off (e.g., of forestry slash or scrub).

8.5.6. Mountain bikes and personal accessories

1) Electric bike battery failure, generally home built systems, or any system whilst on charge).
2) Electrical device battery failures such as mobile phones, etc.

8.5.7. Structure fire

1) Structures and other infrastructure fire such as dwellings and cell phone tower installations.

8.6.People

People and their activities are mostly the mechanism that bring heat sources into contact with a receptive fuel bed causing a fire. This may be Forest or Reserve contractors and visitors or someone causing a fire further away that later impacts the area. The scope area is surrounded by all or some of the following: public and private roads, private land and their land uses including access ways and tracks, commercial forestry, communications, and electricity infrastructure.

The following categorises people for consideration of their activities that may cause a fire.

8.6.1. Recreation visitors

Visitor numbers in the area of interest are large. Recreation predominantly centres around walking, biking, horse riding and camping. Refer to commercial operators below for their operation type.

8.6.2. Property owners

Property owners within the area of interest. This includes those residing or using residential type property in urban or peri-urban settings, farm owners and their staff, and those associated with lands administered by Councils, Department of Conservation, and power companies.

8.6.3. Commercial and other approved operators

Recreation businesses and other operations catering for clients operate within the area of interest. These include but are not limited to Tekapo Springs, Lake Tekapo Campground, NZMCA Campground, Mount John Observatory, Horse Trekking and Disc Golf.

Additionally, there is a significant contractor presence working on the Station Bay subdivision.

8.6.4. Councils

Council staff, volunteer groups, and contractors undertake road and other services maintenance, track construction and maintenance, as well as spraying and mowing operations.

8.6.5. Electricity suppliers

There are high voltage transmission lines running through the scope area, and lower voltage sub-lines within and outside the area of interest. Power company staff and contractors access these for maintenance purposes including track and vegetation maintenance.

9. Risk Analysis

To analyse the risk of a fire starting, spreading, and doing damage, three factors must be present, i.e., enough dry fuel adequately arranged, a heat source, and a way to bring them together (in most cases human activities).

9.1.Fuel condition

The fire environment determines fuel condition and the ability for fuel to burn. The New Zealand Fire Danger Rating System is used to help determine how fuels will burn under given conditions. The New Zealand Fire Danger Class Criteria are used to give qualitative ratings of fire danger based on available fuel to burn and its propensity to spread in the three broad New Zealand fuel types: forest, scrub, and grass. As the fuel cover is a mix of mainly grassland and forest with some pockets of scrub, the most relevant Fire Danger Classes are forest (conifer) and grassland. The Fire Danger Classes occurring for forest and grassland are Low through to Very Extreme, and for scrub all classes except Moderate.

Topography affects wildfire behaviour with slopes increasing spread rate and fire intensity, thereby increasing the damage potential. The Fire Danger Classes do not account for slope effects.

An analysis of the annual average number of days in a year that each class prevailed is presented using eighteen years of fire weather data from the Tekapo Ews RAWS up to the end of June 2021. The following tables summarise the average number of days per year in each Fire Danger Class for each of the three New Zealand fuel types. Refer to Appendix 4.

Fire Danger Class (FDC) annual frequencies based on the Tekapo Ews RAWS:

Table 1: FDC frequencies for forest fuel types

Fire Danger Class	Number of days annually	Months of occurrence	Number of days in the fire season	Months of occurrence in fire season
Low	173.3	All months	48.5	All fire season
Moderate	92.7	All months	68.3	All fire season
High	44.2	Sept - April	41.2	All fire season
Very High	21.6	Oct - April	20.8	All fire season
Extreme	19.3	Nov - April	19.3	Nov - April
Very Extreme	14.1	Nov - March	14.1	Nov - March

Table 2: FDC frequencies for grassland fuel types

Fire Danger Class	Number of days annually	Months of occurrence	Number of days in the fire season	Months of occurrence in fire season
Low	75.8	All months	16.7	All fire season
Moderate	162.9	July - May	82.1	All fire season
High	79.5	August - May	69.5	All fire season
Very High	22.8	Sept - March	20.4	Oct - March
Extreme	20.8	Oct - March	19.9	Oct - March
Very Extreme	3.6	January	3.6	January

The degree of curing is a measure of the proportion (%) of dead grass fuels present, which affects the ease of fire spread. The lower the percentage, the more live green component is present.

Table 3: Degree of grass curing (DoC%) based on annual cycle for Canterbury High Country

Month	July	A	S	O	N	D	J	F	M	A	M	June
DoC%	**60**	**60**	**70**	**70**	**70**	**80**	**80**	**80**	**70**	**60**	**60**	**50**

Table 4: FDC frequencies for scrub fuel types

Fire Danger Class	Number of days annually	Months of occurrence	Number of days in the fire season	Months of occurrence in fire season
Low	59.0	All months	20.7	All fire season
Moderate	0.1	None	0.0	None
High	42.5	All except Jan	13.0	All except Jan
Very High	38.2	All months	14.4	All fire season
Extreme	69.8	All months	36.0	All fire season
Very Extreme	155.7	All months	128.1	All fire season

9.2.Wildfire history - ignitions

Table 5 presents a summary of the FENZ fire incidents that occurred within the scope area over the last ten years up to the 14th of March 2021. A ten-year data set has been used to ensure the information is applicable to current human behaviour related to wildfire risk and for determining general return periods. There was a total of 57 fire related incidents over the period, with over half of these being vegetation fires.

Table 6 provides more specific details for these 57 fire incidents, including fire cause and location. Most fires were concentrated within the area of interest, with others scattered outside but within the scope area.

Listed in Table 7, and grouped by zone, are 20 of the 57 incidents and their cause that are of interest based on their location and potential to accelerate to equilibrium ROS and HFI before impacting on values. Table 8 provides a summary of these specific fire incidents by fire type.

Table 5: Summary of all fire occurrences over the last 10 years

Vegetation	31
Other	11
Mobile Property	7
Structure	8
Total Fires - 10 years	**57**

Table 6: Fire occurrences within the scope area over the past 10 years

Fire type	Date	Cause	General loaction
Vegetation Fire	7/09/2011	Carelessness with Heat Source	SE village
Other Fire	10/11/2011	Deliberately Lit Fire	Lilybank Rd
Vegetation Fire	19/12/2011	Deliberately Lit Fire	SH8 Edward Stream
Mobile Property Fire	19/03/2012	Mechanical Failure or Malfunction	SW village
Structure Fire	26/05/2012	Mechanical Failure or Malfunction	SW village
Vegetation Fire	28/07/2012	Deliberately Lit Fire	Regional Park
Other Fire	8/10/2012	Deliberately Lit Fire	SE village
Other Fire	26/07/2013	Deliberately Lit Fire	NW village
Vegetation Fire	16/09/2013	Undetermined	Godley Peaks Rd
Vegetation Fire	18/12/2013	Deliberately Lit Fire	SE village
Vegetation Fire	14/01/2014	Deliberately Lit Fire	Tekapo Powerhouse Rd
Vegetation Fire	17/02/2014	Deliberately Lit Fire	SH8 Edward Stream
Structure Fire	17/04/2014	Operating Failure	NW village
Vegetation Fire	13/07/2014	Carelessness with Heat Source	SE village
Vegetation Fire	22/10/2014	Carelessness with Heat Source	SE village
Vegetation Fire	29/11/2014	Carelessness with Heat Source	SW village
Mobile Property Fire	2/03/2015	Operating Failure	SE village
Other Fire	25/04/2015	Deliberately Lit Fire	Regional Park
Vegetation Fire	2/07/2015	Deliberately Lit Fire	SW village
Vegetation Fire	2/11/2015	Reckless (involving fire)	Regional Park
Vegetation Fire	3/01/2016	Reckless (involving fire)	NW village
Vegetation Fire	16/02/2016	Carelessness with Heat Source	NW village
Vegetation Fire	21/02/2016	Carelessness with Heat Source	SW village
Vegetation Fire	25/02/2016	Carelessness with Heat Source	NW village
Vegetation Fire	26/06/2016	Carelessness with Heat Source	SE village
Vegetation Fire	9/07/2016	Deliberately Lit Fire	SW village
Structure Fire	14/07/2016	Operating Failure	NW village
Vegetation Fire	30/08/2016	Deliberately Lit Fire	Regional Park
Structure Fire	4/09/2016	Operating Failure	Regional Park
Vegetation Fire	11/09/2016	Carelessness with Heat Source	SW village
Vegetation Fire	9/11/2016	Lightning	NW village
Other Fire	6/05/2017	Deliberately Lit Fire	Regional Park
Mobile Property Fire	6/08/2017	High temperature	SH8 Airport side
Vegetation Fire	19/08/2017	Deliberately Lit Fire	SE village
Vegetation Fire	19/08/2017	Deliberately Lit Fire	Regional Park
Vegetation Fire	30/10/2017	Cooking / Warming	Mt John - lake side
Structure Fire	7/11/2017	Mechanical Failure or Malfunction	SW village
Structure Fire	3/02/2018	Undetermined	Lake Alexandrina
Other Fire	8/04/2018	Operating Failure	Tekapo Powerhouse Rd
Vegetation Fire	29/04/2018	Electrical / Power Lines	Regional Park
Mobile Property Fire	19/05/2018	Mechanical Failure or Malfunction	SH8 Fairlie side
Structure Fire	11/09/2018	Undetermined	SW village
Vegetation Fire	28/12/2018	Incendiaries / Suspicious	SW village
Other Fire	2/02/2019	Undetermined	SW village
Other Fire	28/04/2019	Deliberately Lit Fire	SW village
Mobile Property Fire	3/05/2019	Mechanical Failure or Malfunction	SW village
Other Fire	3/11/2019	Undetermined	SW village
Structure Fire	23/11/2019	Mechanical Failure or Malfunction	SE village
Mobile Property Fire	15/01/2020	Mechanical Failure or Malfunction	NW village
Vegetation Fire	3/02/2020	Natural	SW village
Vegetation Fire	6/02/2020	Natural	SW village
Vegetation Fire	8/02/2020	Natural	SW village
Vegetation Fire	10/02/2020	Natural	SW village
Mobile Property Fire	4/07/2020	Mechanical Failure or Malfunction	SE village
Vegetation Fire	24/10/2020	Cooking / Warming	Regional Park
Other Fire	10/11/2020	Deliberately Lit Fire	SW village
Other Fire	10/11/2020	Deliberately Lit Fire	Regional Park

Table 5: Fires of interest (potential to accelerate to equilibrium)

Zone	Date	Type	Cause
A	10/11/2011	Other	Deliberate
	28/07/2012	Vegetation	Deliberate
	25/04/2015	Other	Deliberate
	03/08/2016	Vegetation	Deliberate
	06/05/2017	Other	Deliberate
	19/08/2017	Vegetation	Deliberate
	24/10/2020	Vegetation	Cooking
B	02/11/2015	Vegetation	Reckless use of fire
	29/04/2018	Vegetation	Powerlines
C	19/12/2011	Vegetation	Controlled burn
	17/02/2014	Vegetation	Deliberate
	19/05/2018	Mobile property	Mechanical
D	14/01/14	Vegetation	Deliberate
E&F	16/09/2013	Vegetation	Unknown
	02/07/2015	Vegetation	Deliberate
	03/01/2016	Vegetation	Reckless use of fire
	14/07/2016	Structure	Operating failure
	06/08/2017	Other	High Temperature
	30/10/2017	Vegetation	Cooking
	03/02/2018	Structure	Unknown

Table 6: Summary of specific fire occurrences of interest by type

Vegetation	13
Other	4
Mobile Property	1
Structure	2
Total Fires of interest	**20**

9.3.Fire Behaviour

Once a wildfire ignites, it goes through an acceleration phase before reaching its optimal forward rate of spread (equilibrium ROS) and head fire intensity (HFI) for the fuel, weather, and topographical conditions. It is the HFI at the equilibrium ROS that helps determine damage potential. Fuel loads are estimated in tonnes per hectare (t/ha), ROS in metres per hour (m/h) and HFI in kilowatts per linear metre (kW/m). ROS is determined from the Initial Spread Index (ISI) component of the New Zealand Fire Danger Rating System.

HFI has been calculated using modelled fuels, adjusting for slope angle, and using selected days with actual weather and fire danger ratings observed from the Tekapo Ews RAWS historical record. Risk zone scenarios were considered when selecting an appropriate fire weather record to use for fire behaviour calculations, including wind direction and time of year.

