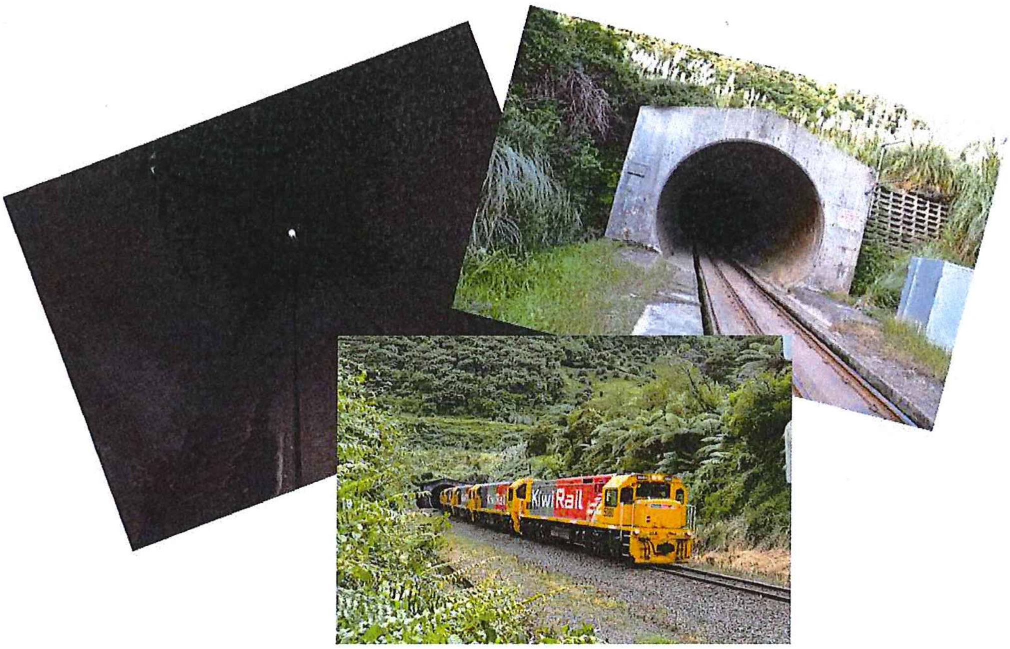
Kaimai Tunnel – a report on the Safe Working Procedures Review

A joint working party report by KiwiRail and the RMTU, March 2014



Executive summary

- The Kaimai Tunnel is one of about 100 tunnels on the national KiwiRail network. It sits on the East Coast Main Trunk line, and is a key part of KiwiRail's infrastructure in the region. It runs for 8.855km under the Kaimai Ranges.

- The Kaimai Tunnel experiences heavy volumes of freight traffic, mainly import and export goods. This high level of activity means that regular track work happens inside the tunnel.

- An incident occurred inside the Kaimai Tunnel in August 2012. KiwiRail recognized the importance of working with the Rail and Maritime Transport Union (RMTU) to review the incident and make recommendations for change.

- The Kaimai Tunnel Review of Safe Working Procedures (the Review) was set up, and it sought input from teams and individuals within KiwiRail and also from outside experts.

- This Review makes a number of recommendations,. It recommends change in a number of areas, including the Kaimai Tunnel Focus Group and other tunnel focus groups; training, monitoring of air quality in the tunnel; communication systems used in the tunnel; the use of petrol- and diesel-driven equipment in the tunnel; tunnel drainage; and workplace culture.

- In June 2012, an incident in the Otira Tunnel was also the subject of a review, and on 6 November 2013 another incident occurred in the Otira Tunnel that is the subject of an investigation by the Ministry of Business, Innovation and Employment (MBIE). A National Rail Tunnel Working Group has also been convened.

- The findings and recommendations of the Kaimai Tunnel Review will inform other ongoing initiatives on safe working procedures in all KiwiRail tunnels.

Summary of recommendations

1. That contractors are included as part of the Kaimai Tunnel Focus Group (KTFG), and that KiwiRail communicates with contractors about the work being done by the KTFG.
2. That the KTFG has a revolving chair between KiwiRail and the RMTU and that it meets no less frequently than three-monthly. The KTFG is to review changes to current and relevant documents and to annually review the tunnel's risk matrix.
3. That a governance structure is created within KiwiRail to ensure focus groups remain active and work through initiatives and issues.
4. That there is national co-ordination with Mines Rescue.
5. The Review believes the relevant KiwiRail training package needs to include responses to emergency situations and obligations with regard to reporting, and accordingly makes the following additional recommendations that:

    a) All training be undertaken in-house (within KiwiRail).
    b) The Tunnel Gas Awareness (TGA) training includes an On-the-Job-Training (OJT) component to demonstrate competency.
    c) A name change for the training be considered.
    d) Clarification is made to the definition of "local knowledge" as it is ambiguous.
    e) Tunnel Gas Awareness (TGA) training is refreshed for longstanding staff.
    f) Locomotive Engineers (LEs)/Mechanical/Plant and Machinery groups/Contractors (that is, all staff) are trained in the same way, with the same training package and OJT component.
    g) Training techniques and currency of training material are reviewed.
    h) Training material is reviewed for ambiguities and wording that might be unclear.
    i) A review is undertaken to align training packages with current rules and procedures.
    j) TGA training is reviewed annually and there is a link into the KTFG when that review takes place.

6. That powered lighting and all other petrol- and diesel-driven plant and equipment be replaced with plant and equipment that uses alternative sources of energy.
7. That environmental monitoring is undertaken for:
    a. Asbestos
    b. Fungus spores
    c. Dust
    d. Heat
    e. Fumes N02 and C0
    f. Diesel particulates
    g. Noise
    h. Lighting
    i. Toxic substances: There may also be specific environmental monitoring, for example, for epoxy-resigns, concrete dust, arsenic and specific freight-related monitoring, that is, dangerous goods.

    A decision will need to be made on the following:

    j. The frequency of monitoring
    k. The location of monitoring, that is, personal-to-person, to task, to workgroup
    l. Type of monitoring
    m. The training required for monitoring.

