Fire and Emergency New Zealand Wildfire Investigation Report

WHAKARATONGA IWI

District Fire Name:	Te Hiku
Fire Name:	Waiharara – Norton Road
Fire Date:	Saturday 18 December 2021
Time Reported:	13:24:45hrs
FENZ ICAD:	F3383177
Sponsor:	District Manager Wipari Henwood
Version:	Final v8

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1. Terminology

Aerial Fuels	All live and dead vegetation located in the forest canopy or above the surface fuels, including tree branches and crowns, snags, moss and high brush.
Aspect	The direction a slope is facing, i.e. its exposure in relation to the sun.
Available Fuels	Those fuels which burn during a passage of a flaming front under specific burning and fuel conditions.
Burning Period	That part of each 24-hour period when fires will spread most rapidly. Typically, this is from about mid-morning to about sundown, or late afternoon.
Combustion	The rapid oxidation of combustible materials that produces heat energy.
Continuity of Fuels	The proximity of fuels to each other that governs the fire's capability to sustain itself. This applies to aerial fuels and surface fuels.
Control Line	An inclusive term for all constructed or natural fire barriers and treated fire edges used to control a fire.
Crown Fire	A crown fire is a fire that has ascended from the ground into usually forest canopy and is advancing from crown to crown in advance of the fire on the ground
Direct Attack	A method of suppression that treats the fire as a whole, or all its burning edge, by wetting, cooling, smothering or by chemically quenching it or mechanically separating it from unburned fuel.
Diurnal	Daily, especially pertaining to cyclic actions which are completed within 24 hours and which recur every 24 hours.
Duff	A mat of partially decomposed organic matter immediately above the mineral soil, consisting primarily of fallen foliage, herbaceous vegetation and decaying wood (twigs and small limbs).
Elevation	The height of the terrain above mean sea level, usually expressed in feet.
Extreme Fire Behaviour	Implies a level of wildfire behaviour characteristics that ordinarily precludes methods of direct control action. One or more of the following is usually involved: high rates of spread; prolific crowning and/or spotting; presence of fire whirls; a strong convection column. Predictability is difficult because such fires often exercise some degree of influence on their environment, behaving erratically and sometimes dangerously.
Fine Fuels	Fuels that are less than 6mm in diameter such as grass, leaves, draped pine needles, fern, tree moss and some kinds of slash which, when dry, ignite readily and are consumed rapidly (also known as Flash Fuels).
Fire Pattern Indicators	As a fire progresses, it will leave visible marks of its passage on combustible and non-combustible objects in its path. These markings are called fire pattern indicators.

Fire Perimeter	The entire outer edge or boundary of a fire.
Flanks of a Fire	The parts of a fire's perimeter that are roughly parallel to the main direction of spread.
Fuel Moisture Content.	The amount of water in a fuel, expressed as a percentage of the oven dry weight of that fuel.
Ground Fire	All combustible materials lying beneath the ground surface including deep duff, roots, rotten buried logs, peat and other woody fuels.
Head of a Fire	The most rapidly spreading portion of a fire's perimeter, usually to the leeward or upslope.
Heavy Fuels	Fuels of large diameter such as snags, logs and large limb wood that ignite and are consumed much more slowly than flash fuels (also known as Coarse Fuels).
Hot Spotting	Checking the spread of fire at points of more rapid spread, or special threat. It is usually the initial step in prompt control with emphasis on first priorities.
Humidity	The measure of water vapour content in the air.
Indirect Attack	A method of suppression in which the control line is mostly located along natural firebreaks, favourable breaks in topography, or at considerable distance from the fire and all intervening fuel is backfired or burned out. The strip to be backfired is wider than in the parallel method and usually allows a choice of the time when burnout or backfiring will be done.
Ladder Fuels	Fuel that can carry a fire burning in low-growing vegetation to taller vegetation. Examples of ladder fuels include tall grasses, low-lying tree branches and shrubs and trees under the canopy of a large tree. This includes both living and dead fuels.
Long-Range Spotting	Large glowing firebrands are carried high into the convection column and then fall out downwind beyond the main fire-starting new fires. Such spotting can easily occur ½ km or more from the firebrands' source.
Mop Up	Extinguishing residual fire to make sure it doesn't continue to spread outside of an established containment area. Mop up includes actions like breaking apart smouldering debris, ensuring embers are completely extinguished, or moving burned debris so it cannot roll downhill and ignite previously unburned fuels.
Precipitation	The collective name for moisture in either liquid or solid form large enough to pull from the atmosphere and reach the earth's surface.
Rate of Spread	The relative activity of a fire in extending its horizontal dimensions. It is expressed as rate of increase of the total perimeter of the fire; or as rate of forward-spread of the fire front; or as rate of increase in area, depending on the intended use of the information. Usually it's (forward) rate of spread is expressed in chains or acres per hour.

Relative Humidity	The ratio of the amount of moisture in the air to the amount which the air could hold at the same temperature and pressure if it were saturated; usually expressed in percent.
Smouldering	Behaviour of a fire burning without flame and barely spreading.
Spot Fire	Fire set outside the perimeter of the main fire by flying (or rolling) sparks or embers.
Spotting	Behaviour of a fire producing sparks or embers that are carried by convection columns and/or the wind and which start new fires beyond the zone of direct ignition by the main fire.
Surface Fire	A fire that burns surface litter, debris and small vegetation.
Surface Fuels	All materials lying on, or immediately above, the ground including needles or leaves, duff, grass, small dead wood, downed logs, stumps, large limbs, low brush and reproduction.
Thermal Belt	An area of a mountainous slope that typically experiences the least variation in diurnal temperatures, has the highest average temperatures, and thus, the lowest average relative humidity.
Topography	The configuration of the earth's surface, including its relief and the position of its natural and manmade features.
Vertical Arrangement	The relative heights of fuels above the ground and their vertical continuity, which influences fire reaching various levels or strata (Surface fuels vs Aerial fuels and their relationships to one another).
Wildfire	1. An unplanned wildland fire requiring suppression action, or other action according to agency policy, as contrasted with a prescribed fire burning within prepared lines enclosing a designated area, under prescribed conditions. 2. A free burning wildfire unaffected by fire suppression measures.

2. Fire Investigators

Senior Specialist Fire Investigator

My full name is John Joseph Foley

I am a Senior Specialist Fire Investigator for Fire and Emergency New Zealand (Fire and Emergency).

I have been responsible for determining the origin and cause of fires as a Specialist Fire Investigator since 2006.

Qualifications:

NZQA:	I hold NZQA unit standards in Fire and Rescue Services Vegetation Firefighting including Fire Investigation qualifications.
NZFS:	I joined the New Zealand Fire Service Blenheim Volunteer Fire Brigade in 1987 where I achieved basic and advanced certificates in structural firefighting.
1998:	I was appointed to the position of Fire Force Controller of the Waihopai Rural Fire Force a position I held for 19 years, until moving into Blenheim.
1999:	I was appointed Deputy Principal Rural Fire Officer (DPRFO) for the Marlborough District Council (MDC).
2005:	I was employed full time by the Marlborough District Council as the Emergency Services Officer, and in December 2012 was appointed Emergency Services Manager.
2006:	I attended a National Rural Fire Authority (NRFA) Origin & Cause Fire Investigation course in Christchurch.
2011:	I attended an Arson Fire Management course in Melbourne Australia.
2012:	The Regions of Marlborough and Kaikoura became one enlarged rural fire district under the management of the Marlborough Kaikoura Rural Fire Authority (MKRFA). My day to day role was to manage operations, response, supporting volunteer crews, and training.
2013:	I attended an Origin and Cause Fire Investigation refresher course in Melbourne Australia.
2015:	I was engaged to assist with reviewing the National Origin and Cause Wildfire investigation course material and delivery of both level 1 & 2 courses.
2015:	Appointed to the position of DPRFO Operations for the MKRFA.
2016:	Lead tutor for the national level 1 & 2 Origin and Cause Wildfire Investigation courses.
2017:	Appointed to the position of Principal Rural Fire Officer for Fire and Emergency NZ for the Marlborough Kaikoura fire District.
2019:	Registered Fire Investigator with the AFAC.
2019:	Attended Bushfire Arson Investigation Course Victoria Police Academy.
2019:	Attended NSW Fire and Rescue Australia, Motor Vehicle fire origin and cause course.
2021:	Undertaking International Association of Arson Investigator CFI Trainer.Net modules

Specialist Fire Investigator

My full name is Gary Peter Beer.

I am a Specialist Fire Investigator for Fire and Emergency New Zealand (Fire and Emergency).

I have served with the New Zealand Fire Service, now Fire and Emergency, since 1995.

I have been responsible for determining the origin and cause of fires as a Specialist Fire Investigator since 2007.

Training courses:

2007 Fire Investigation 1

2009 Fire Investigation Skills Maintenance Course

2009 ESR Forensic Evidence Tutorial

2009 Two day Fire Investigation Course, Queensland Fire and Rescue, Brisbane, Australia

2010 Fire Investigation Skills Maintenance Courses

2013 Fire Investigation 2

Qualifications:

Graduate Diploma of Fire Investigation. Charles Sturt University 2011

Post Graduate Certificate in Executive Management, Otago University New Zealand 2019

Additional experience:

Level 1 Fire Investigation Training Instructor.

Appointed as a Fire and Emergency Inspector under Section 166 of the Fire and Emergency New Zealand Act 2017 on 1 July 2017.

As a Specialist Fire Investigator for Fire and Emergency I am required to respond to significant fires in accordance with Operational Instructions with the principal objectives being to co-ordinate, supervise or undertake investigations into major and serious fires, including fatal fires, by determining the point of origin of a fire and from this establishing the cause of a fire.

I have previously given testimony in the Auckland High Court, Waitakere District Court, Manukau District Court, Kaikohe District Court, and Whangarei District Court.

I have read the Code of Conduct for Expert Witnesses, Schedule 4 of the High Court Rules 2016, and agree to abide with them.