ROS adjustments have been made for narrow accelerating fires in zones D and F of 1/3 for forests and 2/3 for grass fuels of the calculated ROS, based on open fuel types reaching equilibrium sooner.

There is a range of vegetation types likely to impact on values. Based on field observations, vegetation has been categorised for alignment with available fuel models to determine likely fire behaviour. Refer supplementary fire behaviour calculation sheet.

In some cases (mainly forest types), fuel models have been adjusted to get more appropriate ROS or available fuel load (AFL) values. For the larch fuel type, the Deciduous type recommended for larch from British Columbia has been used, and D-1 (leafless) over the recommended D-2 (green) for summer conditions (needles still on) as this gives a more realistic (higher) ROS (D-2 is calculated as 20% of the D-1 ROS). Both deciduous types have the same AFL, so the C-3 Immature pine AFL has been used for the larch scenario with a lot of dead and down.

Table 7: Vegetation and relevant fuel model

Vegetation	Properties	Fuel Type
Grass	Grazed, ungrazed, depleted or grass/tussock mix. Available fuel loads have been determined for each.	O1a and O1b
Plantation	Open and limbed or clean understory or conifer mix.	C6
Plantation	Tight canopy with ladder fuels.	C3
Plantation	Highly variable.	Pine plantation (immature used to give higher AFL)
Plantation	Immature, 2nd rotation to include slash.	Immature pine 5-10 (grass ROS + slash AFL)
Plantation	Mature Larch.	Deciduous (D-1/D-2)
Plantation	Mature Larch with dead & down.	Deciduous (D-1/D-2)
Scrub	Native ground cover.	Scrub Hardwoods

Calculations were conducted for 'worst-case' conditions based on fire weather within the Very Extreme fire danger class, 'worse' based on the Extreme fire danger class, and likely based on the Very High fire danger class. These provide estimates of fire behaviour for periods when vegetation fuels are at or nearing their driest. A grass curing of 90% has been used for worst-case, with 80% used for the worse and likely scenarios.

Table 12 in section 10 shows the ROS and HFI outputs for the range of fuel types and terrain for the 'worst-case', 'worse' and 'likely' zone scenarios.

9.4.Recreation visitor numbers

Visitor data is only anecdotal, except that for the NZMCA campground. The recreation areas are very well used during the summer months and both shoulder seasons of summer, with lower numbers during the rest of the year. Visitors can be expected in these areas at most times of day, every day.

Indications are that visitor numbers will be surveyed in the near term, with results then able to better inform risk assessment.

9.5.Existing treatments

9.5.1. Plans and awareness

1) South Canterbury High Country Strategic and Tactical Fire Management Plan SC_P May 2013, with reference to RUI planning for Lake Tekapo. Fire growth and predetermined response modelling was completed for an ignition in the Defence Area west of Lake Alexandrina. Modelling was undertaken for a prevailing northwest wind direction and under High, Very High, and Extreme fire danger classes.

2) ECan Regional Park Management Plan 2009 has a fire prevention section outlining several actions to manage fire.

3) ECan Regional Park information pamphlet/brochure has advice to users related to fire safety, including the use of BBQs only on beach areas.

9.5.2. Operating guidelines and regulation

1) Fire and Emergency New Zealand (FENZ) in collaboration with industry have compiled activity guidelines for organisations undertaking spark hazardous or hot works activities in the open air. These include specific guidelines for forestry operations, and general spark hazardous operations such as roadside mowing, welding, as well as power reclosure systems. Organisations involved in activities covered in the guidelines are strongly encouraged to adopt them as standard practice.

2) Electricity supply companies undertake line and tower/pole maintenance which reduces the likelihood of failures that can cause fires. They also maintain fuel reduced corridors for transmission and power-lines.

3) ECan and MDC manage fuel-free fire breaks and/or vehicle access roads within their respective forest areas and other lands administered by them. These may provide:

- access for day-to-day management and recreation routes,
- evacuation (escape) routes,
- access for response to wildfire,
- barriers to fire spread.

4) ECan have recreational signage related to fire within the Regional Park.

5) MDC manages reticulated water supplies that are accessible to emergency services through pressure hydrants located on most sealed roads in the village. These can be utilised by mobile water vehicles, but those suitable for servicing aircraft operations would need to be identified and operational setup pre-planned.

6) ECan, MDC, DOC, and private landowners can close areas to the public or restrict operations on their lands when fire dangers exceed their risk tolerance, or an event occurs that impacts the ability to deal with a wildfire. Examples of restrictions that can be imposed are on the use of chainsaws or other motorised machinery, limited operating hours starting and finishing early before the hot and dry part of a day, or operating on colder damper locations on more southerly aspects. The Mount John Observatory can close the access road off Godley Peaks Road. FENZ can also regulate activities and close areas.

7) FENZ regulates the use of fire in the open air using a tiered system of personal responsibility (Open fire season), permits required (Restricted fire season), and fires totally banned (Prohibited fire season). As fuels dry out, the restrictions on activities that could start fires become stronger.

8) FENZ manages fire signage related to wildfire risk. There are Fire Danger Class signs on the western side of Burkes Pass and western side of Lake Tekapo Village. During restricted and prohibited fire seasons related signage is erected at strategic locations to inform the public.

9) ECan has some fire prevention signage in the Zone A picnic area.

9.5.3. Emergency response

10) FENZ provide an emergency service response to fires.

Table 8: FENZ emergency service response

Station/Resource	Estimated arrival time from notification to lake Tekapo Village
Lake Tekapo	Muster of 5 minutes and drivetime of 5 mins or less to most locations in and near the village. Distance is approximately 10km with drivetime to the top of Mount John approximately 15 minutes.
Burkes Pass	Muster time 10 - 15 minutes with drivetime to Lake Tekapo Village approximately 15 - 20 minutes.
Fairlie	Muster time 5 minutes with approximate drivetime to Lake Tekapo Village approximately 30 minutes.
Twizel	Muster time 5 minutes with drivetime to Lake Tekapo Village approximately 40 - 45 minutes.
Defence	Only if on location in the Lake Tekapo Training Area.

10. Risk Evaluation

Wildfire responds to fuel, weather, and topography, with fuel being the one component that is easily modified. To sustain fire, fuel (vegetation), oxygen and heat are all required. Removal of any one of these will result in no fire. In the presence of slopes and gullies, fires will travel faster and be more intense than those on flat ground. Fuel types and species have different flammability levels resulting in different ignitability, development and spread potential. Wildfire poses a risk to the area of interest, and as fire danger increases so too does the probability of ignition and damage potential.

Ignition may occur within the area of interest, or outside it in the wider scope area where fire may then spread towards the area of interest. Depending on ignition location and prevailing wind direction, a spreading wildfire could threaten people and property in all risk zones. When modelling the wildfire impact on zones, wind directions were selected from the climate data set based on respective zone scenarios stated in the risk identification section. For example, a northwest wind was used for the ECan Regional Park, and southerly for the southwest and southeast village RUIs.

Wildfire ignitions that develop in the presence of continuous vegetation over a distance present a higher wildfire damage potential than those contained by fuel barriers and close to values. As fire spreads it accelerates towards equilibrium ROS and HFI, with acceleration time to equilibrium generally accepted to be around 20 to 30 minutes. For example, a fire starting near SH8 south of the MDC forest will have time to accelerate and form a head fire before impacting on the RUI in zone C, as opposed to an ignition on the very edge of that RUI which would be far less likely to develop before being suppressed.

Of the 57 recorded fire occurrences, 20 are located where they potentially have time to accelerate towards equilibrium ROS and HFI. The locations of these fires indicate that all risk zones could be impacted, however the risk levels vary due to ignition return periods being different in each zone. Evaluation of the greatest number of days in a month where forest and grassland fire danger levels

are Moderate to Very Extreme indicates that if there is ignition, fire is likely to spread on more than 26 days in all months of the fire season.

Fire behaviour modelling of the varied vegetation types across and within zones indicates the HFI will vary at different parts of impact areas. This will therefore cause variation in the level of damage potential leading to variation of risk consequence.

The following zone risk scores are based on the 20 recorded ignitions that are located where there is potential for a fire to accelerate toward equilibrium ROS and HFI.

Table 9: Zone overall risk scores

Zone	Likelihood	Consequence	Risk level
A & B – Regional Park	Likely	Catastrophic	Extreme
C – Southeast village	Possible	Severe	High
D – Southwest village	Unlikely	Moderate	Moderate
E & F – Northwest village and Mt John	Likely	Severe	Very High

With effective risk reduction treatments, the risk rating can be lowered over the long term, but there will always remain a level of residual risk. Determining a level of acceptable residual risk at points along the development timeline will help determine the quantum and type of risk treatments that can be applied, and when.

Reducing the likelihood of ignitions is the priority both inside and outside the area of interest. This would require targeted wildfire awareness with neighbours and recreation users, and a requirement for any works operation to adopt and implement appropriate risk reduction activity guidelines. This will require collaboration with the Community, ECan, MDC, DOC, and commercial operators.

The consequences from wildfire can be considered on a scale from insignificant to catastrophic depending on prevailing fire danger. At risk are people's lives, the environment, utility infrastructure, built assets and park assets (including trails). Where possible, measures need to be employed to reduce consequences to these values.

In all cases, preventing ignitions is primary followed by engineering works to limit fire behaviour, fire detection and early fire suppression, and evacuation to keep people safe. Because wildfires develop and spread faster during elevated fire danger, the application of treatments would need to keep pace with increasing fire danger levels.

10.1. Fire Danger

The Fire Danger Classes relevant to the Scope Area are primarily Forest and Grassland, with only some Scrub. Analysis of the 18 years of climate data indicates the average number of days in a fire season that fire danger is Very High to Very Extreme is 55 for forest and 44 for grass. For High fire danger the number of days is 41 for forest and 70 for grass. This amounts to almost a third of a year when wildfire presents a serious risk to the area of interest and wider.

10.2. Ignition risk

Analysis of ignition sources, ignition history and existing treatments suggest that ignitions are most likely to occur on or near roads, access points, tracks, powerline corridors and within structures.

Of the 57 recorded fire occurrences, 20 are of specific interest and have been grouped by zone and listed in Table 7. The majority of these were vegetation fires deliberately lit, with others related to powerlines and mechanical faults, etc. Ignition likelihood has been scored by zone, with scores ranging from likely to unlikely. Refer to Table 11.

10.3. Fire Behaviour

Vegetation and topography vary from zone to zone and within a zone. Likely fire behaviour at areas or locations where people or values require protection has been calculated using vegetation type and dryness, slope, and weather from the climate analysis that fits the direction a fire is likely to spread from.

Resulting ROS and HFI outputs have been calculated for each vegetation type present within each zone using the three scenarios, likely, worse, and worst-case (Refer to Table 12). For risk treatment planning, the 'worse' (Extreme) scenario outputs have been used, with the ROS and HFI outputs presented below for their impact location.

Table 10: ROS and HFIs for specific scenario locations

Risk Zone	Fuel type		Likely	Worse	Worst -case
A	Grass	HFI kW/m	3,484	3,628	4,812
		ROS m/h	4,560	4748	6,297
A & B	Plantation Corsican pine, open & limbed/pruned	HFI kW/m	5,895	12,901	32,734
		ROS m/h	1,675	1,904	2,562
	Plantation Corsican pine, tight canopy with ladder fuels	HFI kW/m	14,021	29,754	89,052
		ROS m/h	2,825	3,399	5,957
C	Plantation Corsican pine, highly variable	HFI kW/m	4,773	7,536	18,863
		ROS m/h	399	605	1,498
	Plantation, clean understory	HFI kW/m	1,929	3,602	9,519
		ROS m/h	200	303	749
	Immature Corsican pine (10 y.o.), with windrows and grass	HFI kW/m	21,977	31,510	105,073
		ROS m/h	1,360	1,851	6,077
	Grass, high fuel load	HFI kW/m	2,794	3,804	12,488
		ROS m/h	961	1,309	4,297
	Depleted grass	HFI kW/m	715	929	2,698
		ROS m/h	887	1,151	3,344

D	Plantation, mixed conifer	HFI kW/m	2,733	3,672	8,521 (C6) 2,738 (C5)
		ROS m/h	283	309	670 (C6) 215 (C5)
	Ungrazed grass (30cm high)	HFI kW/m	829	1,128	3,704
		ROS m/h	453	617	2,026
	Depleted grass	HFI kW/m	675	876	2,544
		ROS m/h	836	1,086	3,153
E	Plantation, mixed mature conifer	HFI kW/m	3,883	6,735	19,037 (C6) 15,612 (C5)
		ROS m/h	624	653	1,498 (C6) 1,228 (C5)
	Larch, mature (green summer condition vs autumn needle drop)	HFI kW/m	1,359	1,650	4,389
		ROS m/h	281	285	707
	Grazed grass (30cm)	HFI kW/m	1,662	1,646	4,485
		ROS m/h	1,239	1,227	3,344
	Native ground cover	HFI kW/m	4,057	4,034	5,480
		ROS m/h	1,207	1,200	1,631
F	Depleted grass (access road)	HFI kW/m	6,774	6,678	12,472
		ROS m/h	8395	8,740	15,457
	Grazed pasture/tussock mix, 30cm (access road)	HFI kW/m	45,548	47,697	65,586
		ROS m/h	17,518	18,345	25,225
	Depleted grass (walking tracks)	HFI kW/m	1,396	1,813	5,266
		ROS m/h	1,730	2,247	6,526
	Grazed pasture 30cm (walking tracks)	HFI kW/m	3,206	4,164	12,092
		ROS m/h	2,390	3,104	9,015
	Larch mature, dead/down with ladder fuels (walking tracks)	HFI kW/m	2,166	3,567	10,028 (D-1/C3) 6,699 (M-1)
		ROS m/h	183	253	674 (D-1/C3 923 (M-1)
	Larch mature, without dead/down (walking tracks)	HFI kW/m	1,035	1,538	4,183 (D-1) 6,180 (M-2)
		ROS m/h	183	253	674 (D1) 743 (M2)

10.4. Life risk

Permanent population of the village is around 500, with anecdotal information indicating this increases by 2000 visitors during the summer months.