8. That health monitoring of employees occurs post-incident.
9. That a long-term strategic approach to having the tunnel lit is adopted.

10. That more reliable technical solutions are found to support communication within the tunnel.
11. That de-barking of log trains is considered to reduce debris.
12. That drain covers are progressively replaced.
13. That CO and NO2 monitors are issued for each LE and for regular track workers in the tunnel and that they are trained in their use.
14. That any CO and NO2 equipment should be fitted with the ability to download data and adjust alarm settings.
15. That procedural documents are reviewed for applicability, ease of use, best fit for audience and consistency across KiwiRail.
16. That an audit is undertaken to ensure conformity between contractors' procedures and those of KiwiRail.
17. That a gap analysis is undertaken between the hazards identified in this report and those identified in other documents used by KiwiRail (for example, the workbook "Working in Tunnels and Gas Awareness.")
18. That KiwiRail appoint a person to be in charge of reviewing standards for operating in tunnels.
19. That reporting requirements are clarified and reinforced throughout KiwiRail.
20. That a culture change is needed to ensure people report issues of concern.
21. That there is emergency planning involving all relevant external agencies and KiwiRail.
22. That additional repeaters be installed to make in-tunnel communications more reliable.
23. That all track-side telephones be operational at all times.

For more detail on the recommendations, **see section 8 Recommendations** of this report.

1. Introduction

The Kaimai Tunnel Review of Safe Working Procedures (the Review) arose out of an incident affecting contractors working in the tunnel on 25 August 2012.

Previously, an incident had occurred in the Otira Tunnel (triggered by an incident involving a banker LE) resulting review in June 2012. This Kaimai Tunnel Review has a different focus to the review of working procedures at Otira, which was triggered by an incident involving a banker locomotive engineer. This Kaimai Tunnel Review is complementary to the Otira Tunnel Review, supplementing its recommendations but with a greater emphasis on infrastructure work. For example, the Otira Tunnel Review did not have infrastructure workers as members, whereas the Kaimai Tunnel review had two infrastructure workers as members.

In addition, another incident occurred in the Otira Tunnel on 6 November 2013, which is being formally investigated by MBIE. A number of Prohibition and Improvement Notices have been issued, and a National Rail Tunnel Working Group has been established.

This Review looks in detail at the situation in the Kaimai Tunnel, which is on the East Coast Main Trunk (ECMT) line and runs for 8.855 km under the Kaimai Ranges. From the Port of Tauranga, it enters at the 63km mark on the East Coast Main Trunk (ECMT) east of Hemopo and exits at the 71km west of Whatakao.

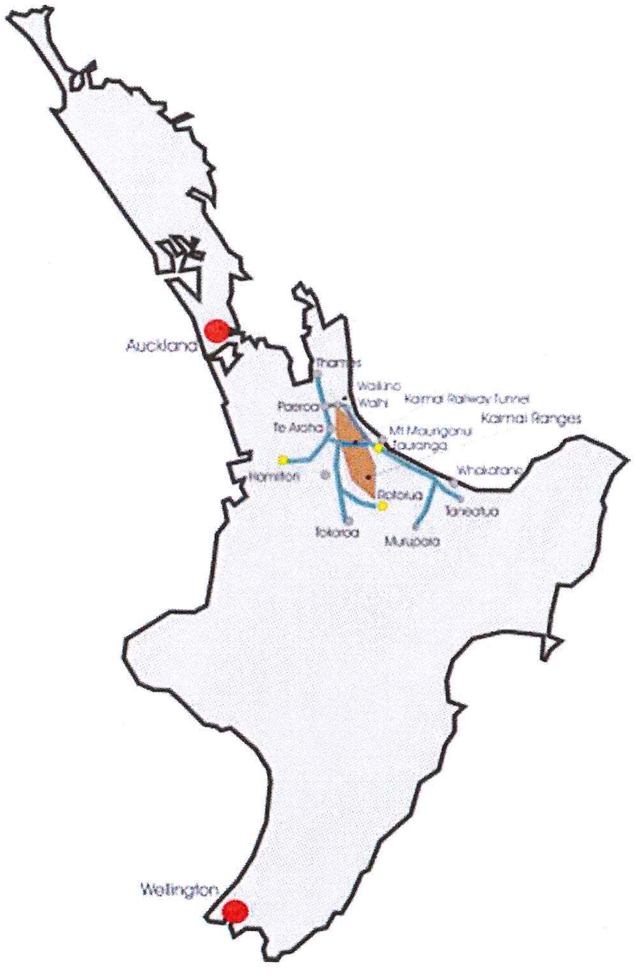


Figure 1: Location of Kaimai Tunnel on the ECMT

The ECMT is a vital link in what is known as the Golden Triangle: it is a critical part of KiwiRail's infrastructure and is central to the Port of Tauranga's MetroPort operations. Freight on the ECMT is mostly import or export traffic. No passenger trains are scheduled to run on the ECMT or through the tunnel, apart from the occasional excursion run by heritage operators or by KiwiRail. There are approximately 28 train movements in every 24 hours through the tunnel.

Staff and contractors regularly work in the tunnel. A variety of routine tasks are carried out and contractors are used for their expertise on tasks.

2. Description of the Kaimai Tunnel

The Kaimai Tunnel is 8.855km long. It is a drained tunnel with a permanently cast slab track. It has a gradient of 1 in 323 from the Western to Eastern Portal. It has telecommunications running throughout, supported by phones in refuges as a backup to the primary communications cable. However, these phones are not all operational. Routine maintenance tasks in the tunnel are associated with cleaning and clearing drains, maintaining and replacing bedplates and track, and completing code checks of the signaling and telecommunications equipment. At the time of this Review, routine maintenance had ceased because arsenic had been found in a section of the tunnel. The arsenic is thought to have a geothermal source.