3. Fire Investigation Terms of Reference

Incident Name: Waiharara ICAD Number F3383177	**Fire District** Te Hiku

Location and Summary of the Incident

- The fire was reported as a bush fire getting out of control.
- The first 111 call was at 13:24:45, the first responding appliance from Kaitaia went K1 at 13:32:39 arriving at 14:02:05.
- On arrival the first responding brigade were confronted with a very dynamic and fast-moving fire through the grass paddock and surrounding scrub fuels.
- Initial access to the site was problematic
- The Sitrep transmitted at 14:03:52 states, large area of grass burning, fire has gotten into scrub, burn area from distance approx. 5ha, fuel loading in front of fire is high, wind 20-25knots SW. (35-45km/h).
- Request was made for 3 Helicopters.
- A National Incident Management Team (NIMT) has been set up to manage this significant fire which has caused considerable damage within the Wetlands and surrounding area.

Names and Contact Details of Key Personnel

Wipari Henwood

[redacted]

District Manager (DM)

Agreed Terms of Reference

1. Before entering the Fire Ground
   - report to the Incident Controller on all aspects of the fire investigation
   - receive a briefing on the circumstances of the fire and any safety measures that are in place
   - obtain a current Incident Action Plan (IAP)
   - ensure that personal protective clothing is always worn while on the fireground

2. Determine the Origin and Cause of the Fire including
   - taking steps initially to secure the scene
   - thorough documentation and collation of evidence
   - record and photograph burn and char patterns
   - describe the path of fire travel
   - report on the impact of the fire on property and the environment
   - fire behaviour
   - canvass witnesses
   - thoroughly document a description of the general area and specific origin areas of the fire
   - secure and document factual evidence on the cause or most probable cause of the fire

3. Advise the DM when:
   - specialists or other experts are required i.e. electrical engineer
   - requesting the police if arson is suspected or other criminal activity is suspected
   - offences under the Fire and Emergency Act 2017 relating to the lighting of fires are determined
   - a formal interview is required with a person
   - Provide a preliminary finding by 14/02/2022

4. Completion:
   - provide a comprehensive written report on all aspects of the investigation as per the Fire and Emergency NZ wildfire template by 28/02/2022

Specific Exclusions:
The terms of reference do not include:

- Talking or discussing the fire origin or cause with the news media or anybody not entitled to the information.

4. Executive Summary

18/12/2020

Incident Report Time: 13:24:45

Location: Waiharara – Norton Road

Area Burnt: 2800 hectares (at the time of writing the report)

Fire Season Status: Restricted

Fire Permit Issued: Yes

GPS Co-ordinates:

☒ Specific Origin Area - Lat -34.91023°, Long 173.1978

☐ Point of Origin

☐ Other (Explain)

Property Owner: Area of ignition, [redacted], Private Property

Incident Injuries: Nil

Type: Nil **Number:** Nil

Incident Information

Investigator(s): John Foley / Gary Beer

Supporting/Other Agencies: Police

Fire Cause Determination: Debris Burning (permitted land clearing burn)

The Fire Classification for this incident has be classified as:

☒ **Accidental Fire Cause Classification**
Accidental fires involve all those for which the proven cause does not involve an intentional human act to ignite or spread fire into an area where the fire should not be. An Accidental Classification does not imply there have not been offences committed under any Act or Regulation.

☐ **Natural Fire Cause Classification**
Natural fire causes involve fires caused without direct human intervention or action, such as fires resulting from lightning, earthquake, wind, and flood.

☐ **Incendiary Fire Cause Classification**
An incendiary fire is a fire that is deliberately set with the intent to cause a fire to occur in an area where the fire should not be.

☐ **Undetermined Fire Cause Classification**
Whenever the cause cannot be proven to an acceptable level of certainty, the proper classification is undetermined.

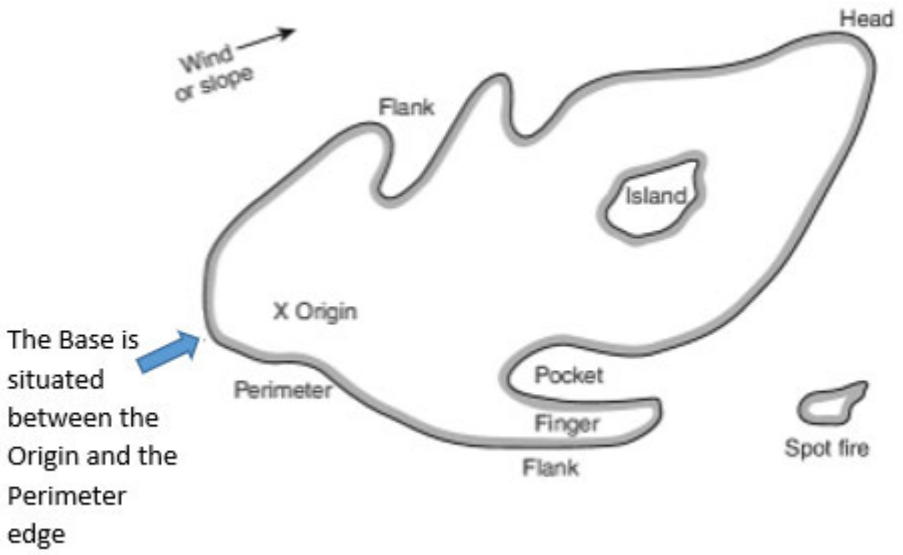
General break down of the parts of a fire

Head – direction the fire is advancing

Flanks - the left and right sides of the fire as it spreads sideways

Origin - is the location where the fire started

Spot fires – are created when hot embers are transported on the hot air dropping ahead of the advancing fire creating new fires



The following Fire Cause Categories were considered during this investigation:

- Electric fences
- Land Clearing burn
- Campfires
- Lightning
- Smoking
- Incendiary devices / accelerants
- Equipment uses
- Children
- Miscellaneous
    - Power lines
    - Glass / Bottles refraction / Magnification
    - Firearms use
    - Spontaneous combustion
    - Vehicle exhaust

The fire occurred in an area of land being developed for Avocado production. While still in the development phase, the land was being cleared of gorse and bamboo.

Other fuels in the paddock comprised a mixture of long taggy Kikuyu grasses of varying degrees of curing. Kikuyu grass creates a thick layer of thatch at ground level enabling the spread of fire leaving the taller green material standing.

A fire permit was issued to the property owner on Wednesday 24 November 2021 for a month to undertake burning. Heavier scrub fuels were pushed into several piles and were set alight earlier in the week and allowed to burn down. The residue was then buried with additional dirt being applied on Friday morning 17 December 2021, the day before the fire.

The morning of the fire the ambient temperature was increasing, Relative Humidity was slowly decreasing, and the wind was beginning to pick up.

Witnesses have stated seeing smoke before midday but thought it was the property owners continuing to burn as they had done earlier in the week.

Another witness stated they thought the smoking remains were not at risk of escape.

By the time the fire was identified as being 'out of control' it was too late for any attempt at containment within the grass paddock.

Once established, the fire was wind-driven eventually burning into the Kaimaumau Wetland.

The weather conditions leading up to the morning of the fire had been:

- Variable winds, a south westerly was recorded on a local weather station. The hills to the South would have had some influence in how the wind was being pushed in variable directions.
- Wind speeds of around 25 km/h, gusting to 43 km/h were recorded locally.
- Similar weather readings were recorded at the Aupouri Peninsula Remote Automatic Weather Station (RAWS).

Aupouri Peninsula RAWS is located approximately 30 kms to the north-west of Kaimaumau. Due to its location, the Aupouri Peninsula RAWS may not provide a true reflection of what Kaimaumau fuel moisture codes and what weather observations would have been on the day.

The Kaimaumau Wetlands crosses the areas of Waiharara, Kaimaumau, and Pukenui to the north.

At approximately 1,860 hectares, it is one of the largest remaining wetlands in Northland. It comprises the Otiaita and Waihauhau swamps, Motutangi Swamp Scientific Reserve, and Lake Waikaramu.

The wetland is home to several endangered species of native birds, mudfish, plants, and lizards including a gecko and an unnamed orchid found only in the far north.