Recreationists and campers are the most at-risk people from wildfire. They are either undertaking their pursuits within a forest and grassland environment or setting up camp in it. Further, visitors from outside the local community do not always have a good appreciation of the wildfire risk in the area they are visiting, or of exactly where they are and the best way to exit safely should there be a wildfire threatening. Visitors also have a range of mobility, with some able to quickly move to safe areas and others much slower, especially young children.

Those working or operating within vegetation areas could be impacted by a threatening wildfire, such as forestry or power company contractors and those operating outdoor businesses with clients.

Residential and commercial property owners on the RUI may be impacted if evacuation is not prompt or if they try to defend their properties from a damaging wildfire. Property owners within the village, but not on an RUI, will also be affected by smoke and embers, with zone C most at risk from considerable ember attack should a fire enter from the south. Residents may be at risk if properties inside the village beyond the RUI become involved in fire and they try to defend or shelter in them. Property owners should remove themselves from fire impacted properties, and heavy smoke and ember transfer situations.

10.5. Asset risk

These include the residential and commercial structures, ecological and recreational assets, commercial forestry, power transmission and distribution utilities, and mobile phone utilities.

10.5.1. Buildings

Zone A: One toilet block at the picnic area and mobile property associated with the NZMCA Campground.

Zone B: One residential dwelling with associated out-buildings. One remnant historic hut.

Zone C: There are 67 dwellings with associated out-buildings along a 2.8km RUI, with the wider village area having dwellings in the hundreds. There are two structures associated with the communications towers to the south, and one with the rubbish transfer station.

Zone D: There are 25 dwellings with associated out-buildings along a 2km RUI, plus 17 vacant sections ready to build on. The wider village is made up of residential dwellings and commercial structures. There is one structure on SH8 associated with road maintenance, and to the south there is one dwelling in a peri-urban setting and one commercial site with structures and containers.

Zone E: There are 53 structures associated with commercial operations of the campground and Tekapo Springs complexes. There are many mobile property vehicles and tents associated with the campground and a large carpark associated with Tekapo Springs. There is one residential dwelling and an out-building on the south side of SH8. There is one structure associated with the electricity substation.

A 2.1km pre-emptive RUI has been identified for the Station Bay subdivision and campground development.

Zone F: There are 12 structures associated with the Mount John Observatory.

10.5.2. Utility infrastructure

Zone A: There are powerlines passing through in two locations. There are internal and external (boundary fences).

Zone B: There are powerlines in three locations, including a set of 3 transformer poles in a group. There are three water supply tanks with above-ground irrigation piping in places. There is a boundary fence.

Zone C: There are two communications poles/towers, the rubbish transfer station, and oxidations ponds. There are numerous fences.

Zone D: There is a powerline running west from Cairns Avenue into zone E and crossing SH8 to the substation.

Zone E: There is an electrical substation with powerlines extending way from it in four directions. There is farm fencing and horse yards.

Zone F: There is one powerline from the substation to Mount John and one communications pole on Mount John. There are above-ground water tanks at the Mount John southern-most building and two at the lake shore with an associated small structure.

10.5.3. Environmental

This risk relates to the loss of biomass, ecosystems (fauna and flora), soil (through erosion) and water quality, as well as the invasion of pest plants and animals.

The ECan Regional Park's primary purpose is soil conservation. Loss of the forest would impact this as well as timber values. The MDC Forest is commercial in status and may lose timber value as well as the sheltering value to the village.

The vascular plant *Chenopodium detestans* which is classified as threatened – nationally critical is found on the foreshore area of the ECan Regional Park and in front of Tekapo Springs. There is a Conservation Covenant on the eastern slopes of Mount John. There is a DOC scientific reserve to the south of zone C with associated values including kettle holes.

If damaged by fire, the aesthetics of the wide-open vistas of grassland would be an eyesore until recovered, with likely weed invasion.

Recreational trail aesthetics would be damaged by fire through the removal of vegetation leaving a destroyed environment that would take many years to recover. Trails and tracks themselves are more likely to be damaged during fire suppression operations or post-fire events through heavy machine operation and heavy rains washing them out. An affected area would need to be closed until roads and tracks are made safe, including the felling of damaged trees.

10.5.4. Businesses

Businesses most at risk from wildfire are those that are situated where fire can have a direct impact. This includes those that are within or on the boundary with continuous vegetation, including the RUI. Examples of businesses that could be impacted are electricity supply, farming, outdoor pursuits, campgrounds, and tourist facilities like Tekapo Springs and Mount John Observatory.

Less at risk are those that may be affected by smoke and embers, or by road closures and evacuations.

10.5.5. Cultural, historic, and archaeological

Iwi have a long history in the area and an interest in protecting many locations of value that are kept secret to them. European settlement occurred in the 1850s when farming began to establish.

11. Risk treatment recommendations

This section outlines wildfire risk treatments aimed at managing wildfire risks identified within the scope area. It is presented by risk area and their associated zones, with each risk treatment aligning with a specific treatment objective.

11.1. Risk treatment summary

Table 11: Risk treatment summary

Ref#	Table #	Priority	Location	Action/activity	Groups concerned
All zones					
A1	14	TBA	Roads and tracks	Access controls	ECAN, MDC, DOC, FENZ and Users
A2	14	TBA	Roads and tracks	Evacuation planning	ECAN, MDC, DOC, FENZ and Users
A3	14	TBA	Roads and tracks	Communicating fire danger	ECAN, MDC, DOC, FENZ
A4	14	TBA	Powerline corridors	Vegetation management	Power company
A5	14	TBA	All RUIs	Use of low flammability vegetation	Property owners
A6	14	TBA	All scope area	Use of FENZ activity control guidelines	All
A7	14	TBA	Powerline corridors	Use of power auto reclosure system	Power company
Risk area 1 - zones A and B					
R1-1	15	TBA	Zones A and B	Use of fire - compliance	FENZ and ECAN
R1-2	15	TBA	Zones A and B	Revegetation planning	ECAN
R1-3	15	TBA	Zones A and B	Vegetation management – site specific	Power company and ECAN
Risk area 1 - zone A					
R1-4	16	TBA	Visitor gathering points	Fire signage	ECAN
R1-5	16	TBA	NZMCA campground	Fire signage	ECAN and NZMCA

R1-6	16	TBA	NZMCA campground	First response firefighting equipment	ECAN and NZMCA
R1-7	16	TBA	Forest area	Vegetation management – fuel reduction	ECAN
Risk area 1 - zone B					
R1-8	17	TBA	Forest road and track network	Track network - evacuation routes and signage	ECAN
R1-9	17	TBA	Forest area	Water supply access and fittings	ECAN
R1-10	17	TBA	Forest area	Vegetation management – fuel reduction	ECAN
R1-11	17	TBA	Private dwelling	Defensible space management	ECAN
Risk area 2 – all zones					
R2-1	18	TBA	Zones C, D and E	Fire Smart self-checks	ECAN and FENZ and property owners
Risk area 2 – zone C					
R2-2	19	TBA	RUI 1 and 2	Vegetation – low flammability species	FENZ property owners
R2-3	19	TBA	RUI 2	Fuel reduced barrier	MDC
R2-4	19	TBA	RUI 3	Road access and vegetation management	MDC
R2-5	19	TBA	RUI 3	Fuel load reduction and low flammability planting	MDC and property owners
R2-6	19	TBA	RUI 4	Fire breaking and fuel reduced barrier	MDC
R2-7	19	TBA	RUI 5	Road access and fuel reduced barriers	MDC
R2-8	19	TBA	RUI 4 and 5	Maintain fuel reduced barriers, roads and tracks, property fences, revegetation with low flammability species, and removal of rubbish and tree trimmings	MDC and property owners
R2-9	19	TBA	RUI 6	Fire breaking and fuel reduction	MDC and property owners
R2-10	19	TBA	RUI 7	Track vegetation maintenance and low flammability species	MDC and property owners

R2-11	19	TBA	Forest road and track network	Forest evacuation system	MDC
R2-12	19	TBA	Communication tower installations	Maintain non-fuel areas around installations	Communication companies
Risk area 2 – zone D					
R2-13	20	TBA	RUI 1	Fuel reduced barrier and other fuel reduction. Low flammability planting	Land managers and property owners
R2-14	20	TBA	RUI 2	Fuel reduced barrier. Low flammability planting	Land managers and property owners
R2-15	20	TBA	RUI 3	Low flammability planting	Property owners
R2-16	20	TBA	Andrew Don Drive	Fuel barrier, fuel reduction and removal of dead down material. Defensible space	Property owners
Risk area 2 – zone E					
R2-17	21	TBA	RUI 1	Low flammability species planting	Property owners
R2-18	21	TBA	RUI 1 campground	Fire breaking, low flammability planting and vegetation management	Property owners
R2-19	21	TBA	RUI 2	Replace flammable fencing materials, defensible space, fire breaking	Property owners
R2-20	21	TBA	RUI 2 and subdivision	Slash pile removal	Subdivision and contractors
R2-21	21	TBA	Tekapo Springs	Replace flammable fencing, vegetation management	Property owners
R2-22	21	TBA	Substation	Remove dead-down vegetation and stacked poles, fuel reduction	Power company
Risk area 3 – zone F					
R3-1	22	TBA	Metal road off the end Lakeside Drive	Vegetation removal/management around water tanks	Mt John Observatory

R3-2	22	TBA	Metal road off the end Lakeside Drive	Fire signage installation	MDC
R3-3	22	TBA	Recreational tracks	Evacuation planning	DOC, MDC, FENZ and Police
R3-4	22	TBA	Mount John access road	Evacuation planning	Mount John Observatory, FENZ and Police
R3-5	22	TBA	Mount John structures	Fire breaking and defensible space	Mount John Observatory

11.2. All risk areas

Table 12: Treatments for all risk areas

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
A1		Recreation tracks and roads	To reduce likelihood and consequence To share the risk To transfer the risk	Reduction	1. In collaboration with FENZ, prepare triggers for implementing limited access (at user risk) and closure of recreation tracks. 2. Prepare access control hardware including relevant fire signage and barriers and identify locations where they will be used.	ECAN, MDC, DOC, FENZ and Users
A2		Recreation tracks and roads	To reduce consequence To share the risk	Readiness	1. Prepare an evacuation plan for all track systems in Lake Tekapo that can be implemented by users in the first instance and followed through by responders. This would include sweeping tracks to ensure people are clear.	ECAN, MDC, DOC, FENZ and Users
A3		Recreation tracks and roads	To reduce likelihood and consequence To share the risk	Reduction	1. Maintain adequate communications relevant to prevailing fire danger conditions.	ECAN, MDC, DOC, FENZ
A4		Powerline corridors	To reduce likelihood and consequence	Reduction	1. Maintain vegetation in powerline corridors to a level that:	Power Company

					a. will not touch overhead lines considering height, lateral line sway and tree fall where possible b. have non-fuel areas beneath poles and towers c. a fire's energy output beneath and beside the lines is low enough not to damage the lines.	
A5		All RUIs	To reduce consequence	Reduction	1. Encourage the use of low or non-flammable boundary fence materials.	Property owners
A6		All scope area	To reduce likelihood & consequence	Reduction	1) Require work operations, including volunteer work, within the Scope Area to apply activity control guidelines based on the New Zealand Fire Danger Rating System. • *Fire Prevention Guidelines for Forestry Operations* are available from FENZ and New Zealand Forest Owners Association. • *Fire Prevention Guidelines for Heat and Spark Hazardous Activities / Hotworks* is available from FENZ.	ALL
A7		Powerline corridors	To reduce likelihood & consequence	Reduction	1) Discuss with relevant power companies the applicability of applying the FENZ *Power Line Auto Re-Closure System Triggers - Fire Risk Guidelines,* and if applicable encourage its use.	Power company