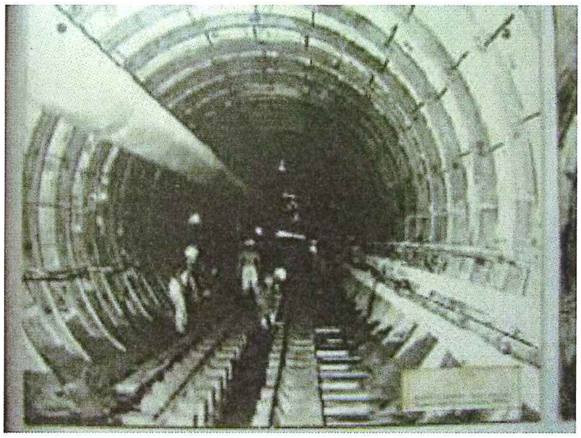


Figure 2: The Kaimai Tunnel

3. The August 2012 incident

On 25 August 2012, a working group consisting of five Abernethy and five Concrete Solutions workers were carrying out repairs to a section of concrete pad in the Kaimai Tunnel, as contracted. The repair involved removing a section of track to allow cracks to be either filled using a two-pack grouting agent or ground out using angle grinders. It was reported that a locomotive had been through the tunnel not long before the start of the work. Inside the tunnel, the Abernethy workers removed a section of the rail and laid it at the side of the track so the Concrete Solutions workers could begin repairing the concrete pad.

Contrary to KiwiRail's risk controls, the personnel from Concrete Solutions were not qualified in Tunnel Gas Awareness (TGA) – therefore they should not have been doing this routine work. Only in an emergency should unqualified staff undertake this work.

In this case, two breaches of the rules occurred as the unqualified staff were also not supervised on site by KiwiRail staff. [1]

At 8.06am the carbon monoxide (CO) gas detector alarm went off. This was probably due to the start-up of the petrol-powered generators. CO is emitted by petrol-powered plant. The gas levels quickly returned to normal when the fans were switched on.

After the Abernethy crew completed their work, they left the tunnel. As there was no effective radio communication between the Concrete Solutions workers and the Abernethy workers, there was no ability for the two groups to maintain contact with each other. In addition, there was no one posted as safety watch outside the tunnel who could remain in contact with those still working in the tunnel.

Inside the tunnel, the rail clamps had been left in situ, reducing the amount of room available for grinding the concrete pad and the grinder shrouds had to be removed. This removal created plumes of dust. The equipment used on the day included a diesel-driven High Rail Vehicle (HRV), a petrol-driven barnce, a rail borer, a rail saw, generators, a motorized clipper, lighting and a pro-line, a drill, a compressor and hand grinders. Fumes from epoxy resin were also present, along with the concrete dust.

At 8.54am the CO gas detector went off again, showing that the short term exposure level (STEL) of 50ppm had been exceeded. The workers did not evacuate. Thereafter, the CO gas detector went off numerous times, until the workers felt so ill they had to evacuate the tunnel.

There was no site-specific evacuation plan so the evacuation was fraught with difficulties – it was delayed due to equipment and gear having to be removed from in front of the HRV before they could depart. The Concrete Solutions staff did not have appropriate masks and filters to protect them from the CO fumes. The evacuation involved driving through the fumes for some distance until the workers exited the tunnel at the Hemopo end. The workers could not evacuate the other way (upwind) through the Whakatao portal because rail had been lifted and the HRV on the other side of the gap had been taken by the Abernethy crew. The Concrete Solutions crew could not contact the Abernethy crew to advise them of their evacuation.

Once outside the tunnel KiwiRail was notified.

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[1] Working in Tunnels and Gas Safety Instructions KRNI-SA-0006, at 3.4, says: "All staff (with the exception referred to in 3.7) must have completed a Tunnel Gas Awareness course..." 3.7 says: "On occasions unqualified contractors and unqualified staff will be required to enter the tunnel in one-off situations to complete a task in the event of an emergency. The contractor or unqualified person **must be** accompanied at all times by a staff member that holds a current Tunnel and Gas Awareness Certificate."

The Concrete Solutions workers complained of headaches, feeling dizzy and nausea. However, when the manager arrived, he did not arrange for the crew to be taken to a medical centre.

A decision was made to re-enter and re-install the track. The gas monitors were not recalibrated prior to re-entry. When the track had been reinstated, all the Concrete Solutions workers went home, some of them driving their own vehicles. The worksite was re-opened to allow trains to use the tunnel. No evidence was gathered at the time about this incident.

An independent investigation was undertaken by Mark Taylor of Safety Matters. His report is attached to this review as an appendix.

In summary, he found the workers did not evacuate when they heard the alarms[2]; they only had one set of gas monitors; the respiratory equipment was not suitable for the gas emergency; the generators and grinders were petrol-driven and they were working in an area which was like a confined space without adequate ventilation. There was no second HRV available on the other side of the gap in the track for an emergency evacuation. There was no method for the different groups in the tunnel to stay in contact with each other. The ten workers were not given access to medical advice when exposed to high CO levels and were allowed to drive home.

To KiwiRail and the RMTU's credit, both parties understood that a more thorough, overarching review of the Kaimai Tunnel ought to take place.

[2] They may not have heard the alarms as the equipment they were using was noisy.

4. Establishment of the Kaimai Tunnel Safe Working Procedures Review

The Kaimai Tunnel Review of Safe Working Procedures was set up jointly by the Rail and Maritime Transport Union (RMTU) and KiwiRail following the incident on 25 August 2012. The Review was established in April 2013. Terms of Reference[3] were signed on 8 May 2013.

The Review team met on 24 April, 8 May, 22 May, 5 June, 19 June, 3 July and had all-day workshop meetings on 19 July, 9 August and 25 October.

Those on the Review who had not done Tunnel and Gas Awareness (TGA) training did so on 3 July. The training was undertaken by KiwiRail trainer.

The Review members were:

- Jeanine Benson, Senior Project Manager
- Mason Erueti, Track Ganger
- William Lanigan, Track Maintainer
- Shane McNae, Train Examiner Maintenance
- Hazel Armstrong, lawyer representing the RMTU
- Karen Fletcher, Health and Safety Advisor, RMTU
- Byden Klink, HSE Advisor
- Bernie Snook, Locomotive Engineer
- Campbell McNee, Freight Regional Manager, Northern
- Peter Dix, I&E Area Manager Hamilton East

Figure 3: Some of the members of the review (L-R William Lanigan, Shane McNae, Mason Erueti, Bernie Snook, Karen Fletcher)

[3] The Terms of Reference are reproduced as Appendix 1.