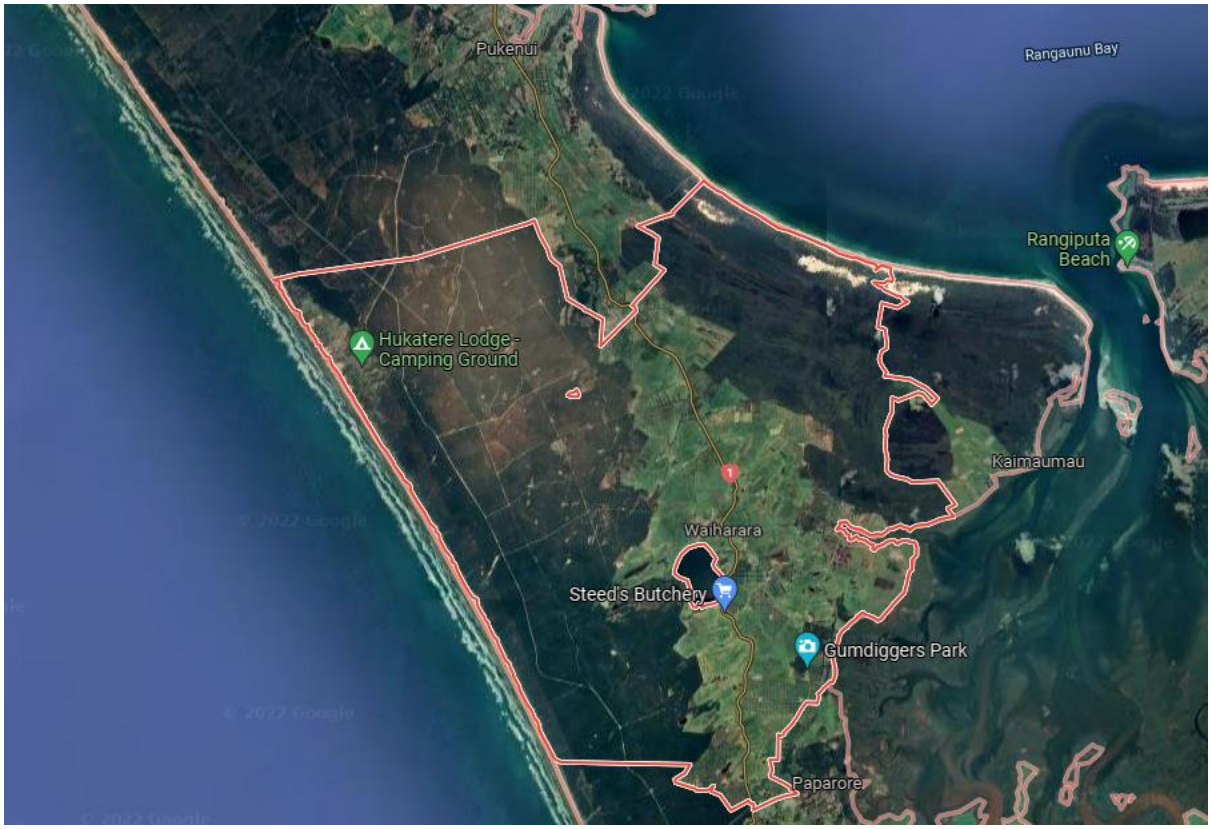


Fig.1. *Satellite image of Waiharara, Kaimaumau, and Pukenui.*

Environmental Impacts

To ascertain the full environmental impacts of the fire on the Kaimaumau Wetlands and surrounding area, suitably qualified subject matter experts will need to be engaged to undertake this work.

A Science for Conservation 155 paper published by the Department of Conservation (DOC) March 2011 titled "Options for managing the Kaimaumau wetland, Northland, New Zealand" section 10.1 Controlled Burning page 64, discusses the impacts fire can have on vegetation.

Environmentally the damage caused by wildfire will have lasting impacts on sensitive areas. Some native species rely on periodic fire for their survival, others will be destroyed or slower regrowing than some weed species.

Some introduced weed species regrowth can be accelerated by fire and their dense regrowth can displace native species creating a woody weed control issue.

As weed species such as the Sydney golden wattle regrow this additional fuel load will create additional fire control issues in the future.

Hicks, D.L.; Campbell, D.J.; Atkinson, I.A.E. 2000. Options for managing the Kaimaumau wetland, Northland, New Zealand. Science for conservation 155. 75 p.

5. Process of Investigation

Locating a qualified Wildfire Investigator was problematic at the time. One investigator who was on site was filling the role of Incident Controller and knew the property owner personally so elected not to undertake the investigation.

Two investigators examined the scene but were not qualified Wildfire Investigators. They requested a qualified investigator be sent to determine origin and cause.

John Foley, Senior Specialist Fire Investigator was contacted by Todd O'Donoghue, Fire Investigation Manager on 24 December 2021. Arrangements were made to travel to Waiharara on 27 December to join the other investigators on site.

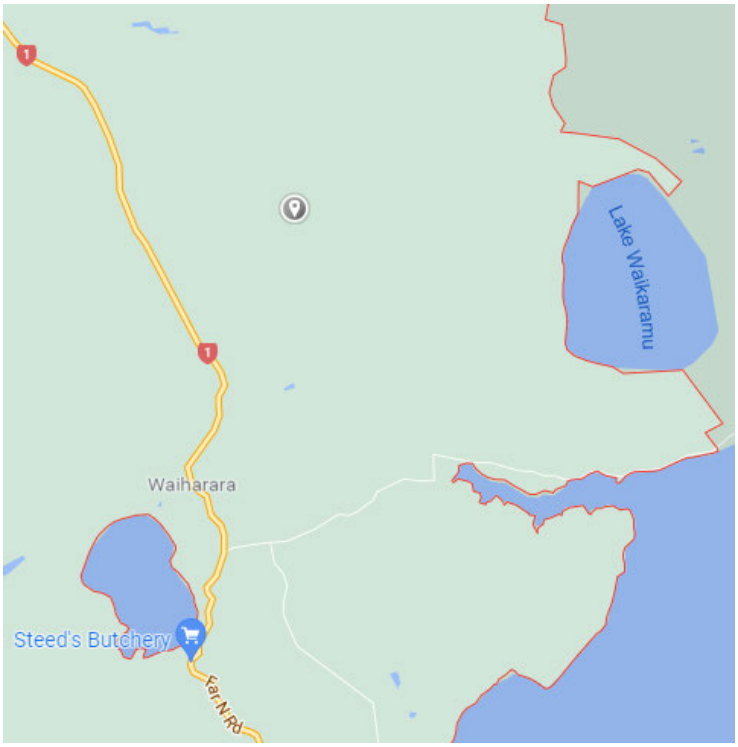


Fig. 2. *Map showing Waiharara area.*

On arriving at Waiharara Community Hall at 11:45 John Foley spoke with the Incident Controller, Gary Beer Structural Investigator and Kevin Ihaka Level 1 Wildfire Investigator who had examined the scene.

We (Gary Beer and John Foley) travelled to the [redacted] where a witness was working at the time of the fire making a 111 call.

From there we travelled over to Norton Road, through the [redacted] Avocado Orchard out into a large open paddock where earthworks were being carried out to develop the area into an Avocado Orchard.

External Scene Examination:

Parking at the south end of the fire, we walked to the north until we came to the edge of the Kaimaumau Wetlands. Burn indicators in this area identified the fire had come from the south. From this location we zig-zagged our way across the paddock identifying fire pattern directional indicators. These led us back in a southerly direction.

Identifying the base[1] of the fire, we continued to zig-zag across an area of unburnt grass which measured approximately 150 m. There were no signs of ember transfer[2] into the unburnt grass.

Looking around the area there had been several piles burnt and then buried.

To the east of this location there was a track that ran north to south up to the Kaimaumau Wetlands. On the east side of the track five to six piles had been burnt. Most had been buried but at least two still had exposed burnt material. These piles were approximately 40-50 m away from the base of the fire. None of the piles were burning at the time of the investigation.

[1] Base of the fire is the area between where it has started and spread backwards to the perimeter edge

[2] Burnt organic material carried by the wind, if still hot when it lands it can start spot fires

We finished the first day at 17:05. Gary Beer was on annual leave so did not return for the rest of the investigation.

Fig. 3. *Area walked through following directional indicators.*

Fig. 4*. Looking south, General Origin Area.*

- *Yellow ellipses approximate burn pile locations*
- *Yellow line fire edge*
- *White circle specific origin area, location of where an ember/s has landed*
- *Red arrow, head fire run*, *Blue arrow base of fire*

Fig. 5. *Looking south, orange dotted area base of the fire.*

- *Yellow eclipse identifies burn pile locations, these had been buried.*
- *Blue arrow 150m gap between burn piles and base of fire, no signs of spot[3] fires within gap.*

Fig. 6. *Looking north towards the Kaimaumau Wetlands, vehicle track is running north/south. Several Piles had been burnt to the east (right) of the track. These piles have been identified as area of interest 3. Yellow arrow points in the direction of area of interest 3.*

[3] Spot fires can start when hot embers transported by the wind land in dry vegetation, start burning and spreading creating another fire away from the main fire.

Fig.7*.** Looking east from track, yellow circles area of interest 3. Approximate burn pile locations not visible in ***Fig. 6 .

General Origin Area - Internal Scene Examination:

After looking externally at the head[4] fire runs and identifying areas of transition into flanking fire, I (John Foley) began an internal investigation in the general origin area.

Fig. 8. *Specific origin area within yellow circle. White arrow pointing at the white cone marking vegetation that did not fit the scene.*

Working my way through the general[5] origin area fire pattern directional indicators identified enabled me to identify the fire's direction of spread. This was made difficult as vehicles had driven through this area during fire suppression activities.

Despite the scene contamination, I was still able to identify a specific[6] origin area the fire had started within.

While reducing the area down to the ignition[7] area I located a piece of burnt vegetation that did not fit with other surrounding vegetation. This was situated west of the vehicle track on a small rise.

GPS Reference Lat -34.91023° Long 173.1978°.

[4] Head fire, the portion of the fire that is moving the fastest, generally driven by the wind and or slope
[5] General origin area, the area of the fire that the investigator can narrow down based on macro-scale indicators, witness statements, and analysis of fire behaviour.
[6] Specific Origin Area is the smaller area, within the general origin area, where the fire's direction of spread was first influenced by wind, fuel, or slope.
[7] Ignition area is within the specific origin area, an exact point of origin where the first fuels were ignited cannot always be identified. The ignition area may be the smallest area the investigator can identify.

Fig. 9. *Left side, vegetation located in ignition area that did not match other surrounding vegetation types. Right side scaled, 20 mm x 25 mm.*

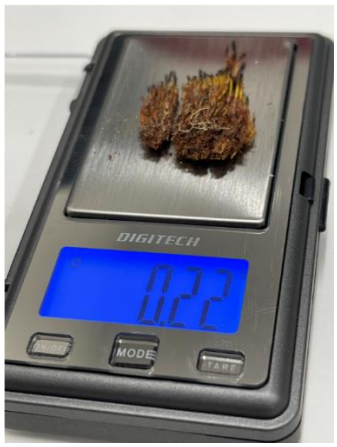
Fig. 10. *The tips of the vegetation were burnt measuring approximately 5mm. The rest of the vegetation had a scorched discoloured appearance. On checking the surrounding area, I couldn't locate any vegetation that matched.*

There are two hypotheses how this vegetation has come to be in this location:

1. vegetation has been carried by the wind
2. vegetation has dropped off a vehicle.

As the vegetation is burnt, I believe it is related to the Waiharara fire.

I cannot determine whether it was carried by the wind or dropped off a vehicle. Wind speeds at the time would have been strong enough to carry this vegetation.



I sent an email to the Auckland Botanical Society asking if they could identify the vegetation. Based on the photograph provided (**Fig.34**. P37), they believe it contains old grass stems (culms) and a clump of leafy moss which looks like a species of Campylopus.