11.3. Risk area 1

11.3.1. All zones

Table 13: Risk area 1 – all zones

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R1-1		Zones A and B	To reduce likelihood and consequence To share the risk	Reduction	FENZ and ECAN maintain compliance monitoring related to the use of fire, cooking apparatus and incendiaries such as fireworks.	FENZ and ECAN
R1-2		Zones A and B	To reduce the consequence	Reduction	With the long-term goal being to replace the conifer forest with representative native for the area, consideration needs to be given to the flammability of selected species. It is advisable that during the preparation of a planting plan that a species mosaic incudes buffers of low flammability species that can act to slow fire spread. It is suggested that such buffers could be designed in conjunction with the final track and road network.	ECAN
R1-3		Zones A and B			Reduce fuel, especially threatening trees along the powerline corridors from SH8 to Lilybank road and on to the village; and review fuel reduction where the line runs down the campground access road and the first section as it runs north.	Power company and ECAN

11.3.2. Zone A

Table 14: Risk area 1 – zone A

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R1-4		Visitor gathering points	To reduce likelihood	Reduction	Install 'No Fires' signs at the picnic ground and campground as well as known problem areas on the lake shore.	ECAN
R1-5		NZMCA campground	To reduce consequence	Reduction	Install clear and concise signage outlining evacuation procedure, including what to do when the threat of fire is imminent.	ECAN and NZMCA
R1-6		NZMA campground	To reduce consequence	Reduction, Readiness & Response	During the fire season months, strategically locate and secure a cache of vegetation firefighting hand tools for quick access (include a backpack sprayer).	ECAN and NZMCA
R1-7		Forest area	To reduce consequence	Reduction	Reduce the forest fuel load in areas where it is denser with tight canopy and ladder fuels. Create a more open understory to keep fire on the ground and at lower intensity. The main area is between the campground access road, north to the powerline corridor and out to Lilybank Rd. Priority areas are around the campground and the Lilybank Rd edge.	ECAN

11.3.3. Zone B

Table 15: Risk area 1 - zone B

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R1-8		Forest road and track network	To reduce consequence	Readiness	1. Prepare an evacuation route system that leads to safety zones. Use the existing road and track network but install new routes if considered necessary. Fire Behaviour modelling indicates fires would spread very fast.	ECAN

					2. Install signage to mark the routes, and at junctions gives clear and concise directions. 3. Collaborate with MDC and DOC for consistent evacuation sign messaging at all Lake Tekapo recreation locations. 4. Include an evacuation map in public awareness materials and at main entry points to the forest.	
R1-9		Forest area	To reduce consequence	Readiness	1. For the three water tank sites, clear sufficient area around them for 4x4 vehicles to turn without the need to reverse. 2. Provide outlet couplings compatible with FENZ and have a bleed system (summer only) to fill backpack sprayers. 3. Install water direction signage on main arterial roads.	ECAN
R1-10		Forest area	To reduce consequence	Reduction	1. Undertake fuel reduction in parts of the forest that are dense and have either canopy closure or ladder fuels to the ground or both. Prioritise the edges of evacuation routes followed by other track and road edges incrementally widening the treated area. 2. Also apply fuel reduction around the water tanks and the edge of Lilybank Rd and the powerline corridor.	ECAN
R1-11		Private dwelling	To reduce consequence	Reduction & Readiness	1. Apply defensible space criteria to the dwelling and its outbuildings.	ECAN

11.4. Risk area 2

11.4.1. All zones

Table 16: Risk area 2 – all zones

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R2-1		Zones C, D & E	To reduce likelihood and consequence	Reduction	1. Deliver Fire Smart self-checks to all properties in Lake Tekapo. 2. For those properties where trees and forest slash lie upwind, emphasise the possibility of ember showers impacting properties well in from the RUI.	ECAN and FENZ and property owners

11.4.2. Zone C

Table 17: Risk area 2 – zone C

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R2-2		RUI 1 and 2	To reduce consequence	Reduction	1. On property boundaries plant low flammability species (native or exotic) on their boundary with rural lands, and if planting trees, plant medium height, lower flammability trees intermittently with low flammability ground cover species between and, if higher flammability species are required, plant in clusters surrounded by low flammability options.	FENZ property owners.
R2-3		RUI 2	To reduce consequence	Reduction	1. Maintain a 3m wide low grass (<10cm) fuel break at property edges.	MDC?

R2-4		RUI 3	To reduce consequence	Reduction	1. Maintain existing 4x4 access road behind property boundaries as non-fuel 3m wide (no middle grass strip, run grader over it). 2. Maintain access 4x4 track between RUI 2 and 3 as non-fuel 3m wide.	MDC
R2-5		RUI 3	To reduce consequence To share the risk	Reduction	1. Between RUI 2 and 3, remove lower limbs on the scattered and groupings of mature trees from ground to 3m or 4m height, and remove surface fuel 10m back from the RUI 4x4 road. 2. Where there are eucalyptus trees, remove any hanging bark. 3. Grass areas that meet the 4x4 road need to be reduced to 10cm high for a distance of 3.5m. 4. Properties with mature trees on their boundary to remove lower limbs and remove surface fuels. 5. Property boundary plantings to be low flammability species (native or exotic) and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species or managed grass between.	MDC and property owners
R2-6		RUI 4	To reduce consequence To share the risk	Reduction	1. Install a mineral earth firebreak/metal 4x4 road 3m wide behind the properties that links RUI 3 with RUI 5. 2. On the forest side of the road, maintain a 3.5m wide grass strip <10cm high.	
R2-7		RUI 5	To reduce consequence To share the risk	Reduction	1. Maintain the existing metal road behind the RUI 5 boundaries as non-fuel 3m wide (no grass strip down the middle).	

					2. On the forest side of the road, maintain a 3.5m wide grass strip <10cm high. 3. On the property side of the road, maintain grass <10cm and where there are trees remove lower limbs to 3m and any surface fuel. 4. At the western end of RUI 5 between the upper and lower tracks/roads, remove lower limbs of individual or grouped conifer trees. Remove all surface fuel under the trees.	
R2-8		RUI 4 and 5	To reduce consequence To share the risk	Reduction	1. Maintain the area between the lower track/road and property boundaries as either grass <10cm or low flammability species (native or exotic) and, if planting trees, plant medium height lower flammability trees intermittently, with low flammability ground cover species between. Existing mature trees need lower limbs removed to 3m and surface fuel removed. 2. Properties with high flammability fences encouraged to have no flammable fuel on the structure side to avoid fire spread to the structures or, if replacing fences, consider non-flammable materials that can act as a radiant heat barrier. 3. Maintain the forest access track at the top of the grass slope to the south as non-fuel and link to the RUI 3 4x4 road/s. Do this all the way west (above RUI 5) to link with the rubbish transfer station road. 4. Remove any dumped or felled-to-waste tree branches or slash between the upper track and	MDC and property owners

					lower 4x4 track/road, and the lower track/road to the property boundaries. 5. Revegetation of the area between the upper and lower track/roads (not including low grass area) should be low flammability groundcover and, if higher flammability species are required, plant in clusters surrounded by low flammability options.	
R2-9		RUI 6	To reduce consequence To share the risk	Reduction	1. Create a non-fuel firebreak between the property boundaries and the second fence line to the south around 8m - 10m wide and link to the rubbish transfer road at the top and the walking track at the bottom. 2. Remove limbs and surface fuels for the mature forest between the properties and the immature Corsican forest compartment. 3. Mature trees on the property boundaries to have lower limbs removed and surface fuel removed. Also remove limbs that overhang the firebreak and those that overhang structures.	MDC and property owners
R2-10		RUI 7	To reduce consequence To share the risk	Reduction	1. Maintain foot track as 2m wide non-fuel with mown edges 1m each side. 2. Plant low flammability species (native or exotic) on property boundaries and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species between. If higher flammability species are required, plant in clusters surrounded by low flammability options.	MDC and property owners

R2-11		Forest road and track network	To reduce consequence	Readiness	1. Prepare an evacuation route system that leads to safety zones. Use the existing road and track network, but install new routes if considered necessary. Fire behaviour modelling indicates fires would spread very fast. 2. Install signage to mark the routes, and at junctions gives clear and concise directions. 3. Collaborate with ECAN and DOC for consistent evacuation sign messaging at all Lake Tekapo recreation locations. 4. Include an evacuation map in public awareness materials and at main entry points to the forest.	MDC
R2-12		Comms tower installations	To reduce consequence	Reduction	1. Maintain non-fuel areas around communication structures, tower/pole bases and cable anchor points.	

11.4.3. Zone D

Table 18: Risk area 2 – zone D

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R2-13		RUI-1	To reduce consequence To share the risk	Reduction	1. Maintain a 3m wide grass strip of <10cm tall behind boundaries. 2. Limb lower branches of mature trees to 3m and remove surface fuel. 3. Plant low flammability species (native or exotic) on property boundaries and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species between. If higher flammability species are required,	Land managers and property owners

					plant in clusters surrounded by low flammability options.	
R2-14		RUI - 2	To reduce consequence To share the risk	Reduction	1. From the terrace edge where the conifer trees stop, maintain a 6m grass strip <10cm tall. 2. Plant low flammability species (native or exotic) from the edge of the low grass and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species between. If higher flammability species are required, plant in clusters surrounded by low flammability options.	Land managers and property owners
R2-15		RUI - 3	To reduce consequence	Reduction	1. Property boundaries not visible, but generally depleted grass boundary. Maintain this and if property owners plant their boundaries, then suggest planting low flammability species (native or exotic) from the edge of the low grass and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species between. If higher flammability species are required, plant in clusters surrounded by low flammability options.	Property owners
R2-16		Andrew Don Drive	To reduce consequence	Reduction	1. The residential property off the south end of Andrew Don Drive should reduce fuels on its southern boundary with the industrial area. For example, by preparing a grass strip 4m wide and removing lower tree limbs to 3m. Remove surface slash from pruning and existing dead-down material.	Property owners

					2. The structures in the industrial area should apply standard defensible space criteria.	

11.4.4. Zone E

Table 19: Risk area 2 – zone E

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R2-17		RUI - 1	To reduce consequence	Reduction	1. This RUI is estimated due to ongoing development. Wildfire is more likely to spread across slope and/or burn downslope. It is suggested that if revegetation occurs on the RUI that a planting plan be based on low flammability species (native or exotic) and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species between. If higher flammability species are required, plant in clusters surrounded by low flammability options.	Property owners
R2-18		RUI -1 Campground			1. There should be a non-fuel barrier between the campground boundary and campsites and structures within the campground. Based on the present grass fuel, the width of the barrier would need to be at least 3m. 2. Campground boundary and internal planting plan should be based on cluster planting to break vegetation continuity. Breaks in continuity can be achieved by either non-fuel areas such as pathways and roads, or mown grass. This approach limits the probability of fire spreading from one	Property owners

					compartment of campsites or structures to another. 3. Plant low flammability species (native or exotic) and, if planting trees, plant medium height lower flammability trees intermittently with low flammability ground cover species or managed grass between. If higher flammability species are required, plant in clusters surrounded by low flammability options.	
R2-19		RUI - 2	To reduce consequence	Reduction	1. This is an estimated RUI due to subdivision development. Once the development is in place, most of the Tekapo Springs complex and the western end of the campground will not be on the RUI. The Station Bay subdivision outer housing line will make up nearly all the RUI. These structures will have vegetation fuel beyond their boundaries that will need to be assessed for fire potential. In the interim, there are some points to keep in mind: a. Property boundary fencing materials should be either non-flammable or low flammability. b. Property owners should apply defensible space criteria with boundary plantings of low flammability species. c. If the conifer forest adjacent to the subdivision remains, then there needs to be fuel reduction undertaken to reduce wildfire intensity at property boundaries. Based on the present	Property owners

					forest, install a non-fuel firebreak at least 4m wide at the boundary, followed by a 10m grass strip <10cm tall back to the forest. d. If structures are very close to the boundary with vegetation, then the firebreak and grass strip widths in 'c' above will need to increase. 2. For areas of the RUI that may be open larch forest, install a 4m non-fuel firebreak at the boundary, and for 5m back remove the lower tree limbs to 3m and remove the pruned material.	
R2-20		RUI 2 and subdivision	To reduce consequence	Reduction	1. The risk associated with burning of heaped slash piles needs to be carefully considered in regards their ability to spread via ember transfer to other exposures downwind, and the smoke associated with burning.	Subdivision and contractors
R2-21		Tekapo Springs	To reduce consequence To share the risk	Reduction	*1. Note the subdivision development will change the present fuels, therefore the recommendations below may need to be re-assessed.* 2. The southern boundary fence is high flammability with high flammability cluster plantings on the inside such as toetoe and tussock that are very close to structures and infrastructure. Maintain a non-fuel barrier between the fence and the forest, and limb trees in a 4m wide strip to 3m high and remove surface slash material. 3. The rest of the boundary is with Larch forest and has a general downhill burn	Property owners

					direction. Maintain the boundary fuel as short grass where terrain allows.	
R2-22		Substation	To reduce consequence	Reduction	1. Outside the western edge of the hard surface and beneath the powerlines are piles of old slash and one pile of poles lying on the ground. Remove this fuel to avoid increases in fire intensity that may damage poles and lines. 2. On the southwest corner of the structure remove tree branches that are within 3m and remove lower tree limbs to 3m high and remove the slash.	Power company