5. Kaimai Tunnel Focus Group

Typically in the past all regions have had focus groups for tunnels. The Kaimai Tunnel was no exception. However, this focus group stopped functioning in 2007. The Area Manager Hamilton East recently re-started this focus group and its first meeting was held on the 24 April 2013. This focus group is key to helping manage the investigation and implementation of the recommendations of this report. These will be discussed later in more detail.

The Review recommends including contractors as part of the Kaimai Tunnel Focus Group (KTFG)[4], and that KiwiRail facilitates communications with contractors regarding the work that has been done by the KTFG and the Review.

The KTFG should include representation from the following groups:

- Mechanical (Freight)
- Freight (LEs)
- Contractor representatives
- Te Rapa Freight Management
- Hamilton East Area Manager
- Train control
- Infrastructure and engineering (I&E) track representation (x 2)
- RMTU

It is recommended the KTFG have a revolving chair between KiwiRail and the RMTU, and that they meet no less frequently than three-monthly. The KTFG should review changes to current and relevant documents and annually review the tunnel's risk matrix.

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[4] This group could be renamed, perhaps the Northern Region Focus Group.

6. Governance of rail tunnels generally

It was noted by the Review that there is no governance structure that sits above the various tunnel focus groups (Rimutaka, Otira, Kaimai). The review has recommended that KiwiRail prioritise the risk in tunnels and develop (and enhance) internal expertise around tunnel risks. There are about 100 tunnels throughout the network.

It is recommended that a governance structure be created within the business to ensure the focus groups remain active and work through initiatives and issues. The focus groups ought to have a greater regional focus, for example, northern, central and southern groups could provide oversight of the tunnels in their regions. A national group would provide oversight for all groups.

(Subsequent to the Review making this recommendation, the first meeting of the National Rail Tunnels Working Group was held on 19 December 2013.)

It is recommended that there is national coordination with Mines Rescue, with someone at a national level owning the relationship. The Review noted that relationships exist well at a local level with Mines Rescue (Otira and Kaimai at least), however, to ensure there is a consistent, coordinated approach to tunnels (noting their differences) someone must own that role at a national level.

7. The Review's activities

7.1 Input from KiwiRail teams

The Review sought internal expert advice from KiwiRail staff, including Murray Marshall, People and Safety team, who gave the Review the Ontrack Kaimai Tunnel Emergency Procedures Q132, effective from 22 February 2009. Todd Moyle, Earthquake Recovery Manager, attended by phone on 22 May. Todd explained how the Southern Tunnel Focus Group is assisting KiwiRail to deliver on recommendations from the Otira Tunnel Review. He explained that the DX fleet poses a risk of fire and unfortunately the fire suppression system that KiwiRail had embarked upon proved to be unsuitable. KiwiRail is therefore implementing a new programme for fire suppression on the DX fleet, and it has banned some locomotives from tunnels. The fire suppression project was completed by the end of 2013.

The Review also discussed whether the Kaimai Tunnel was a confined space. The Australian New Zealand Standard 2865:2001 defines a confined space as:

> *An enclosed or partially enclosed space that is at atmospheric pressure during occupancy and is not intended or designed primarily as a place of work, and:*
> *(a) Is liable at any time to:*
> (i) *Have an atmosphere which contains potentially harmful levels of contaminants;*
> (ii) *Have an oxygen deficiency or excess; or*
> (iii) *Cause engulfment; and*
> (iv) *Could have restricted means of entry and exit.*

MBIE regards rail tunnels as a high hazard workspace that require particular expertise to manage the risks, but it has not defined a rail tunnel as a confined space.

7.2 Input by Air Matters

The Review obtained external advice from Carol McSweeney of Air Matters. Carol discussed the alarm settings on the monitors. The monitors could be set to sound the alarm just before the Workplace Exposure Standard (WES) is reached to act as a warning: the second alarm could sound at 75% of the STEL. Todd Moyle, from KiwiRail, agreed that this was something KiwiRail and the RMTU could usefully discuss.

The Review requested that monitoring by Carol McSweeney take place in the tunnel for hazards, including:

- NO2
- CO
- Diesel particulate
- Heat
- Noise
- Dust
- Fumes, for example, from epoxy resin.

At the time of writing, this monitoring had not occurred because routine maintenance was not being undertaken while arsenic remains in the tunnel. (See section below, 9.3 Health and environmental monitoring.)

7.3 Input from staff

The Review convened a meeting with track staff at the Mt Maunganui depot.

The following questions were put to staff. Their response indicated a lack of knowledge of the safe working procedures. At a minimum, the training should clarify these questions:

- When do you put on your mask?
- When should the alarm sound? – before or at the point of the exposure limit?
- When do you turn off your machinery?
- When do you leave the hazard (in order to move a safer area)?
- Where should the mask be stored?
- How far away from you is it acceptable for the mask to be stored?
- Where is the monitor placed in the workgroup?
- Where should the monitor be in the workgroup?
- What capacity should the filter on the mask have?
- When should you change your filter?
- When do you entirely evacuate from the tunnel?
- Do you re-enter after the STEL has been reached?
- When can you re-enter, after an exposure to fumes?

7.4 Risk assessment

A KiwiRail risk assessment matrix was developed as part of the Review.