Both are widespread in New Zealand and would have been growing in the open.

Fig. 11. *Left - Weight of vegetation 0.22g.*

6. Fire Spread and Behaviour

6.1. Weather Factors

Rainfall recorded at Waihopo on Kimberly Road 20 km north of Waiharara between 1 to 18 December was 51.5 mm. Rainfall of 37.5 mm fell between 13 and 15 December.

There was only 0.5mm of rain between 15 and 18 December.

On 13 December a Heavy Rain Watch was issued for the north and east of Northland. This covered a period of nine hours from 16:00 Tuesday 14 December to 01:00hrs on Wednesday 15 December. There was a forecast of heavy rain that may approach warning amounts.

A local weather station recorded 38mm for the month with 27.4 mm falling on 14 December.

Generally, the top layer of soils appeared to be free draining with sandy soils. Although there had been rain in the days leading up to the fire and 0.2mm that morning, the surface fuels had dried out with warm temperatures enabling the fuels to ignite, sustaining ignition, and spread in the windy conditions.

On the day of the fire, windspeeds were recorded at a local weather station at 11:00 with an average windspeed of 23.3 km/h gusting 43.1 km/h.

A witness noticed smoke at 11:07 but thought it was the property owners having another burn as they had done during the week. Unfortunately, their view was blocked by a stand of Bamboo.

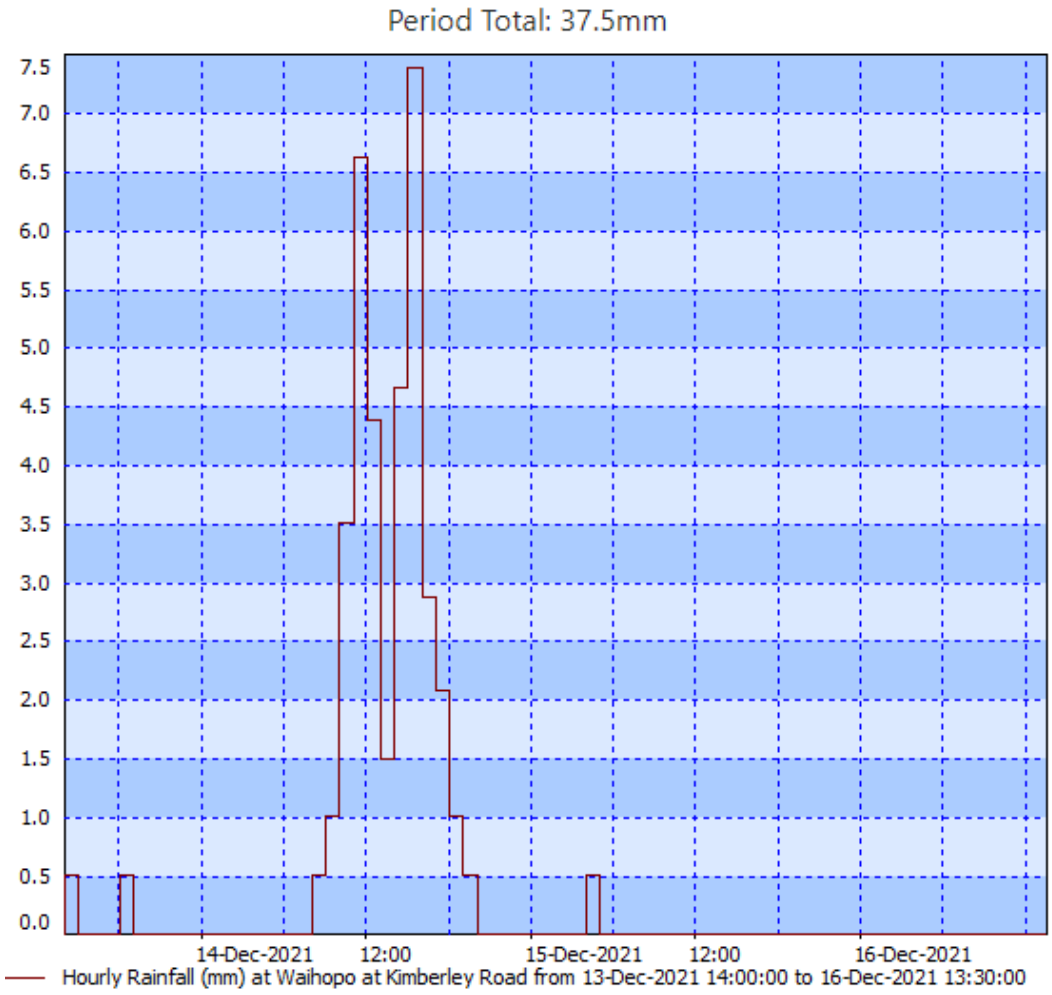


Fig. 12. *Rain graph from Waihopo 13 to 16 December 2021.*

Fire Behaviour:

Fire behaviour is determined by the surrounding conditions, influences and modifying forces of topography, fuel, and weather.

Unfortunately, there is no calibrated Fire and Emergency RAWS in the Waiharara area. Fire Weather Indices have been taken from Aupouri Peninsula RAWS approximately 30 km north of Waiharara. These may not show a true reflection of the conditions that were present in Waiharara.

A local weather station at Waiharara has provided local wind speeds, Temperature and Relative Humidity readings within 1 km of the fire site.

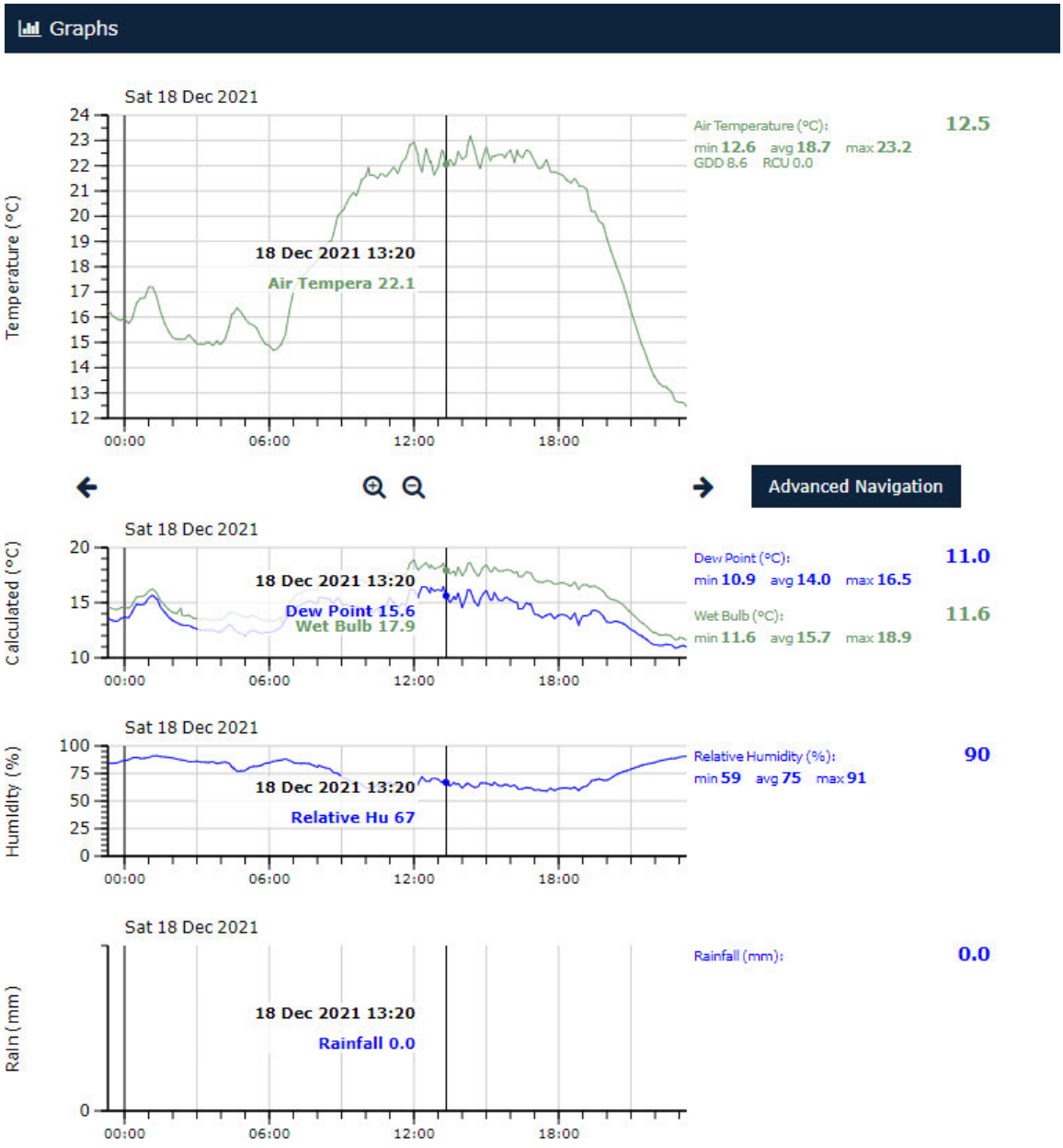


Fig. 13. *Local Weather Station data at 13:20.*

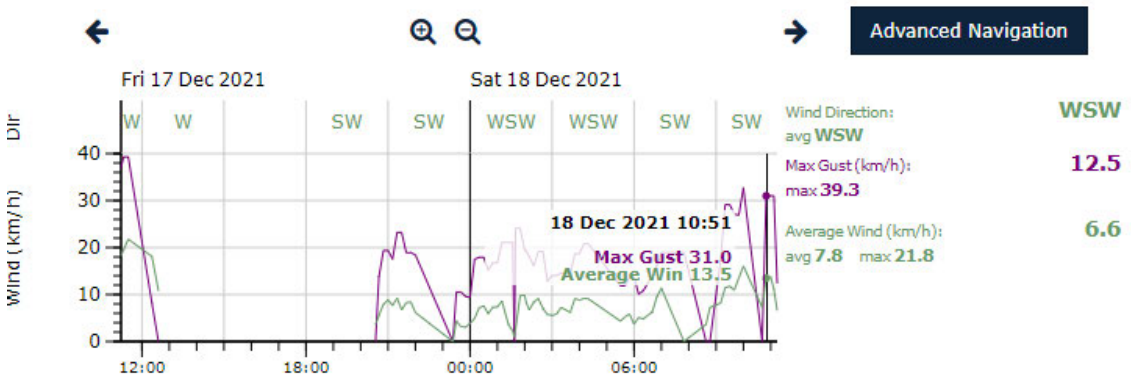


Fig. 14. *Local Weather Station Windspeed data at 10:51.*

Witnesses have stated they noticed smoke several hours before the fire was reported through the 111 system. Temperatures recorded at both the Aupouri Peninsula RAWS and a local weather station at Waiharara are very similar +/- 2° C.