11.5. Risk area 3

11.5.1. All risk area (zone F)

Table 20: Risk area 3 – zone F

Ref #	Priority	Location	Treatment Objective	Function	Action/activity	Groups concerned
R3-1		Metal road off the end Lakeside Drive	To reduce consequence	Reduction	1. Clear trees and scrub 3m off the water tanks and structure.	Mt John Observatory
R3-2		Metal road off the end Lakeside Drive	To reduce likelihood & consequence	Reduction	1. Install 'no fire' and 'no camping' signs at the beginning of the metal road leading to the Lake.	MDC
R3-3		Recreational tracks	To reduce consequence To share the risk	Readiness	1. Apply actions listed in 'all risk areas' – refer section 10.2 evacuation planning and limited access/closure procedure.	DOC, MDC, FENZ and Police

					a. The loop nature of the Mount John walking track system is problematic in that alternative evacuation routes are not available. Safe areas are either at the start point, the lakeshore, or the hard-surface areas at the top of Mount John such as the carpark. The upper slopes tend towards depleted grass with areas of very little fuel where a fire's intensity may not injure but smoke would be a problem. b. The option for users is to either carry on to a safer location, return to their start point, or stay where they are if moving puts them in danger of being burnt over. To this end, the evacuation procedure should include a search of tracks and escorted removal of any users present. c. On the southern slopes where the track passes through Larch forest, fire is likely to be narrow and spreading slower than grassland and may be interrupted in places where there is little surface fuel. Where the track runs up and across grassland faces above the upper edge of the forest to Mount John is where users are more likely to be caught. Quick evacuation action is required if a fire is detected that could impact this aspect. d. On the northern slopes, users would be most at risk on the track section that leaves the lakeshore and sidles on to the flatter northern shoulder of Mount John. Users	

					would need to be found and escorted off the northern track system to a safe location.	
R3-4		Mount John access road.	To reduce consequence. To share the risk	Readiness	1. Road users are most at risk from fire approaching the road from below. The vegetation is variable over the length of the road, with steep slopes below once it begins switchbacks on to the northern shoulder and sidles predominantly along the rising shoulder to the top. Flame lengths, even under the likely scenario, are 4.5m to >10m at the head when reaching the road. The road is narrow and only 4 or 5m wide, and visibility will be severally limited. Taking this information into account, the evacuation plan must: a. Close the road and evacuate visitors from the top only if there is time for an orderly withdrawal. b. Do not use the road when it is imminently threatened by an advancing wildfire. Close it but allow for anyone on their way out to get through. c. Those already on the road to make their way to a safe point at the top facilities or to the road entry point off Godley Peaks Road, and thence either north or south whichever is safest. d. Do not release vehicles from the top until there is no chance fire can make a run toward the road. e. Vehicles in the top carpark are at risk on the impact edge of an advancing fire, especially the south side. The vegetation around the	Mount John Observatory and FENZ/Police

					carpark is generally very depleted and on the west side there is a non-fuel barrier 40 or 50 m downslope. If vehicles catch fire, they will compromise the carpark as a safe area. If vehicles catch fire, a safer location may be at the Mount John facilities on the high point hard surface as the area has barriers on some sides or very little vegetation. Smoke will be a problem. Alternatively, the hard surface surrounding the lower southern structure may be a safe option from fire coming from the west. f. Vehicles should be escorted off Mount John only when safe to do so.	
R3-5		Mount John structures	To reduce consequence.	Reduction	1. The southern structure is protected to the east through north to west by sufficient hard surface. On the south side where the water tanks and service structure are, install a non-fuel firebreak to the edge of the bank and around the sides to link with the hard surface. 2. For the northern structure (residential), apply defensible space criteria to the south and east sides.	Mount John Observatory

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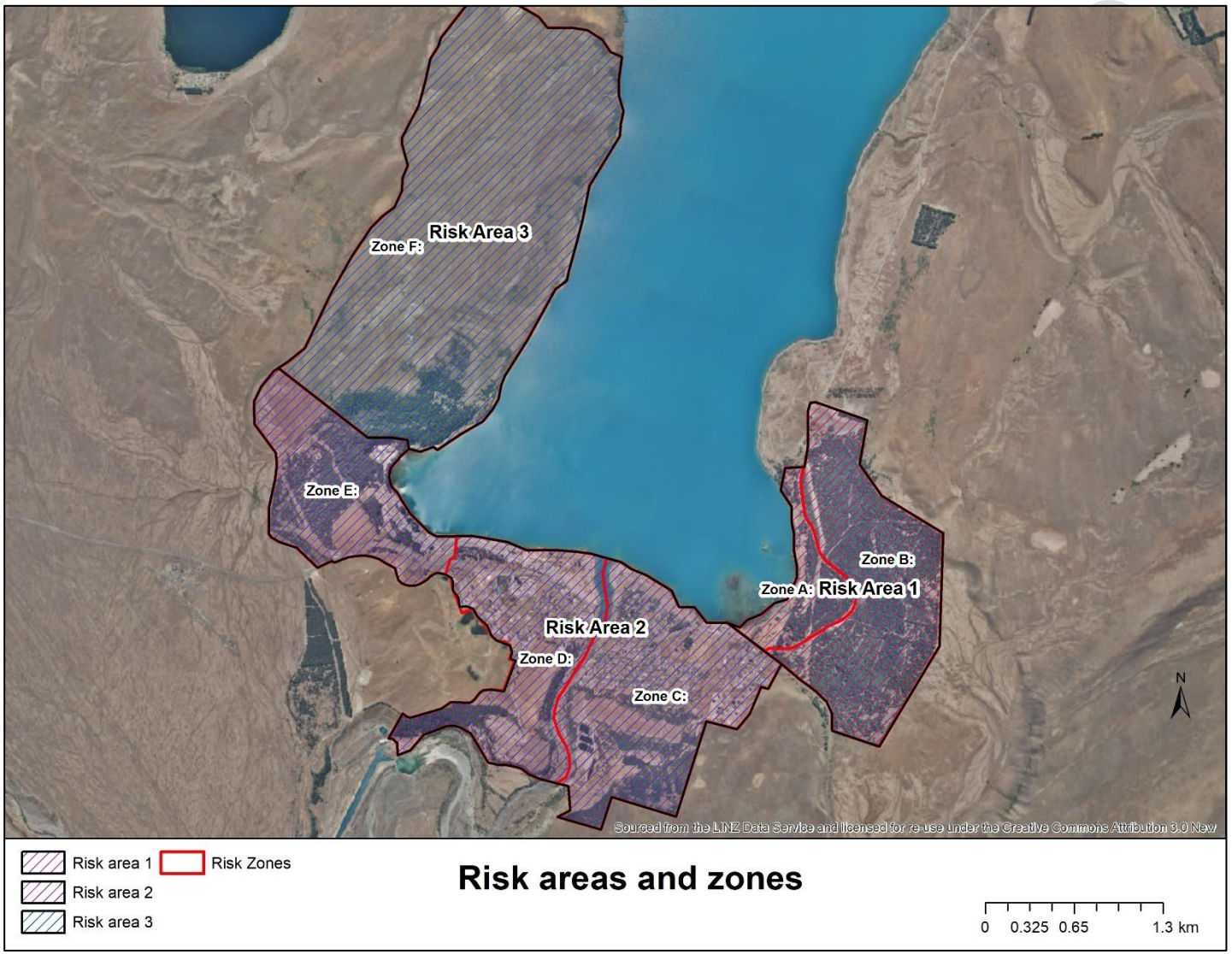
13. Appendices

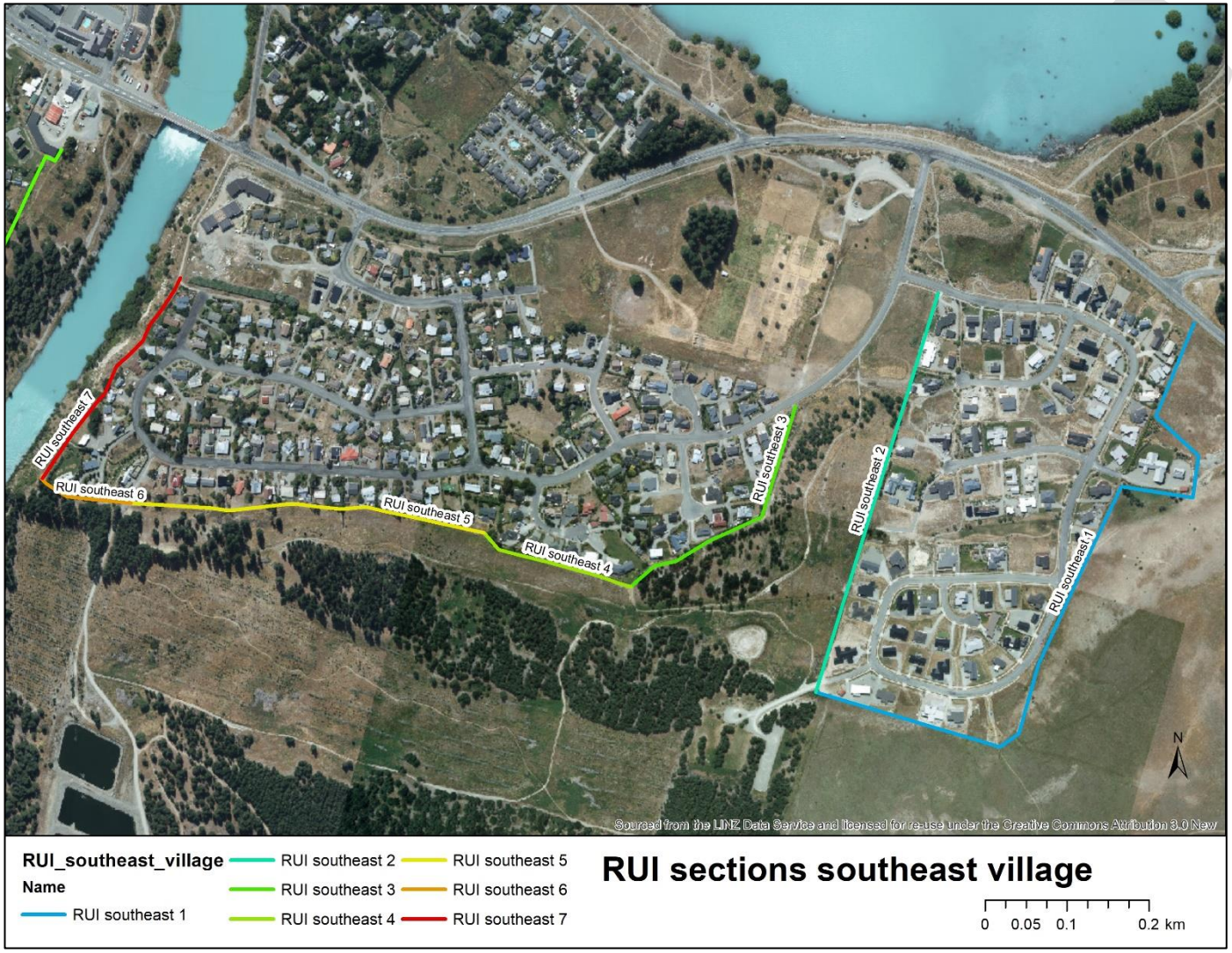
13.1. Appendix 1: Scope area and area of interest