- A weather event
- Noxious gases inside the tunnel during I&E work or from train movements. The mitigations were:
    - Tunnel gas training for all personnel
    - Ensuring all workers understand the procedures when the alarms sound
    - Ensuring staff can access and use gas masks
    - No re-entry when the STEL is reached
    - Understanding recalibration of the monitors
    - No petrol- driven plant in the tunnel
    - No refueling in the tunnel
    - Measuring air quality prior to entry, especially when a locomotive has just been through the tunnel
    - Use of work trains
    - Contractors to work under supervision of rail personnel
    - Gas masks available for safe evacuation
    - Safety plan and briefing prior to entry
    - Provision of gas monitors to all workers
    - Monitoring of wind direction
    - Evacuation procedures – shut down plant that is creating CO and NO2

- Evacuation
    - Procedures to be in place before work begins
    - Monitoring of air flows

- Gas monitors for all evacuating work groups

- Communication
  - Inspection and maintenance of communication devices
  - Emergency phones to be operational
  - Testing of devices before entry
  - Hand-held communication available at all times
  - Establishing the channel for communication with train control

- Fire
  - Pre-inspection
  - Emergency procedures and equipment and personnel training and competence
  - Gas masks for each individual and gas monitors for each work group
  - Maintenance programme for plant and equipment
  - Material Safety Data information
  - Sources of ignition eliminated

- Traffic volumes influence the presence of fumes in the tunnel. The timing of the most recent train, and the number of trains going through a tunnel, need to be taken into account when determining when a tunnel can be entered (or re-entered).

- Working alone
  - Inspectors should take in hand-held radios if getting out of an HRV during an inspection.

- Lighting for infrastructure work is currently diesel powered – the provision of lighting ought to be fume-free

- Slips, trips and falls
  - Cleaning of debris
  - High lace-up boots

- Toxic compounds
  - Good hygiene
  - Facilities to wash hands
  - Disposable gloves

- Contractors must be supervised
  - Contractors trained in TGA
  - Contractors managed by a trained and competent person

- Trained personnel
  - All persons entering the tunnel to be trained in TGA
  - All persons inducted
  - Competent and trained KiwiRail person to lead work gangs.

8. Recommendations

8.1 Training

The Kaimai Tunnel Review was tasked by its Terms of Reference to review the training materials concerning safety in the tunnel. The training that KiwiRail has developed is titled Working in Tunnels and Gas Awareness (the training). The Review noted gaps and inconsistencies with the training when compared to other KiwiRail Rules and Procedures, and with standards set by MBIE. In this section of the Review, we note these discrepancies.

I&E KiwiRail staff have the most developed training. They have dedicated trainers, time is set aside for the training, and they are given a workbook. All contractors should receive the same training as KiwiRail staff but we are aware on occasion that this has not been the case. KiwiRail does hold a rule that allows people who are not trained in TGA to enter the tunnel, but only if they are not doing any physical work and are accompanied by a person trained in TGA. The types of situation that this rule has applied to in the past are when surveyors go into the tunnel or when a local member of Parliament wants to enter the tunnel in an observation role. Police, fire and St John Ambulance Service personnel can enter the tunnel without TGA but only in an emergency.

LEs are not trained to the same level as I&E staff. The I&E training package for TGA is more comprehensive than the training for freight (primarily for LEs). Note: people from the Review who had previously been trained in freight attended I&E training. Mechanical employees do not appear to receive the training at all.

The safety briefing in the Training material example states: "A designated person in each work group must be trained and competent to read the monitors." This implies that only a designated person needs to know how to read the monitors. **The Review considers** that all workers in the tunnel must be able to read the monitors.

The Review was advised that the alarm on the monitor goes off on every shift at the WES for CO. On one shift in five the second level alarm (the STEL) goes off for CO. The two-stroke motor on the disc saw is reported "to get the second alarm every time", and likewise if the monitor is stationed beside a HRV or operating plant. **Therefore it is vital that each and every worker understands how the monitors should be read and interpreted.**

The monitor could be set to sound the alarm just before the WES Time Weighted Average for an eight-hour day (TWA) is reached to act as a warning. At that point, steps should be taken to eliminate the hazard, or to isolate the workers from the hazard: plant should be turned off to eliminate further fume emission; and workers moved to a point in the tunnel where it is safer. Workers should take steps to bring the level down below the WES.
This advice is consistent with that given by Robin Kerr, Site Manager Locomotives, Palmerston North, KiwiRail Freight, to KiwiRail workers in Palmerston North. He advised that at the first alarm for NO2:

- Stop what you are doing
- Turn engines off
- Open any building doors
- Ensure extraction fans are working
- Move to another area or outside if monitors continue to sound.

It was of concern to the Review that when asked about the alarm workers thought that when it sounded they could keep on working. The Review believes this uncertainty has arisen from the training given. The training safety briefing example said: "First Alarm TWA – regular monitoring of readings, look at worksite lay out, number of plant running etc." The materials did not give advice on what to do. It appears that clear instructions on how to respond to the first alarm are not given. This is in stark contrast to the Robin Kerr briefing, where it is arguable the environment is far less hazardous than a tunnel.

It is not envisaged that teams just continue working when the WES TWA alarm sounds, or that they should continue working with their masks on, changing them every 20 minutes, masks are to be used as a last resort whilst workers are leaving a hazardous situation. Nor is it envisaged that workers work without masks when levels are above the WES. The advice should be aligned (as appropriate) with the advice set out above from Robin Kerr.

Carol McSweeney from Air Matters suggested a second alarm could sound at 75% of the STEL, and at this point masks should be donned and workers should start evacuating the tunnel. Filters have an effective time window – 20 minutes. If the worker is exposed to the STEL, with a 20-minute filter capacity, they have only 20 minutes before a change of filter is required. Exposure to the STEL should not be longer than 15 minutes and **our recommendation** is that if the STEL is reached, workers leave the tunnel and do not re-enter for the rest of the shift.

The Review team understands that the workers will stop working and evacuate when the second alarm sounds. It was of concern to the Review that even though the workers were evacuating, they might not be putting on their masks for the evacuation. The training safety briefing example for the second alarm says: "Uplift masks and evacuate tunnel." The briefing does not say, "Don the masks." Thus the advice is unclear.

The advice provided by Robin Kerr for the second alarm for NO2 was:

- Stop what you are doing
- Turn engine off
- Move immediately outside
- Await for air to clear (min. 15 minutes)
- Recalibrate monitor in fresh air
- Re-enter worksite with monitors on.