From around 06.30hrs the morning of the fire there was a steady climb in temperature reaching 21.3° C at 11:10.

At 08:00 the Relative Humidity (RH) was 82%, by 10:50 it had dropped to 63%. This significant drop in RH would have reduced the moisture content of dead dry fuels assisting in their ignition.

Aupouri Peninsula recorded 0.2mm of rain at 10:00. A local weather station in Waiharara also recorded 0.2mm of rain between 01:00-02:00 on 18 December.

From 08:30 there was a steady increase in wind speeds and gusts. By 10:04 wind gusts had reached 32.7 km/h followed by a drop in the wind over the next hour with gusts reaching 31.0 km/h at 10:50 staying relatively constant for 15 minutes slowly dropping until they picked up again later that afternoon.

13:09 wind gusts reached 43.1 km/h, 15 minutes before the fire was reported.

Residents have described the wind as very strong and gusty.

Contributing factors for the fire to spread were:

- an increase in temperature – preheated fine fuels
- wind - strong gusty winds made this a wind-driven fire
- both temperature and wind have dried off any wet dead fine fuels
- previous land clearing burn - smoke was seen but assumed it was the property owner burning
- high available fuel load (AFL) – At first glance it was hard to see how this fire had spread through the green grass. Below the standing grass was a layer of thatch in the Kikuyu grass providing a dry layer of fuel to burn through
- a 200 m strip of dry grass where an old fence had been removed acted as the path for the fire to burn from the origin to the Kaimaumau Wetlands. The Rate of Spread (ROS) has been calculated at 627 m/h. This would have taken anywhere from 10 – 20 minutes to burn 200 m in the variable wind conditions at the time
- the fire burnt into the surrounding elevated scrub fuels being predominantly gorse, and then eventually burnt into the Kaimaumau Wetlands containing elevated heavy dry fuels.

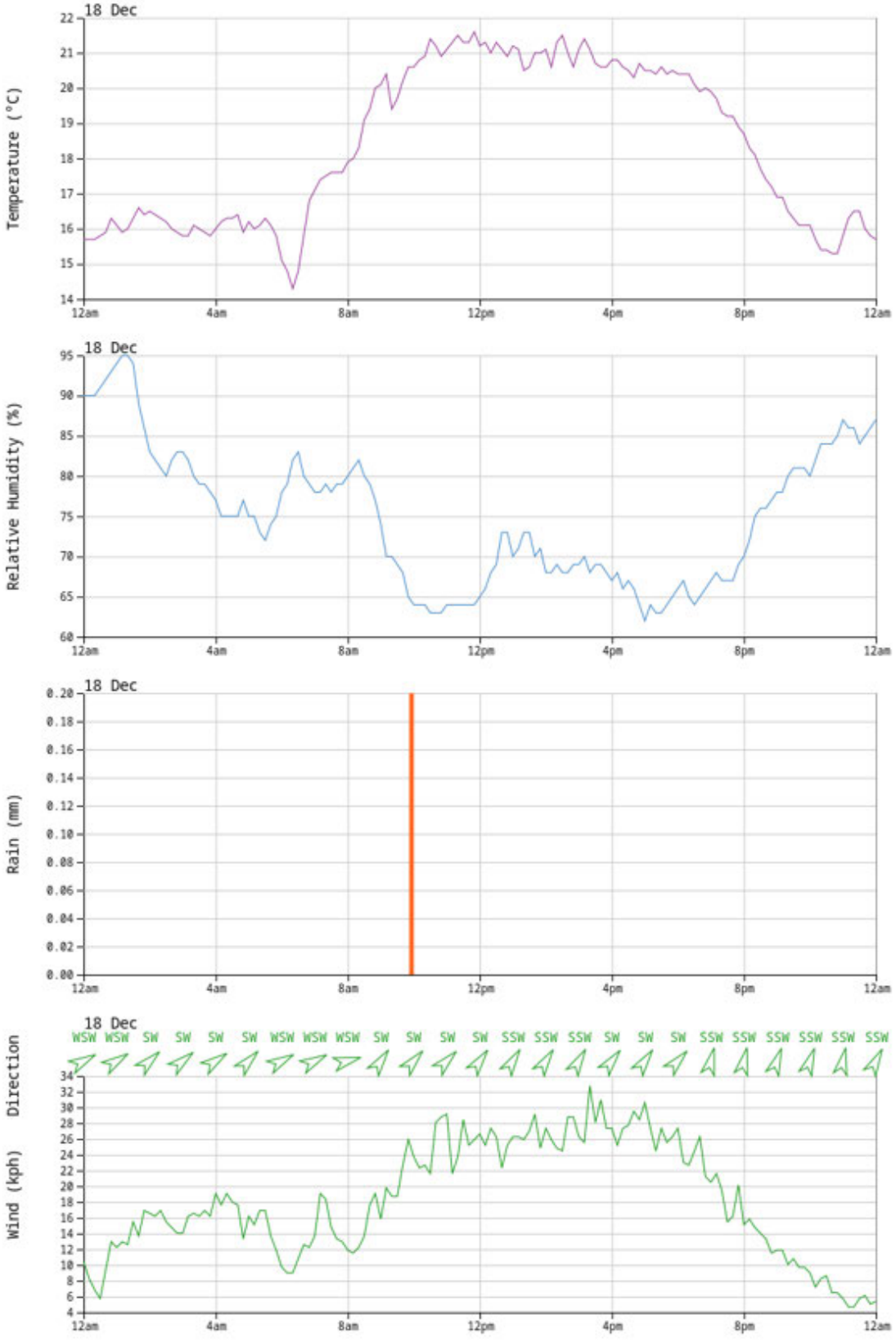


Fig. 15. *Aupouri Peninsula RAWS Data.*

6.2. Fuel Factors

Moisture content of fine fuels was highly variable, from 0% cured to strips of very dry grass along with what appeared to be old fence lines approximately 80%+ cured.

There were several dry strips that enabled the fire to spread. As mentioned, these were old fence lines running beside the edge of the vehicle track, drains, and across the paddock.

The fire did not consume all fuels in the paddock, only those dry enough to burn.

Fig. 16. *Variable moisture content of grass fuels.*

On first viewing the area it was difficult to see how the fire had spread. The dry strips along with an understory of Kikuyu grass provided the fuel for the fire to spread slowly through the green grass.

The dry fuels were dry enough not only to ignite but to sustain ignition and spread as the wind pushed the fire through the dry fuels.

The fuels ability to increase and decrease its moisture content is influenced by the daily rise and fall of relative humidity (RH).

- Low RH in the mid-day period will lead to a low fine fuel moisture content in mid-afternoon.
- Low RH indicates an increase in the potential for ignition of fine fuels.
- RH affects the flammability of fuels because water vapour is continuously exchanging between the atmosphere and dead fine fuels. Dead fuels give up moisture to a dry atmosphere and absorb moisture from a humid atmosphere.

Although the Fire Weather Indices (FWI) target the mid-afternoon period for potential ignition, it doesn't mean conditions won't exist earlier allowing a fire to start and spread.

A Witness has stated they saw smoke as early as 11:07. This would indicate the fire had already ignited the surrounding dry grass fuels and was slowly spreading. As the wind increased closer to the time of the 111 call, the rate of spread would have also increased pushing the fire down the dry strip into the Wetland before arriving crews could stop it.

Fig. 17. *Burnt strip leading down to the Kaimaumau Wetlands.*

Fig. 18. *Left - Average grass height outside of the burn area was approximately 300 – 500 mm, with a ground cover of 100%.*

Available Fuel Loading (AFL) for the grass based on 350 mm has been estimated at < 6 t/ha.

Head Fire Intensity (HFI) in grass fuels based on flame lengths of 2 m is calculated to be 1250 (kW/m). This would have increased with the wind gusts. In the Wetland the fires HFI would have increased to over 18000 kW/m.

A HFI >2000-4000 kW/m is too dangerous for ground crews to attack the head fire.

On site fire behaviour doesn't always follow modelled fire behaviour. Variation can and will occur when available fuel, fuel loadings and topography change.

The small strip of dry grass running the length of the vehicle track (Fig. 16.) has been estimated to be an area of 0.02 h. Approximately 200 m long x 1.0 m wide.

Fire Weather Indices:

The Build Up Index (BUI) recorded at Aupouri Peninsula RAWS was 8.5. A BUI of >60 is considered as **Very High**.

The BUI is a numerical rating of the total amount of fuel available for combustion that combines the Duff Moisture Code (DMC) and the Drought Code (DC).
The closest Fire and Emergency RAWS to the fire site is Aupouri Peninsula RAWS situated approximately 30 kms to the northeast of the general origin area.

Forest	Scrub	Grass	FFMC	DMC	DC	ISI	BUI	FWI	TEMP	RH	DIR	WSP	RN24	GC%
L	E	M	82.6	4.5	161.6	5.7	8.5	5.7	21.2	70	212	26.3	0.2	50

Fig. 19. *Aupouri Peninsula FWI figures observed 18 December 2021 12:00hrs NZST.*

To provide some context around the FWI figures, temperature, relative humidity, rainfall, wind speed and direction are the only actual figures recorded at 12:00 NZST (13:00 daylight savings). The additional figures are modelling projections for fire behaviour around mid-afternoon.