13.2. Appendix 2: Risk areas and zones

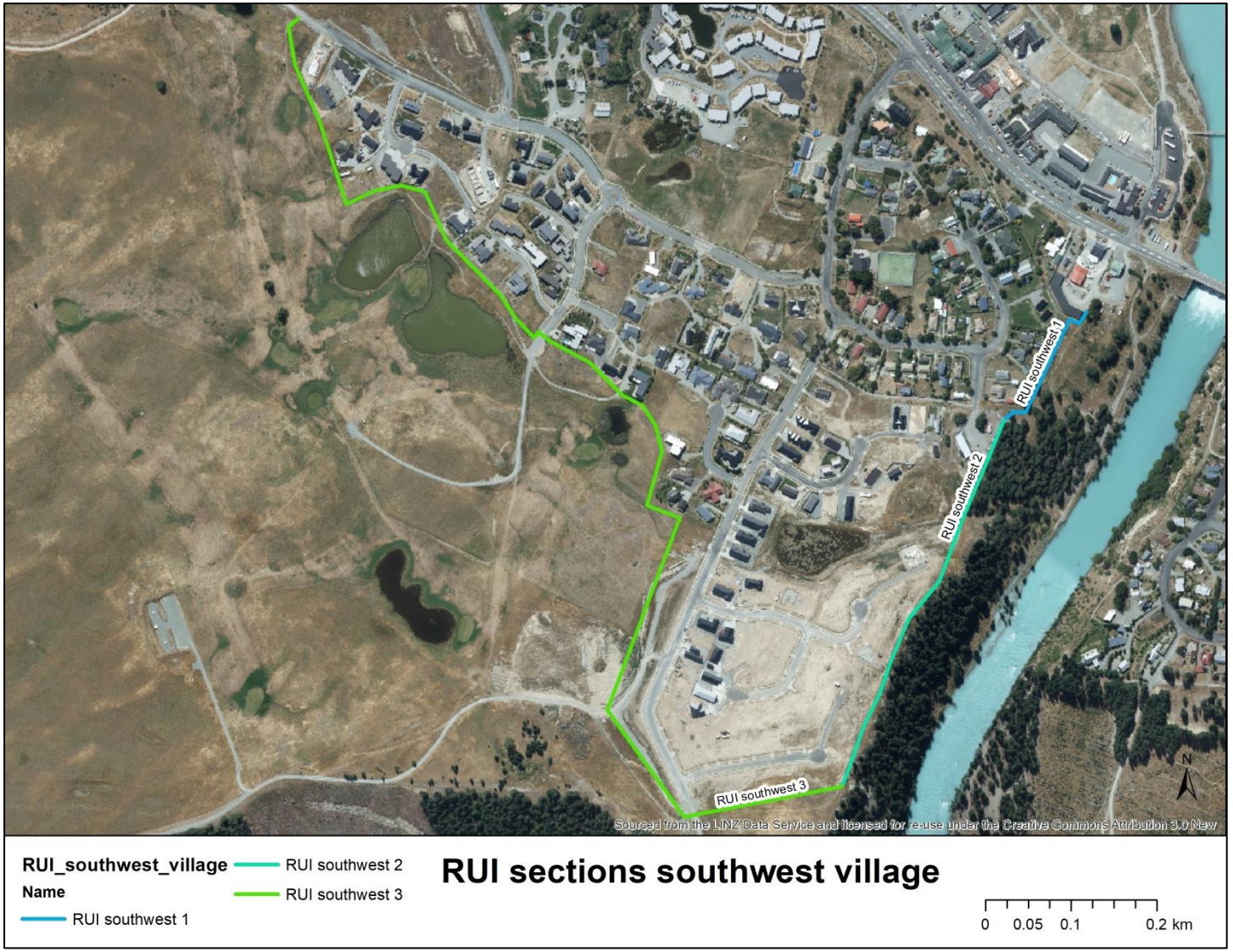


13.3. Appendix 3: RUI section maps

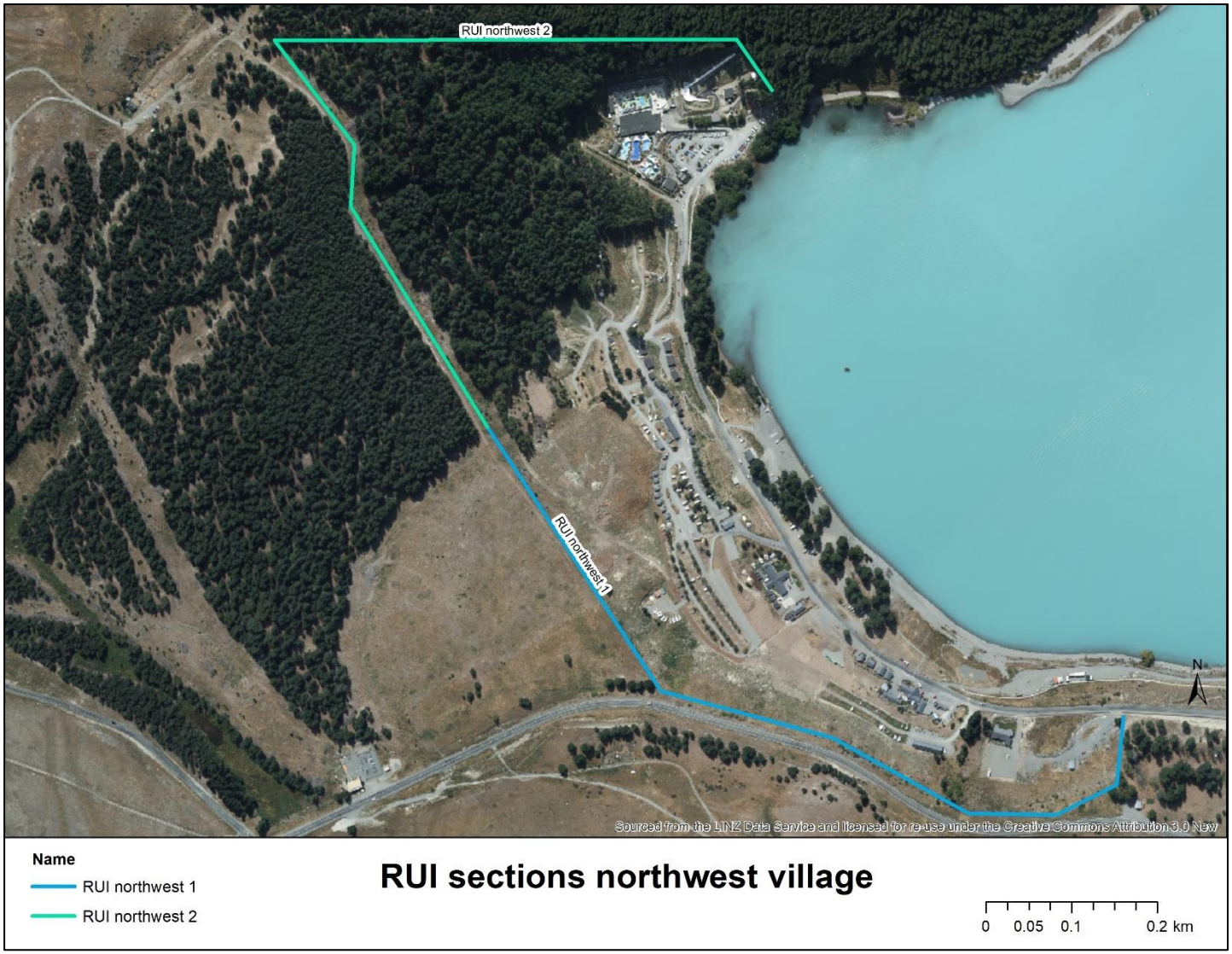
Southeast village



Southwest village

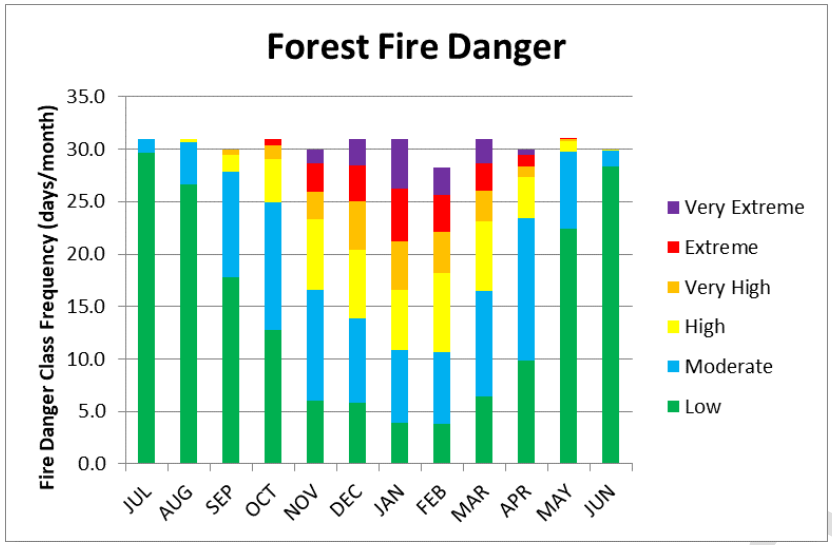


Northwest village



13.4. Appendix 4: Fire Danger Class summary

Station Name: Tekapo Ews (Tekapo_Ews)						Period: 2003-06-19 - 2021-07-01					Length of record: 18 years			
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YEAR	FIRE SEASON
Forest Fire Danger Class (FFDC) Frequency														
Low	29.5	26.9	17.4	12.6	6.2	6.1	3.8	3.9	6.8	10.1	22.6	28.2	**174.2**	**48.5**
Moderate	1.5	3.7	10.4	12.5	10.4	8.4	6.6	6.9	9.9	14	7.4	1.6	**93.2**	**68.3**
High	0	0.4	1.7	4.1	6.7	6.5	5.6	7.3	6.7	3.6	0.8	0.1	**43.5**	**41.2**
Very High	0	0	0.5	1.3	2.6	4.5	4.6	4	2.8	0.8	0.2	0	**21.4**	**20.8**
Extreme	0	0	0	0.6	4.1	5.5	10.2	6.2	4.8	1.5	0	0	**33**	**33.4**
Low	29.6	26.6	17.8	12.7	6.0	5.8	3.9	3.8	6.4	9.8	22.4	28.4	**173.3**	**48.5**
Moderate	1.4	4.1	10.1	12.2	10.6	8.1	6.9	6.9	10.0	13.6	7.4	1.5	**92.7**	**68.3**
High	0.0	0.3	1.6	4.1	6.7	6.5	5.8	7.5	6.7	3.9	0.9	0.1	**44.2**	**41.2**
Very High	0.0	0.0	0.5	1.3	2.6	4.6	4.6	3.9	2.8	1.0	0.2	0.0	**21.6**	**20.8**
Extreme	0.0	0.0	0.0	0.6	2.7	3.4	5.1	3.6	2.7	1.2	0.1	0.0	**19.3**	**19.3**
Very Extreme	0.0	0.0	0.0	0.0	1.4	2.6	4.7	2.6	2.3	0.5	0.0	0.0	**14.1**	**14.1**
Grass Fire Danger Class (GFDC) Frequency														
Curing source		Canterbury (Hill & high Country)												
Curing%	**60**	**60**	**70**	**70**	**70**	**80**	**80**	**80**	**70**	**60**	**60**	**50**		
Low	8.1	8.7	3.1	2.9	1.8	1.9	1.4	1.6	2.6	5	9.5	30	**76.5**	**16.7**
Moderate	21.8	20.6	18	15	10.8	8.5	6.2	6.2	14.4	21.1	19.9	0	**162.4**	**82.1**
High	0.9	1.5	6.2	8.3	10.7	12.2	11.4	13.8	9.8	3.3	1.4	0	**79.5**	**69.6**
Very High	0.2	0.2	1.8	2.6	2.8	4.5	4.5	3.3	2.2	0.6	0.2	0	**22.9**	**20.4**
Extreme	0	0	0.9	2.2	3.9	4	7.6	3.3	2.1	0	0	0	**24**	**23.4**
Low	7.9	8.4	3.3	2.8	1.8	1.8	1.4	1.6	2.4	4.9	9.5	30.0	**75.8**	**16.7**
Moderate	22.0	20.9	18.0	15.1	10.8	8.1	6.5	6.1	14.6	21.0	19.9	0.0	**162.9**	**82.1**
High	0.9	1.5	6.1	8.3	10.7	12.1	11.3	14.0	9.8	3.4	1.4	0.0	**79.5**	**69.5**
Very High	0.2	0.2	1.7	2.7	2.7	4.6	4.4	3.3	2.2	0.6	0.2	0.0	**22.8**	**20.4**
Extreme	0.0	0.0	0.9	2.2	3.9	3.5	5.7	2.4	2.1	0.1	0.0	0.0	**20.8**	**19.9**
Very Extreme	0.0	0.0	0.0	0.0	0.1	0.9	1.8	0.8	0.0	0.0	0.0	0.0	**3.6**	**3.6**
Scrub Fire Danger Class (SFDC) Frequency														
Low	7.6	7.6	3.8	3.8	2.5	2.6	2	2.3	3.1	4.8	8.8	10.1	**59.1**	**20.7**
Moderate	0	0	0	0	0	0	0	0	0	0	0	0.1	**0.1**	**0**
High	7.6	7.3	2.9	2.4	1.4	2	0.8	1.4	2.5	3	5.8	6.7	**43.8**	**13**
Very High	5.9	4.2	2.7	3.2	1.9	2.1	1.9	1.5	1.7	2.5	4.7	6.3	**38.6**	**14.4**
Extreme	9.8	11.9	20.6	21.6	24.2	24.3	26.3	23.1	23.7	19.8	11.7	6.9	**223.8**	**164.2**
Low	7.5	7.3	4.2	3.7	2.6	2.5	2.1	2.3	2.9	4.6	8.8	10.4	**59.0**	**20.7**
Moderate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.1**	**0.0**
High	7.3	7.2	2.9	2.3	1.3	1.9	0.8	1.3	2.4	3.0	5.6	6.5	**42.5**	**13.0**
Very High	5.9	4.4	2.7	3.1	1.8	1.9	1.9	1.4	1.7	2.4	4.6	6.1	**38.2**	**14.4**
Extreme	7.2	7.6	7.9	5.7	4.5	3.7	3.4	3.1	7.2	8.4	6.4	4.7	**69.8**	**36.0**
Very Extreme	3.1	4.6	12.2	16.2	19.8	20.9	22.8	20.1	16.8	11.5	5.6	2.2	**155.7**	**128.1**