It would seem that putting masks on is not required in Palmerston North. However, this may be because a tunnel (unless one is working at the portal) poses more difficulty for a quick evacuation so the use of masks would be required, whereas it may not be mandatory in a mechanical depot where the outside fresh air is only minutes away.

Robin Kerr's advice is that re-entry is permitted after 15 minutes. The KiwiRail meeting on 4 December 2013, convened by Liam Fay, agreed that after the STEL alarm sounds, there should be no re-entry.

The instructions on the filter will advise the capacity of the filter. A CO 20 filter should last 20 minutes. Filter re-use has to be carefully checked. The spec sheet for the CO 20 states it must only be used once in the presence of CO for 20 minutes within a shift and then must be replaced with a new filter. NO2 filters may be used once per shift and then must be replaced with a new filter. **It was of concern to the Review** that workers did not know how long their filters would last for upon each exposure to fumes.

The training provided a safety briefing example that stated, "Gas masks to be kept within 100 metres at all times." Carol McSweeney of Air Matters did not think a 100-metre sprint to masks was advisable. The procedures should state that masks be available where the worker is working.

The text in the training book states that WESs indicate the difference between "safe and hazardous gas levels". Further, the text defines the standard as "safe". The term "safe" is misleading, and the text in the training book must be aligned with the standard issued by the regulator. The 7th Edition of the Workplace

Exposure Standard (The Standard) issued by MBIE, effective February 2013, gives the following advice with regard to WESs:

> *The Workplace Exposure Standard (WES) must not be used to differentiate between safe and inherently hazardous exposure levels.*

The Standard also refers to workload, which is not mentioned in the training book. The training book ought to refer to workload as it influences the uptake of fumes and gases. It may also influence the choice of respiratory equipment. The following is an extract from The Standard on workload:

> *An increase in workload can influence the uptake of a substance by increasing the lung ventilation rates and blood flow. For gases and vapours, the extent of this increase is dependent on, among other factors, the solubility of the substance in the blood. If the substance is very soluble in blood, the uptake is related directly to the lung ventilation (in litres per minute), as this determines the speed of its access to the uptake site. Lung ventilation depends on the minute ventilation rate (average volume of air breathed per minute) and peak inspiratory air flow (the instantaneous flow rate during the inhalation phase of the breath). If the substance is only slightly soluble in blood, the blood circulation rate becomes the determining factor, and respiratory volume does not have a significant influence. Exposure standards have generally been derived assuming a moderate work load. This factor should be borne in mind, especially where both the workload and exposure are high. The following table presents lung ventilation rates at different workloads*

1. *to indicate if additional care should be taken in interpreting the monitoring results in relation to the WES; and*
2. *to determine the type and effectiveness of respiratory protection.*

Assessment of Work Load	Average ventilation rate litres/minute	Peak inhalation rate litres/minute
Low, e.g. writing, typing, small bench too work, standing while drilling or milling small parts	11-20	100
Moderate, e.g. hammering in nails, filing, pneumatic hammering, walking 3.5-5.5 km/h	**20-31**	**150**
High, e.g. carrying heavy loads, shovelling, digging, pushing or pulling heavy cart, walking 5.5-7.0km/h	31-43	200
Very high, e.g. working with axe, intense shovelling or digging, climbing ladder, stair or ramp, walking in excess of 7km/h	43-56	250

Table 1: Lung ventilation rates impacted by workload[5]

Information on the limitations of applying the flow rates is provided in AS/NZS 1715:2009 Selection, Use and Maintenance of Respiratory Protective Equipment. It should be noted that these ventilation rates represent average values and can vary substantially from individual to individual. Current research on values for peak inspiratory air flow indicate that these are underestimated at present.

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[5] 7th Edition of the Workplace Exposure Standard issued by MBIE

The text of the training book asks those working in the tunnel to consider whether gas monitors and masks are necessary[6]. The text states that the "Person in Charge" makes this decision[7]. The Review believes, as recommended in section 9.7, that monitors and masks should be a mandatory requirement for all those working in the tunnel.

The training notes that one gas mask and two filter canisters are issued per person.[8] The text in the training manual should be amended to clear up any ambiguity about the mandatory requirements that each worker should have a mask and two filters and a monitor.

The text in the training manual says. "If you are working on the infrastructure in a tunnel, there is usually one set of monitors for each work group."[9] The Review believes that each person working in the tunnel needs a monitor, because each person's exposure is different depending on the task. The allocation of monitors would be part of the job planning.

The text only requires reporting of an incident when a person is exposed to a concentrated or substantial level of toxic gas fumes and the person was not wearing a mask. The Review believes that incidents should be reported when persons are exposed to a high level of fumes, even when they are wearing a mask. The reason for this is that KiwiRail needs to have an understanding of "exceedances" in order to control them effectively without relying on Personal Protective Equipment (PPE), which is only a minimization intervention. **Therefore the Review recommends** that all exceedances should be reported and the text changed accordingly.

The text says that staff may re-enter the tunnel once gas levels drop to a safe level. This advice is not included in The Standard, and the Review does not know the origins of this advice. The Standard has this to say on CO levels:

> *CARBON MONOXIDE (CO): Exposure to carbon monoxide should be controlled to maintain a carboxyhaemoglobin (COHb) level below 3.5% (the Biological Exposure Index for CO). Under most conditions, this will be achieved if the average level over an eight-hour day does not exceed 25ppm, but there is also a need to control brief periods of high CO exposure. The CO level should not exceed 400ppm at any time during the day (Ceiling value). The sum of the exposure periods during the day at a particular level should not (in total) exceed the period indicated.*

The Review understands The Standard to mean that if the ceiling is reached, or the STEL is reached and sustained for 15 minutes, then there would be no re-entry for continued work that day, even when PPE is being worn.