The following indices were showing as elevated: Fine Fuel Moisture Code (FFMC), and the Initial Spread Index (ISI) recalculated to be 11 on site.

The grass curing percentage set at Aupouri Peninsula RAWS is an estimate of the general area not a specific location within. I have calculated the grass curing of dry grass on site at 80%.

Fine Fuel Moisture Code (FFMC) of 82.6: means that, there was a moderately easy chance of ignition.

Drought Code (DC) of 161.6: The DC is a numeric rating of the average moisture content of deep compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and the amount of smouldering in deep duff layers and large logs that would occur during a fire.

- A DC of 161.6 would indicate (in most locations) the fire would not become deep-seated except in those areas which may contain heavier dry fuels or dry Peat.
- With the Wetlands containing high levels of Peat the fire has burnt into this dry layer.
- A DC of 300 indicates mop up will be difficult and prolonged.

Initial Spread Index (ISI) 11: The ISI is a numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on the rate of spread without the influence of variable quantities of fuel. (ISI 11 has been calculated from local recorded windspeeds).

An ISI of 8-15 indicates rapid spread of fire. An ISI of 16+ indicates an extremely fast-moving fire. The ISI has been adjusted to allow for local conditions.

Wind speed: 12.2 km/h, Gusting 43 km/h

Relative humidity (RH) reading of 63: Relative Humidity is the amount of moisture in the air compared with the amount of moisture the air can hold. When the air is saturated its RH is 100%, extremely dry air can have a reading of zero percent.

Relative humidity %

- Below 60% contributes to fire development
- Below 30% contributes to rapid fire development
- Below 15% contributes to extremely rapid-fire development

Fire Weather Index (FWI) 5.7: This fire in the early stages, while in the grass paddock would have been relatively easy to contain and control, with the blustery wind it quickly pushed the fire into the Wetlands where it became uncontrollable.

Using the FWI figures from Aupouri Peninsula RAWS may not provide a true reflection of the conditions in Waiharara area at the time of the fire. Regardless of their accuracy, the fine fuel on the day was receptive not only to an ignition but was able to sustain ignition spreading out to other available fuels becoming a wind-driven fire.

7. Visual and Physical Evidence

Two burn piles within area of interest 3 were not completely buried with burnt material visible **Fig. 26**.

Photographs were taken of the burn piles, fuels, and general area.

A piece of Campylopus moss was secured for identification **Fig.34**.

8. Elimination of Fire Cause Categories

Before a conclusion of causation could be established, a thorough process of elimination was carried out. The following Fire Cause Categories were considered during this investigation and ruled out:

- Electric Fences
- Campfires
- Lightning
- Smoking
- Incendiary devices / accelerants
- Equipment uses
- Children
- Miscellaneous
    - Power lines
    - Glass / Bottles refraction / Magnification
    - Firearms use
    - Spontaneous combustion
    - Vehicle Exhaust

Cigarettes:
Research shows for a cigarette to 'likely' cause a fire the RH requires to be around 0-18%. An RH of 18-22% tends to make ignition marginal and unlikely, an RH of >22% no fire starts.

There are a number of other variables required to assist with an ignition. Ash content which impacts on the exterior temperature of the tip, shrinkage of the tobacco during burning, exposure time between fuel and cigarette, fuel bed composition and dead fuel moisture content.

Fine dead fuel moisture (FDFM) of ground fuels is required to be less than 14%.

Steensland, Paul; Cigarettes as a Wildland Fire Cause

Countryman, Clive; Ignition of Grass Fuels By Cigarettes; Research Forester (R), USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Riverside, California.

I did not observe any discarded cigarette butts in the area.

Electric Fences:

The boundary fence was electric but was not energized and was situated 130 m away from the ignition area.

Firearms/tracer ammunition:
I did not observe any discarded ammunition cases in the general origin area.

Incendiary devices / accelerant:
After a thorough inspection I did not observe any signs of accelerant or any incendiary devices having been used. This cause was investigated with the support of Police and eliminated.

Spontaneous combustion:
I have ruled out spontaneous combustion as I did not observe any piles of decaying organic matter or "bird's nests" from any logging operations to support this hypothesis.

Electrical Faults:
There were no transmission lines in the general origin area.

Lightning:
On reviewing LightningMaps.org web site for the 17 – 18 December there were no recorded lightning strikes for the Waiharara area.

9. Origin and Cause

Fire Cause Determination

A scene examination[8] and supporting Witness statements have enabled the investigators to identify the permitted burn area to the east of the vehicle track where 5-6 piles of gorse and bamboo had been burnt as the most competent ignition source for the fire. Two burn locations that had been covered with dirt still had exposed burnt vegetation sitting on the surface **Fig. 28**.

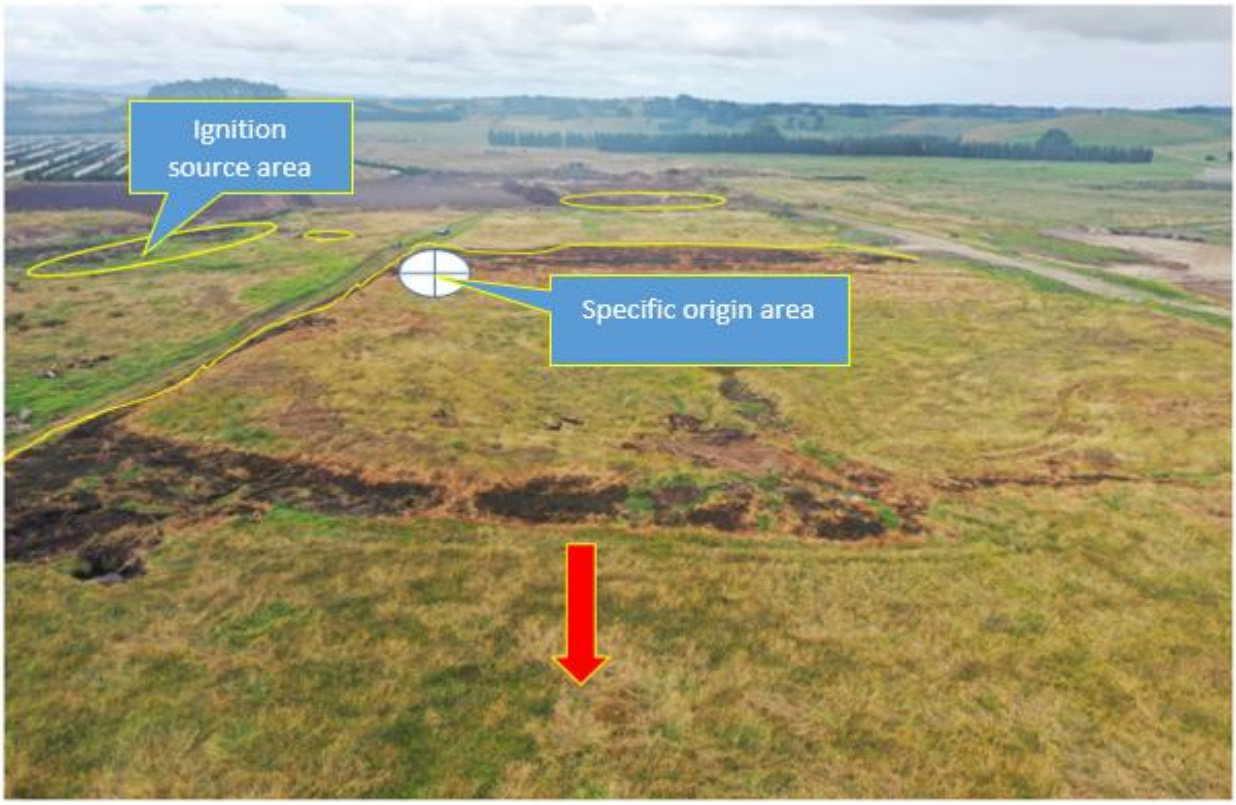


Fig. 20. *Looking South back towards the base of the fire. Red arrow fire direction of travel towards the wetland.*

[8] The examination entails following fire directional indicators and fire patterns back to the where the fire started. The smallest area identifiable was the specific origin area. The ignition area sits within the specific origin area.

SKETCH 5.

Subject:

Date:

Fig. 21. *Sketch drawn by John Foley and signed off by Witness 3 and 4 as being an accurate representation of the area. (Witness ID has been removed), North is at the top of the page.*

Sketch 2 (Not to scale)

Subject: General origin area.