Forest Fire Danger
Fire Danger Class Frequency (days/month)
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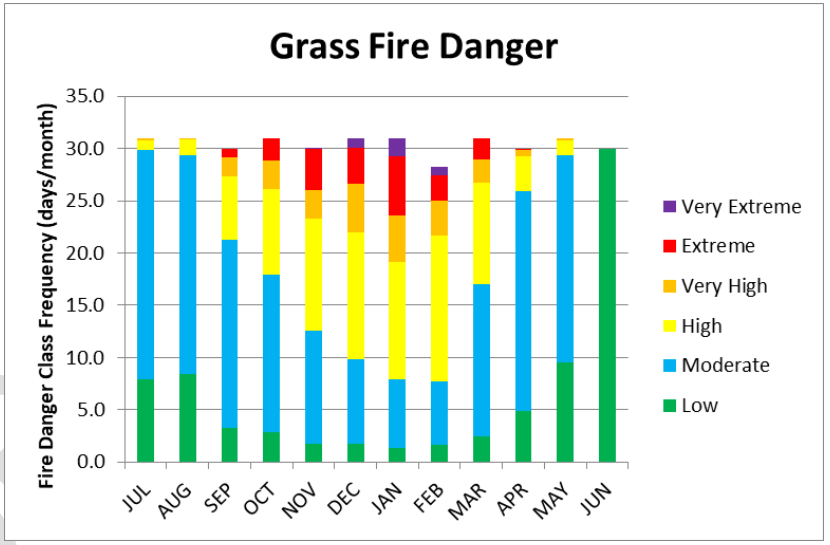
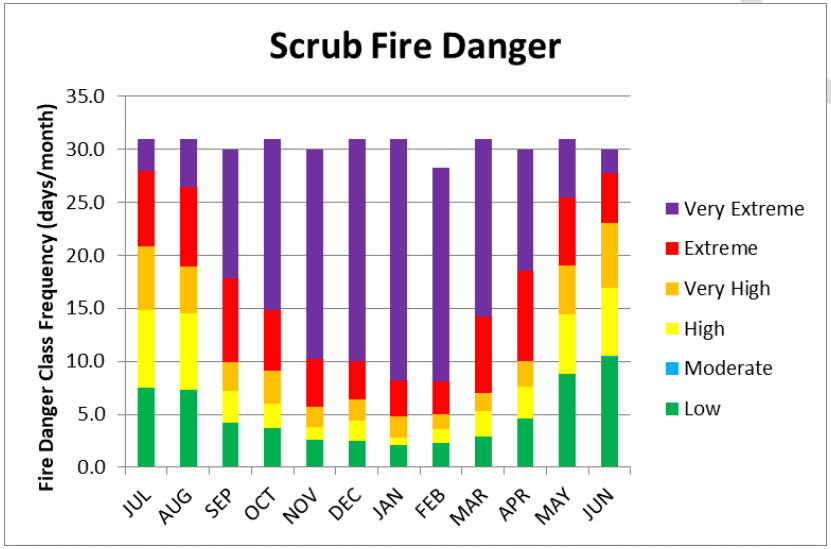
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
Very Extreme
Extreme
Very High
High
Moderate
Low

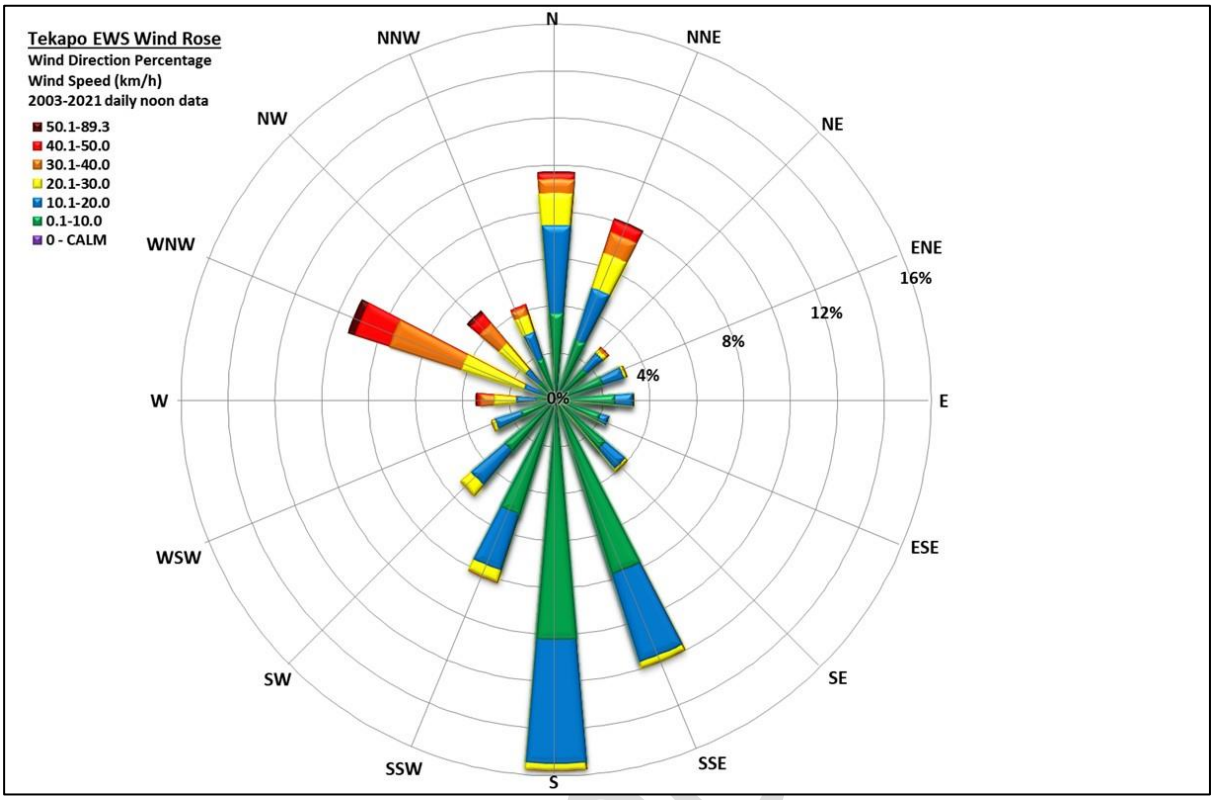

Grass Fire Danger
Fire Danger Class Frequency (days/month)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
Very Extreme
Extreme
Very High
High
Moderate
Low


Scrub Fire Danger
Fire Danger Class Frequency (days/month)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
Very Extreme
Extreme
Very High
High
Moderate
Low