The Standard also outlines the limitations of the Standard:

> *Defining an exposure level that will achieve freedom from adverse health effects is the major consideration for assigning these WES. However, compliance with the designated WES level does not guarantee that all workers are protected from discomfort or ill-health. The range of individual susceptibility to hazardous and toxic substances is wide, and it is possible that some workers will experience discomfort or develop occupational illness from exposure to substances at levels below the WES. WES are assigned to approximately 650 hazardous or toxic substances. About 50 substances have been removed from this edition because at the time of publication they were not approved for use in New Zealand under the HSNO Act. In many cases well-documented data exist to help determine WES. But for some substances, the available toxicological and industrial hygiene information is insufficient to enable highly reliable standard-setting. Therefore, it is inevitable that*

[6] Page 10
[7] Page 22
[8] Page 21
[9] Tunnel Gas Awareness Training, page 19

some current WES will be lowered in the future, as more information about the effects from these substances becomes known.

Training materials list the common hazards as:

- Toxic gases
- Dark
- Confined space
- Wet, slippery underfoot conditions
- Dust
- Trip hazards
- Cold.

The Review felt this list omitted the following hazards:

- Fire
- Fumes, for example, from epoxy resins
- Diesel particulate
- Noise
- Communication
- Heat
- Extreme weather events
- Working with untrained personnel
- Working with inadequate supervision
- Toxic compounds, for example, arsenic, asbestos
- Working alone
- Traffic volumes
- Electrical.

The Review believes the training package needs to include responses to emergency situations and obligations with regard to reporting, and **makes the following recommendations**:

- It is recommended that all training be undertaken in-house (within KiwiRail).
- The TGA training should include an On-the-Job-Training (OJT) component to demonstrate competency.
- The definition of "local knowledge" is ambiguous and needs to be clarified.
- TGA training is refreshed for longstanding staff.
- It is recommended that LEs/Mechanical/Plant and Machinery groups/Contractors (that is, all staff) are trained in the same way, with the same training package and OJT component mentioned above.
- It is recommended that the training techniques and currency of training material are reviewed.
- It is recommended the training material is reviewed for ambiguities or wording that might be unclear.
- It is recommended that a review is undertaken to align training packages with current rules and procedures.
- It is recommended that TGA training is reviewed annually and that there is a link into the National Governance Group when that review takes place.

8.2 Hazards in the tunnel

Work trains and HRVs are powered by diesel which emits NO2. The HRV trucks also provide generation for the lighting to illuminate the work area and the truck. This means that when the alarm goes off (signaling elevated levels of fumes) the truck cannot be turned off to reduce fume emissions, otherwise the workers are plunged into darkness and they cannot drive the truck to exit the tunnel.

Some of the plant used is petrol driven: the rail saw, lancing and welding all create CO fumes, which regularly trigger alarms. The Review was told that alarms will go off on every shift when a track worker is undertaking infrastructure work in the tunnel. It is worse in the middle of the tunnel.

The Kaimai Tunnel (unlike Otira) has no ventilation system. The wind is the principal ventilation system, hence on windless days and nights there is the potential for fume build up. The wind often changes direction during the day. Sometimes local ventilation is used, which is run by a diesel generator.

The Review recommends investigating alternatives to powered lighting and to all other petrol- and diesel-powered equipment and plant in the tunnel so as to reduce emissions (this includes any equipment and plant the Mechanical team may take into the tunnel in an emergency).

The Review also recommends eliminating all petrol-driven equipment and plant in the tunnel.

The Review was made aware of a pilot of diesel-powered hydraulic minor plant. The findings from the pilot will be made available presently.

If trains have driven through the tunnel, the fumes should be purged before work begins.[10]

8.3 Health and environmental monitoring

At the Health and Safety Action Team (HASAT) meeting in Hamilton East on 27 March 2013, the possibility of asbestos being present in the Kaimai Tunnel was raised. Testing was prescribed. During the Review, the test results came out – asbestos and arsenic were found to be present in and around the tunnel. Following the release of the results, a toolbox briefing was undertaken by KiwiRail. The written brief said: "While asbestos has been found in small quantities at the Whatakao end of the tunnel only, and only at the 72 km mark, the samples also indicated that the dust had arsenic present at two locations – this was at 65.5 km at 670 mg/kg and at 67.5 km at 80 mg/kg." The levels are significant. To ascertain the extent of the problem, Air Matters undertook further asbestos sampling of nine sites and found no asbestos was present. However, as a result of the initial finding of asbestos and arsenic, as a precautionary measure, all further infrastructure work (other than inspection) ceased until it was clear there was no asbestos and arsenic present. There are plans currently underway to do a cleanup in the tunnel, with further monitoring for this material to be undertaken after the cleanup has taken place.

The Review recommends environmental monitoring is undertaken for:

- Asbestos
- Fungus spores
- Dust
- Heat
- Fumes N02 and C0
- Diesel particulates
- Noise

[10] This may prove to be a challenge in the Kaimai Tunnel, so the job plan must take fumes from recent locomotive traffic, into account, when considering entry into the tunnel for maintenance work,

- Lighting
- Toxic substances: there may also be specific environmental monitoring, for example, epoxy-resins concrete dust, arsenic, and specific freight-related monitoring, that is, dangerous goods.

A decision will need to be made on the following:

- The frequency of monitoring
- The location of monitoring, that is, personal-to-person, to task, to workgroup
- Type of monitoring
- The training required for monitoring.

The Review also recommends mandatory health monitoring of employees post-incident.

The Review also understands that health monitoring of employees is currently being investigated by the People and Safety team, and that this will be incorporated into monitoring activities in the Kaimai Tunnel.

8.4 Lighting

LED lighting could be considered in the tunnel. There is currently a body of work being contemplated that would set minimum asset criteria for each tunnel across the KiwiRail network, based on each tunnel's traffic patterns, geography, gradient and so on. Given it is generally I&E staff who are in the tunnel, the lighting needs to be specific to the work they are actually doing.

The Review recommends that either a long-term strategic approach to having the tunnel lit (as will be recommended in the Asset Management Plan [AMP]) is adopted or alternative forms of lighting are considered. When other forms of lighting are investigated, enhancing the light spill on the work area should be considered.