Date: 28/12/21 **Time:** 12.12hrs

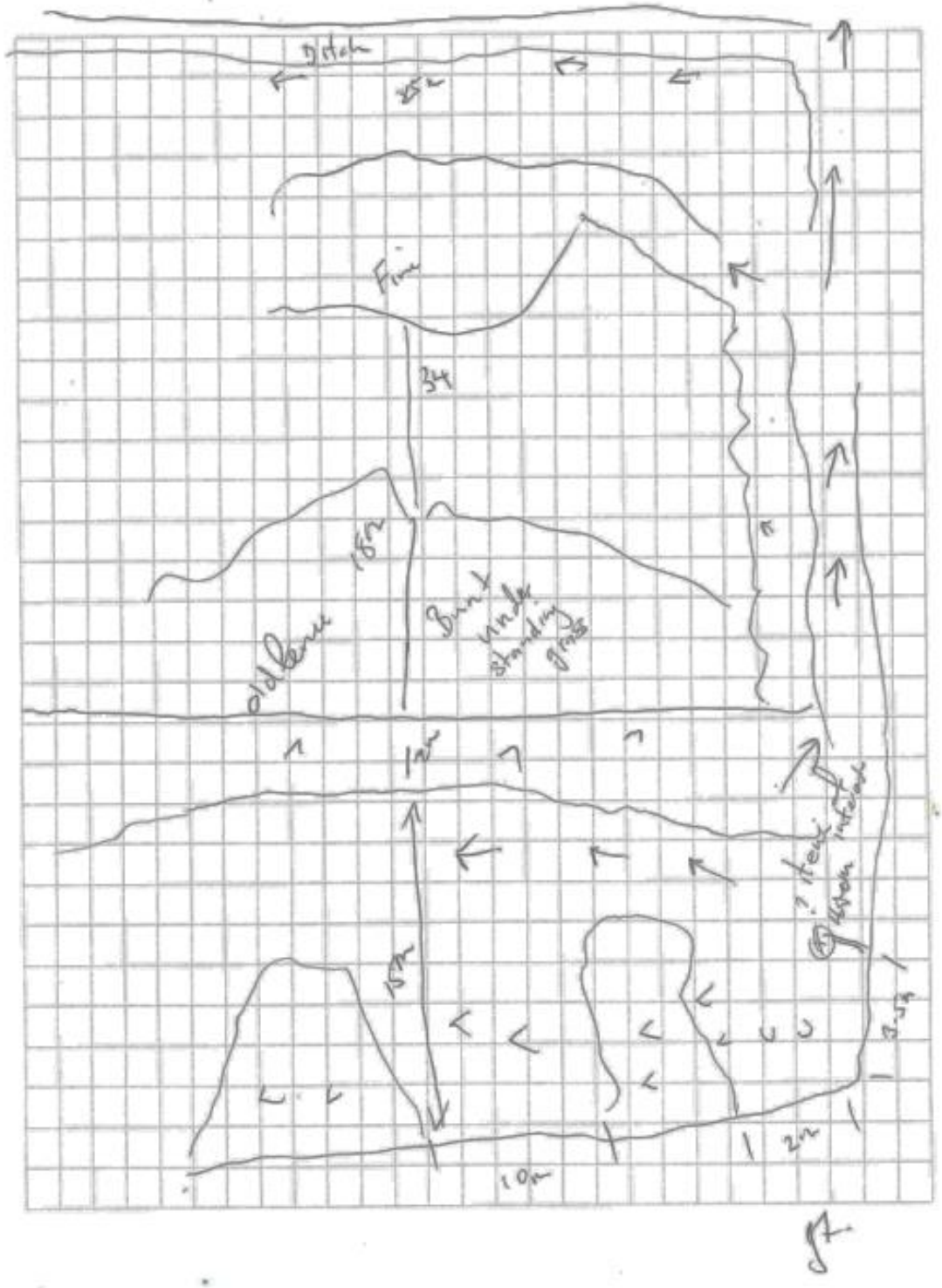


Fig. 22. *Sketch by John Foley of general origin area.*

Three areas of interest were identified.

Area 1: South end of the fire

- 150 m south of the base of the fire, there were several burn sites
- These burn sites had been buried
- An area of grass between the base of the fire and the burn sites was 150 m wide, we did not observe any embers or spot fires within this area.

These sites have been ruled out as a competent ignition source due to the distance, not observing any spot fires or embers within the 150 m strip, and the fact the burn piles were well buried.

Area 2: Location of Campylopus moss located on the west side of vehicle track

- The moss was out of place and not consistent with surrounding vegetation
- Tips of the moss were burnt
- Body of the moss was discolored from fire
- Moss weighted 0.22 g, it may have been wind driven or dropped off a vehicle

This cannot be ruled out as an ignition source but would only be considered as possible.

Area 3: East side of vehicle track

- There were approximately six burn sites that had been buried
- At least half of the burn sites were in front of the specific origin area so have been ruled out
- The other half were east, south east of the specific origin area
- The distance from these sites to the specific origin area was 40-50 m
- These piles were identified by a witness as smoking on the Saturday morning
- Two of the buried sites had exposed burnt wood material.

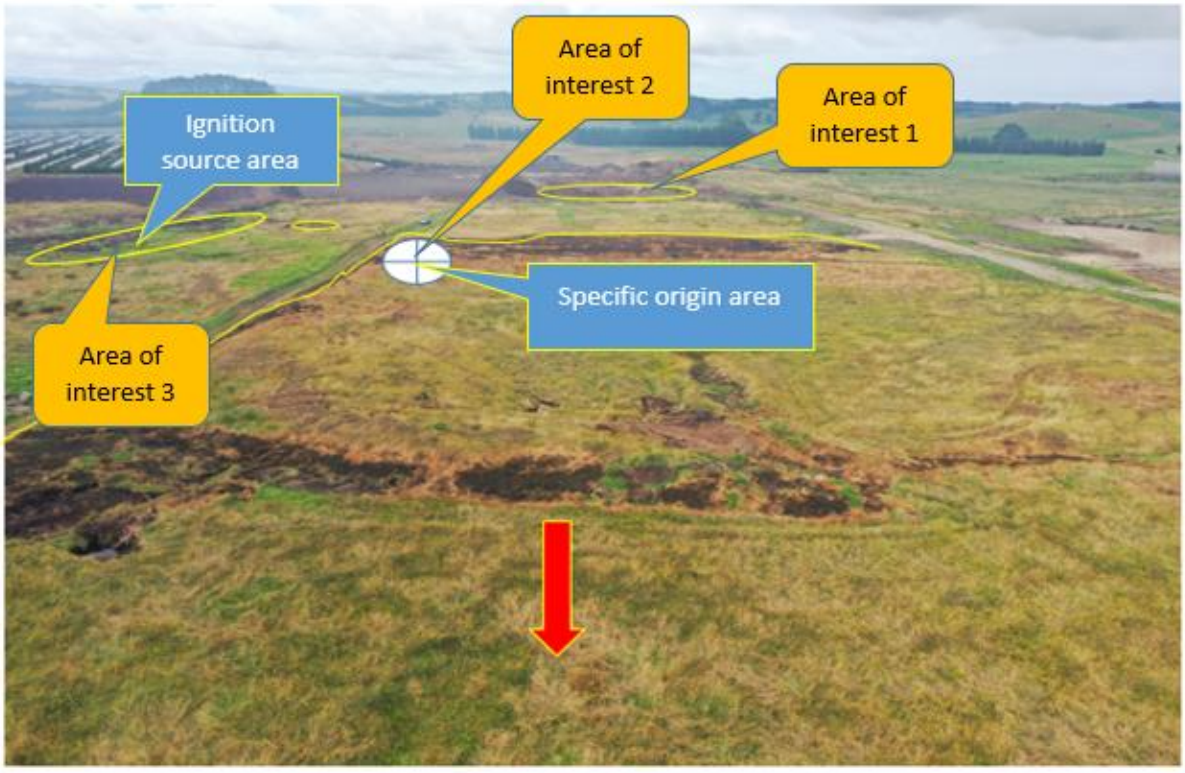


Fig. 23. *Areas of Interest.*

A thorough investigation was undertaken identifying the permitted burn area to the east of the vehicle track where six piles of gorse and bamboo had been burnt and buried as the most probable and competent ignition source of the fire. Although there was an attempt to bury these piles there was burning material left exposed.

A Witness has identified the piles were smoking on the morning of the fire. Embers have been transported by the gusty winds 40-50 m into the surrounding dry vegetation to the west of the burn sites.

Once the ember/s have landed they have ignited the dry grass where it has smouldered for some time before becoming established. It is possible the fire has slowly spread through the thatch for serval hours creating smoke as it slowly spread to other dry grass.

Burning to the west it burnt over a small rise creating a large amount of smoke. It is at this point a Witness has noticed the fire was out of control. To the north a 200 mm strip of dry grass ran down an old fence line towards the Kaimaumau Wetlands. This strip of grass has allowed the fire to burn in a northerly direction eventually burning into the Wetland.

The fire has burnt along several old fence lines out into the paddock, there are also areas the fire has crept through the Kikuyu thatch.

Fig. 24. *Specific origin area within yellow circle. White arrow pointing at the white cone marking vegetation that did not fit the scene. Red arrow illustrates the direction of the fire as it burnt along the old fence line towards the wetlands. Yellow arrow direction ember/s have come from landing in the specific origin area.*

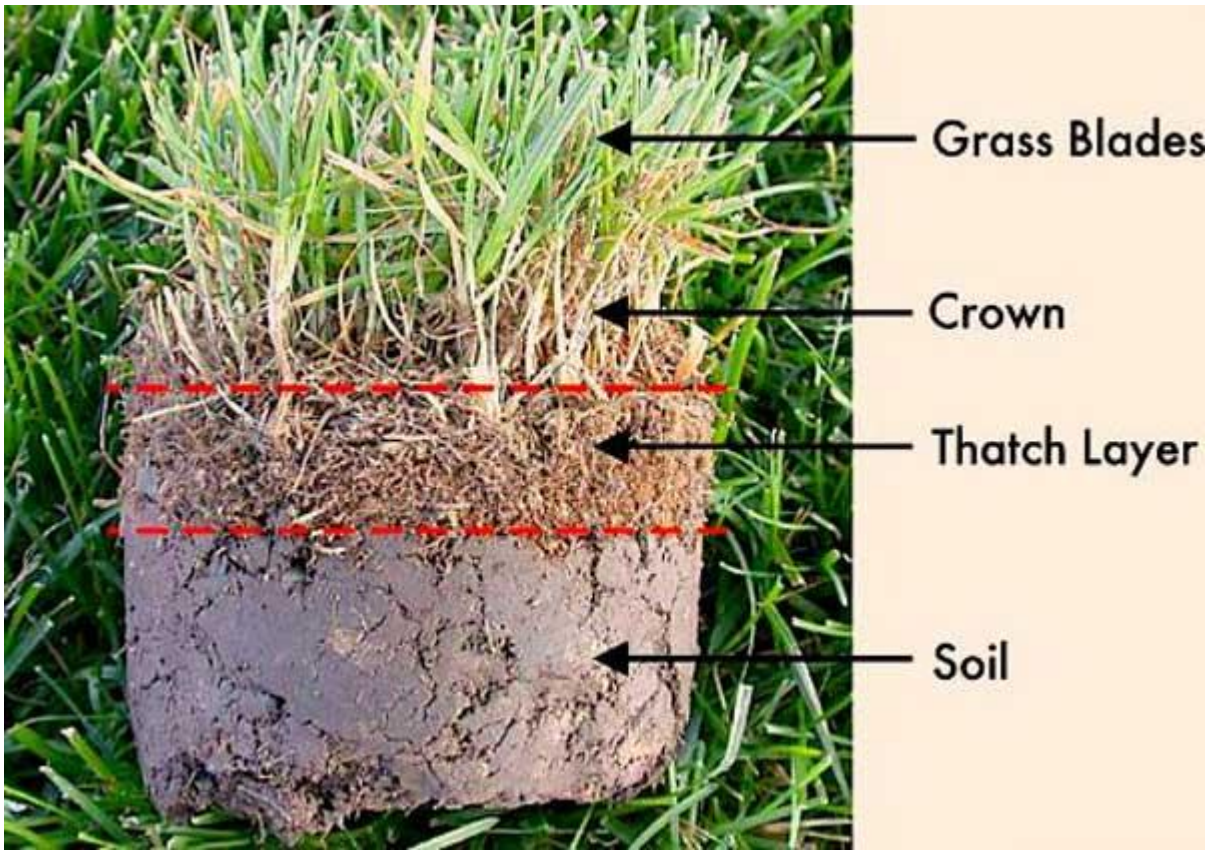


Fig. 25. *The dry thatch layer has allowed the fire to burn through the grass slowly (Example only).*