13.5. Appendix 5: Fire Weather Index Summary

Station Name: Tekapo Ews (Tekapo_Ews)						Period: 2003-06-19 - 2021-07-01					Length of record: 18 years			
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YEAR	FIRE SEASON
Temperature, degrees Celsius														
mean	4.5	6.7	10.1	12.6	15.5	17.6	19.5	19.1	16.5	12.9	9	5.1	12.4	16.2
median	4.6	6.8	10.1	12.7	15.3	17.8	19.5	19.2	16.6	13	8.8	5	12.4	16.3
max	15	17.3	20.2	23.4	26.5	26.9	31	31.2	28.8	23.8	19.3	17.1	31.2	31.2
min	-7.6	-2.4	0.3	0.1	1.2	3.5	5.2	6	3.4	0.5	-0.8	-6.8	-7.6	0.1
Relative Humidity, %														
mean	66.7	61.9	50.5	46	42.1	43.4	41.2	44.6	48.7	53.8	63.3	69.6	52.7	45.7
median	65	61	48	43	39	41	38	42	47	52	61	70	50	43
max	100	99	98	100	95	96	96	99	97	98	100	100	100	100
min	23	14	11	10	8	11	4	8	7	14	17	20	4	4
Wind Speed, km/h														
mean	10.8	10.8	15.8	17.3	18.9	16.7	18.3	14.9	13.8	12.4	11.1	10.2	14.2	16.1
median	7.6	7.6	10.4	12.6	14	13	13.3	11.2	9.7	8.3	7.2	7.2	10.4	11.9
max	66.2	63.4	71.6	89.3	65.9	54	64.8	61.2	49.3	66.2	67.7	56.5	89.3	89.3
min	0	1.4	2.5	2.5	0.9	2.9	4	1.4	2.2	1.8	0	0	0	0.9
24-hr Rainfall, millimeters														
mean	1.6	1.3	1.3	1.5	1.4	1.4	1.2	1.4	1	1.6	2.4	1.7	1.5	1.4
median	0	0	0	0	0	0	0	0	0	0	0	0	0	0
max	47.8	31.3	24.9	61.1	62.1	65.2	43.8	70.9	29.4	38.9	117.2	55.5	117.2	70.9
min	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Rainfall, millimetres														
mean	50.5	42.1	35.8	47.9	42.7	44	36.8	39.8	31.7	49.6	65	52.4	44.9	41.8
max	161.5	79.6	95.7	123.5	136.2	140.9	101.3	172.8	59.6	98.5	184.2	113.3	184.2	172.8
min	9.2	6	9.4	10.3	5.4	8.6	2.4	4.1	4.6	6.5	8.6	11.6	2.4	2.4
Seasonal Rainfall, millimetres														
mean													538.4	286.9
max													750.3	409.4
min													338.8	182.4
Fine Fuel Moisture Code, FFMC														
mean	68.7	69.6	77.1	78.9	82.5	82.7	84.9	83.5	81.8	76.6	67.9	64.1	76.5	81.6
median	77.2	77.3	83.6	85.2	88.1	88.1	89.6	88.4	86.9	84.7	76.2	72.6	84	87.4
max	89.1	93.2	94.4	96	96.5	96.4	98.4	97.3	97.2	94	92	91.7	98.4	98.4
min	2.7	5.1	14.5	15.1	6.8	9.2	14	10.8	16.5	2.7	1.6	6.9	1.6	2.7
Duff Moisture Code, DMC														
mean	2.6	5.1	12.3	20.7	31.6	44.9	52.3	50.2	43.5	27	9.5	3.9	25.2	38.6
median	2.1	3.6	10.4	19.3	28	39.8	42.4	48.6	39	23.7	6.6	2.7	16.2	32.8
max	14.9	21.5	39.3	55.8	102.3	130	163	140.3	126.8	93	55	20.2	163	163
min	0	0	0.1	0.5	1.9	1.3	4.9	6	3	0.2	0	0	0	0.2
Drought Code, DC														
mean	137.3	91.6	85.6	104.5	166.9	264.5	363.6	447.9	492.1	470.7	335.7	212.2	263.2	328.6
median	133	53.4	55.3	97.1	167.3	261.8	346.2	446	506.9	494.5	332.9	225.4	244.4	321.2
max	421.2	319.9	300	269.4	347.4	508	643.3	736.3	763.6	725.6	597.6	592.8	763.6	763.6
min	0	0	0.1	1	2.6	50.3	118.9	104.1	147.9	92.6	0.4	0.1	0	1
Initial Spread Index, ISI														
mean	2.2	2.5	5.4	7.6	10.8	9.5	12.8	9.1	7.5	5	2.7	1.8	6.4	8.9
median	1.4	1.5	3.3	4.4	6.5	6.6	7.8	6.2	4.7	3.3	1.4	1.1	3.2	5.5
max	29.1	49	62	78.7	104.4	70.3	96.7	69.3	55.7	65	39.8	34.1	104.4	104.4
min	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buildup Index, BUI														
mean	4.6	7.8	15.7	25.5	41	60.8	73.6	76.2	68.4	45.7	17.2	7.1	36.7	55.8
median	3.4	4.7	13.5	24.7	39.9	57.3	65.4	76	65.1	41.6	12.5	4.4	25.1	49.3
max	26.3	30.9	53.6	65.3	103.3	150.9	195.9	154.2	169	132.8	88.2	37.2	195.9	195.9
min	0	0	0	0.9	1.8	2.5	9.3	10.5	6	0.5	0	0	0	0.5
Fire Weather Index, FWI														
mean	1.5	2.5	6.7	11.1	18.8	21.2	27.6	23	18.7	11.2	3.9	1.6	12.2	18.8
median	0.6	0.6	4.4	7.8	14.8	17.9	23.4	20	14.9	8.5	1	0.5	5.9	14.4
max	20.4	42.4	46.3	79.3	101.2	104.3	134	119	105	107.8	40.3	34.4	134	134
min	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daily Severity Rating, DSR														
mean	0.2	0.4	1.4	3.3	7.7	9	14.1	10	7.6	3.5	0.7	0.2	4.8	7.9
median	0	0	0.4	1	3.2	4.5	7.2	5.4	3.2	1.2	0	0	0.6	3
max	5.7	20.7	24.1	62.6	96.4	101.7	158.4	128.4	102.8	107.7	18.9	14.3	158.4	158.4
min	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Severity Rating, MSR														
mean	4.9	11.4	45.2	103.3	231.6	250.4	448.9	282.1	231.6	91.2	20.7	6.7	144	234.2
max	16.5	48.2	119.6	403.9	606.7	505.8	1020.3	492.1	697.3	195.9	92.7	38.5	1020.3	1020.3
min	0	0.1	11.6	36.8	24.4	66.2	165.2	83.5	49.4	21.5	0.2	0	0	21.5
Cumulative Daily Severity Rating, CDSR														
mean													1728	1672.8
max													2575.8	2706.4
min													832.5	761.8

Windrose – percentage wind direction and speed



13.6. Appendix 6: Fuel photos

Plantation, clean understory

Plantation, mixed mature conifer

Plantation, mixed conifer

Plantation Corsican pine, highly variable

Immature Corsican pine (10 y.o.), windrows and grass

Larch mature, without dead/down

Larch mature, dead/down with ladder fuels

Ungrazed grass (30 cm high)

Grazed pasture (30 cm)

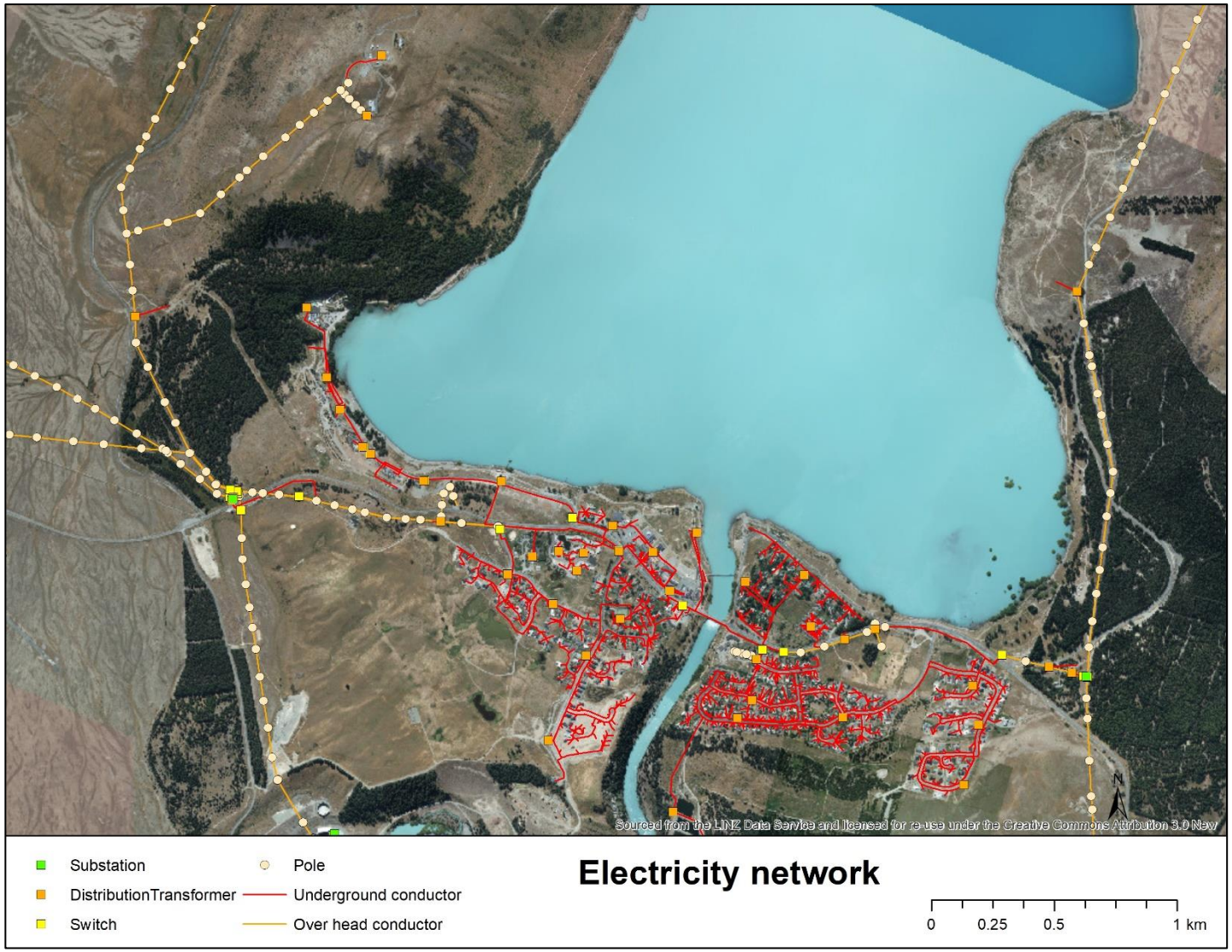
Grazed pasture/tussock mix

Depleted grass

Native ground cover

13.7. Appendix 7: Road and track layout

13.8. Appendix 8: Electricity network



13.9. Appendix 9: Risk level matrices

Likelihood of ignition and spread

Likelihood of ignition and fire spread matrix						
Descriptor	**Description**	**Number of days in a month that fire danger is Moderate to Very Extreme**				
		30/31	**24 - 29**	**16 - 23**	**7 - 15**	**1 - 6**
Almost certain (5)	Expected to occur one or more times every year.	**100.0**	**92.9**	**74.0**	**51.0**	**30.0**
Likely (4)	Expected to occur once every two years.	**89.9**	**83.5**	**66.5**	**45.8**	**27.0**
Possible (3)	Expected to occur once every three to five years.	**49.9**	**46.4**	**36.9**	**25.4**	**15.0**
Unlikely (2)	Expected to occur once every six to ten years.	**19.9**	**18.5**	**14.7**	**10.1**	**6.0**
Rare (1)	Expected to occur once every eleven to thirty years.	**9.0**	**8.4**	**6.7**	**4.6**	**2.7**

Consequence level

Consequence level					
Consequence level	**Wildfire ignition and spread**	**Evacuation opportunity and safety zones**	**Level of harm to people**	**Level of property damage (losses)**	**Level of environmental, cultural and historic damage (losses)**
Catastrophic (6)	Location of ignition and the subsequent fire spread will impact values in a very short time.	No time to evacuate, and no adequate vegetation clear areas that could be used as safety zones. Burn-over of people will most likely occur.	Multiple fatalities. Search and rescue involvement. Incident investigated by coroner.	Greater than $10 million.	Permanent loss of nationally significant values
Extreme (5)	Location of ignition and the subsequent fire spread will impact values in a short time.	There is little time to evacuate and no adequate vegetation clear areas that could be used as safety zones. There is no place for people to shelter from an advancing fire, or little time to move sufficiently away from it to a safe location. Access/egress may only be one way in and one way out as well as narrow roads and traffic congestion.	Multiple fatalities. Search and rescue involvement. Incident investigated by coroner.	Between $5 and $10 million.	Permanent loss of nationally significant values
Major (4)	Location of ignition and the subsequent fire spread will impact values in a relatively short time .	There are vegetation clear areas of sufficient area, and time to re-locate to them, or to evacuate to somewhere clear of a spreading fire. People who are not particularly mobile may not move fast enough to a clear area or are unable to evacuate quickly. Access/egress may only be one way in and one way out as well as narrow roads and traffic congestion.	Single person fatality or major injury to multiple (more than 3) subjects. Search and rescue involvement. Incident investigated, possibly by coroner.	Between $500,000 to $5 million	Permanent loss of regionally significant values
Moderate (3)	Location of ignition is somewhat away from values and may develop sufficiently to cause damge. Subsequent fire spread may eventually cut off evacuation routes.	Generally there is time to evacuate or move sufficiently away to a safe location. People may be impacted if travel away from a fire is difficult, including very narrow roads and/or traffic congestion, steep up and down tracks or zig zagging tracks, poor track surface, no track. A fire may cut off their evacuation route or some peoples mobility may result in slow evacuation.	Serious injuries to an individual requiring rescue party, or moderate injuries to multiple subjects. Incident investigated. Medical treatment required, including immediate off site assistance, e.g., follow-up emergency medical treatment. Incident reported.	Between $50,000 and $500,000 million.	Significant damage with long term recovery time required (>20y) or district level losses.
Minor (2)	Direction of fire spread is not aligned for a direct impact on values, or a fire is unlikely to develop sufficiently to cause too much damage to nearby values, however dense smoke and ash maybe dispersed over or near them, or a flanking	People would either evacuate or move sufficiently away to avoid smoke and ash fallout or a flank fire impact.	Minor injuries requiring first aid treatment - managed by those on site, e.g., minor cuts and bruises. No incident follow-up.	up to $50,000.	Moderate damage with medium term recovery time required (up to 20y) or local level losses.
Insignificant (1)	Direction of fire spread disperses low density smoke over values, or values are well away from a spreading fire and are not directly effected. Visual only	People do not need to take evasive action to protect themselves. Evacuation may be precautionary in situations where people have existing health issues. People may continue to go about their activities.	No injuries, "fright factor". No incident follow-up.	Minor or no cost	Minor damage only - short recovery time.

Risk level

Risk levels							
Likelihood level	Almost certain (5)	Medium	Medium	High	**Very High**	**Very High**	**Very High**
	Likely (4)	**Low**	Medium	High	High	**Very High**	**Very High**
	Possible (3)	**Low**	Medium	Medium	High	High	High
	Unlikely (2)	**Low**	**Low**	Medium	Medium	High	High
	Rare (1)	**Low**	**Low**	**Low**	Medium	Medium	Medium
		Insignificant (1)	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Extreme (5)**	**Catastrophic (6)**
	Consequence level						