Fig. 26. *Cropped photograph of DJI_0712jpg, burn pile.*

Fig. 27. *Burn pile with exposed burnt material.*

Fig. 28. *Close up of* ***Fig. 26****. burnt material centre of photograph.*

Fig. 29. *Exposed burnt material.*

Fig. 30. *Black narrow strip old fence line. Red arrow, head fire direction to Wetland, white arrow specific origin area, black eclipse burn piles.*

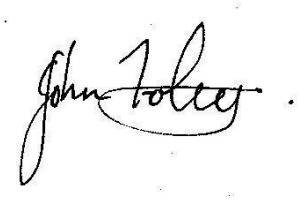
Fig. 31. *Looking from burn piles to flagged specific origin area.*

Fig.32. *Fire in foreground has burnt along a drain left to right. White arrow specific origin area.*

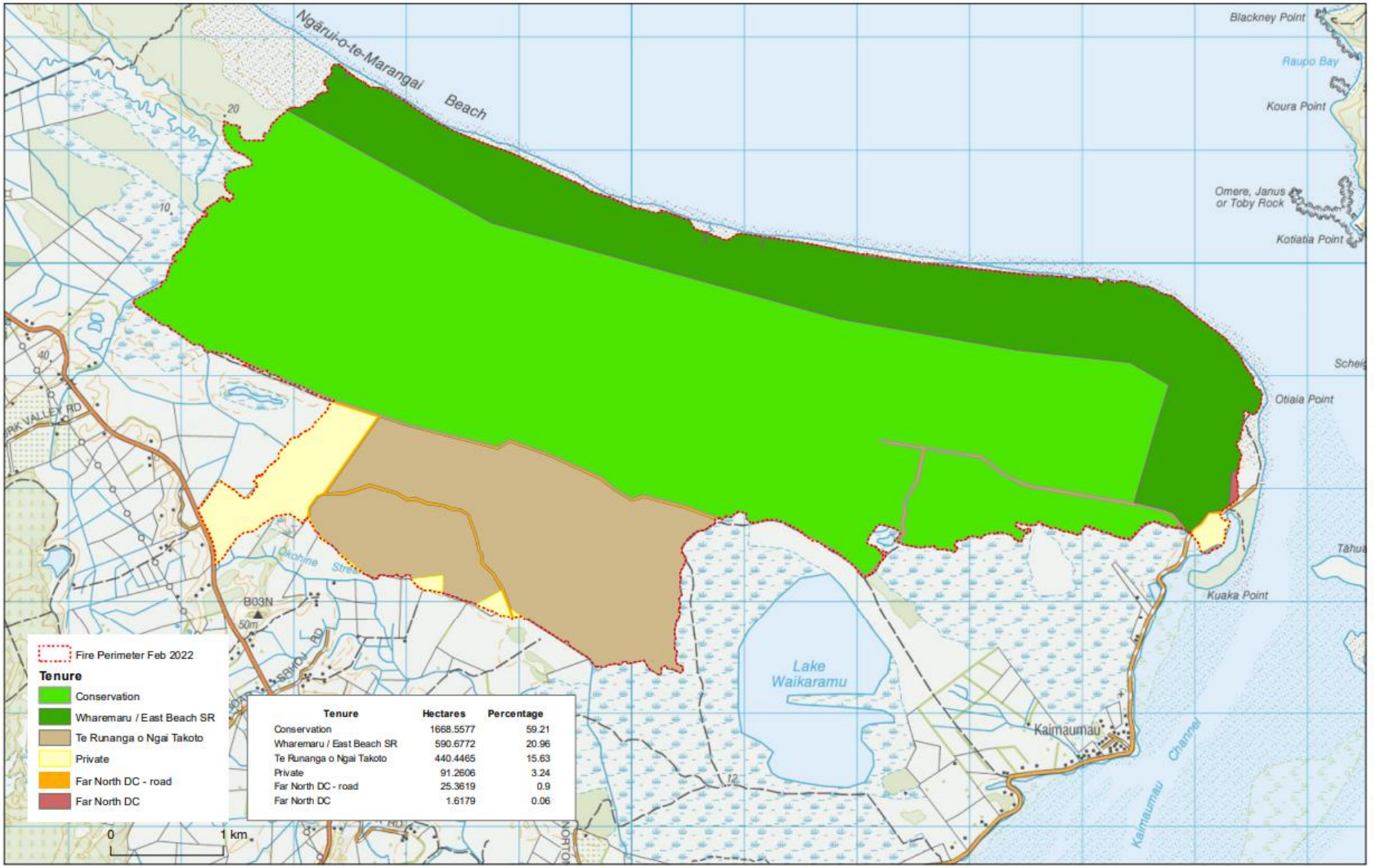
Fig.33. *Scrub fuels predominately gorse on the edge of the Wetland.*

Fig.34. *Photo of vegetation sent for identification to the Auckland Botanical Society.*

Report completed by:

Fire Investigator:	Signature:
John Foley	

Appendix 1: Maps of Fire Area (Topographical, Satellite, Annotated)



Tenure	Hectares	Percentage
Conservation	1668.5577	59.21
Wharemaru / East Beach SR	590.6772	20.96
Te Runanga o Ngai Takoto	440.4465	15.63
Private	91.2606	3.24
Far North DC - road	25.3619	0.9
Far North DC	1.6179	0.06

Department of Conservation
Te Papa Atawhai

Created scale 1:30000 @ A3
25 February 2022

Waiharara Fire - 2817.9218 ha
Tenure by percentage of burn

NZGD 2000 New Zealand Transverse Mercator
Not for publication nor navigation | 1:30,000
Crown Copyright Reserved |
DOC, Geospatial Services | 25/02/2022

New Zealand Government

Left Image - Fire and Emergency Smart Maps. Right image - Google Maps later imagery showing scrub fuels long creek

Appendix 2: Statements

Witness statements have been provided by the following.

Witness Reference	Witness Name
Witness 1.	[redacted]
Witness 2.	
Witness 3.	
Witness 4.	
Witness 5.	
Witness 6.	
Witness 7.	
Witness 8.	

Appendix 3: Annotated Photograph of General Origin Area

Sketch 1. Fire spread from Specific Origin Area. Looking from the head of the fire to the base.

White arrow identifies specific origin area.

Red arrows identify initial head fire run towards Kaimaumau Wetlands

Yellow identifies flanking fire off the main head fire run

Black eclipse approximate burn pile locations

Appendix 4: ICAD Report Cover Sheet ONLY

Full report available on request.

Fire and Emergency New Zealand
Incident Report

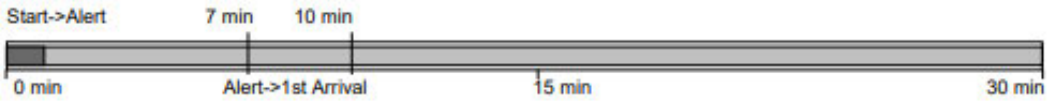
CADNumber F3383177 **Start Date Time** 18 December 2021 13:24:45

Incident Details

Type:	VEG	**1st Caller:**		
Method:	111			
PFA:				
Result:				
Location:	NORTON RD, WAIHARARA,FAR NORTH DISTRICT	**NZTM:**	*E*	1618860
			N	6136145
Common Name:				
Zone:	125402	**Station:**	1272	KAITAIA
Incident Info:	BUSH FIRE -			

Incident History

		Elapsed Time (hh:mm:ss)
Created:	13:24:45 18 Dec 2021	
Confirmed:	13:25:41 18 Dec 2021	00:00:56
Alerted:	13:25:52 18 Dec 2021	00:01:07
1st Response:	13:28:04 18 Dec 2021	00:03:19
1st Arrival:	14:02:05 18 Dec 2021	00:37:20
2nd Arrival:	14:11:33 18 Dec 2021	00:46:48
3rd Arrival:	14:43:02 18 Dec 2021	01:18:17
Stop:	23:53:18 21 Dec 2021	82:28:33
Closed:		



Responses

Alarm Level	Call Sign	Dispatched Day	Dispatched Time	Response Time	Arrival Time	Departed Day	Departed Time
3	KAIT721	18	13:25:52	13:32:39	14:02:05	16	18:31:54
3	KAIT7211	18	13:49:20	13:49:23	14:11:33	16	19:20:14
3	HOUH5471	18	13:26:07	13:35:17	14:43:02	16	18:42:53
3	HOUH5476	18	13:48:46	13:55:13	15:21:07	16	18:53:47
3	SONORTH07	18	14:04:29	14:06:52	15:58:59	05	17:40:33
3	RANG5371	18	14:57:47	15:44:44	16:39:04	13	11:58:50
3	KARI5271	18	14:37:53	15:04:20	16:39:21	16	06:16:50