8.5 Communication

The Review identified communication as a key issue for people working in the Kaimai Tunnel. The Review considers that there is considerable scope to improve communication between workers, and between work groups, when they are working in the tunnel. This is particularly important as there is potential for workers to become overwhelmed by fumes or gases, and to become disorientated as a consequence. It is also important because there can be more than one work group in the tunnel at the same time. However, they may be unable to reach each other on an HRV because the rail has been uplifted between the two groups. If an incident occurs affecting one work group, they need to be able to communicate with the other work group.

The radio telephone has limited reach. There is also an issue of radio failure. At the 27 March 2013 HASAT meeting in Hamilton East, it was reported that radios were not working "the other week".

There are 24 trackside phones located in the refuges, which serve as a back-up if the radio telephone system fails. Half of these phones don't work with the worst end being at Hemopo. The Review understands that Signals Technician and Engineering (ST&E) has currently prepared a proposal to address this and other forms of communication in the tunnel.

There is a requirement that KiwiRail ensures primary and secondary forms of communication are functioning.

The work in the tunnel is noisy so workers wear grade 5 hearing protection. When staff have to put their masks on, their method of communicating is through hand signals. There is no formal training in hand signaling for I&E staff. Whilst hand-signals might not be used regularly, they are an important way of communicating with others when other communication methods are unavailable (that is, radios).

There are cables in the tunnel that run on the right-hand side as follows:

a) a 1-in-10 pair lead-sheathed paper-insulated cable, which is considered obsolete technology. This has a back-up via a telecom connection. This cable needs an air machine to blow air through the cable to keep it dry. This cable transmits radio, trackside phone and Centralized Train Control (CTC) information. In the AMP, it is suggested the 10-pair lead-sheathed cable be considered for renewal as it is obsolete and unreliable technology.
b) In additional there are two pairs of copper cables for trackside phones, two pairs of copper cables for the radio signal, a leaky cable for the locomotive cab to Train Control transmission and power cables for the signal heads in the tunnel.
c) There is a TelstraClear (now Vodaphone) fibre optic cable in the tunnel that KiwiRail has access for four fibres (dark fibre).
d) There are four repeaters spaced throughout the tunnel for the train-control leaky cable radio system. There are two repeaters at either end of the tunnel. **The Review recommends** the investigation of additional repeaters to make in-tunnel communications between work groups more reliable.

There is an AMP to address improvements in tunnel communication based upon:

a) Extending the fibre optic network to a point near each end of the tunnel
b) Having digital analogue converters at either end of the tunnel
c) Replacing the 10-pair cable with a modern plastic insulated grease-filled copper cable.

The Review recommends that a technical solution is reached to address the issue of phones working (or not working) in the tunnel and that an investigation is undertaken to look at better, more reliable technical solutions to support communications in the tunnel.

Signals and communications

There are 24 trackside phones which should serve as a backup if the radio systems fail. There are two outer-station signals heads at the loops at either end of the tunnel.

8.6 Drains, drainage and drain covers

A significant amount of water runs through the tunnel. The tunnel drains east to west. The circular profile of tunnel drains are nominally 228m deep and 230mm wide at the base.

Figure 4: Tunnel drain

Timber cover walkways are rotting in some places and have been removed in others. They are suffering from age and subsequent deterioration. The AMP has recommended that the timber side drain covers be replaced with steel grating through the horseshoe section.

Figure 5: Drain cover in the tunnel

Figure 6: Drain cover in the tunnel

The AMP mentions that the amount of debris and abrasive agents entering the tunnel and being carried in the drain may increase with increasing freight volumes. These flows need to be controlled, and cleaning regimes need to be maintained. Programmes of inspection and regular cleaning of the drains and sumps, and so on, will assist in maintaining the drains.

Special attention needs to be given to transition structures and the circular profile side-drain sumps as these areas increase the risk of drainage issues.

We are aware wood chip wagons have recently been covered, and there is no debris coming off container wagons and the CET (coal) wagons are covered.

Figure 7: Debris in the tunnel

The Review recommends that a cost/benefit analysis be undertaken to ascertain whether it may be more efficient to de-bark log trains at source.

We are aware that debris occasionally comes off ballast wagons but this is difficult to address.

Figure 8: Drainage Hemopo end

The structural condition of the tunnel's drain was determined to be a category 2 (where '1' is 'best' and '5' is 'worst') in most places, with instances of category 3 and 4 every 100m or so (at the lower end of the circular profile).

Figure 9: Tunnel grating

The drainage asset should not cause water to rise onto and around the track slab. Prevention of blockages is the key to this. The timber covers need to be replaced with galvanized steel providing a safe work area around work vehicles and access into the tunnel.

The Review agrees with the AMP and recommends replacement of the drain covers to provide a safe environment for track workers and safe access for LEs in an emergency.

8.7 Monitors

At present a set of two monitors (CO and NO2) are given to a designated person in the work group. The Review understands there are eight sets of monitors for infrastructure staff working in the tunnel.

LEs are each issued with one monitor that detects and measures both gases (CO and NO2). The LE picks up the monitor and takes it with them when travelling into the tunnel. There is a book where the LE signs out the monitor they take with them. Bernie Snook advised the Review that some LEs are not picking up monitors at the beginning of their shift. This practice should be audited.

There are two types of monitors in use by staff working in the tunnel to monitor CO and NO2. I&E is using the Toxi-Pro monitors and Freight is (normally) using the Draeger Pac 3 models.

The Review recommends that equipment is standardized across all parts of KiwiRail. Toxi-Pro monitors are more cost effective, both in their upfront capital cost and their on-going calibration costs. I&E support staff have also been trained to re-calibrate this equipment.

There is no standard procedure around how the monitors are used. For example, if a work group is working across 30 metres should more than one monitor be issued? Should a monitor be provided to each worker who is known to be exposed to fumes? A work site within the tunnel can spread between 30 and 200 metres, depending on the job. Therefore it is vital to clarify who has monitors and where the monitors should be located.

The Review recommends that C0 and N02 monitors are issued for each LE and for each regular track worker (including contractors) in the tunnel and that they are trained in their use. Plant Machine operators and Mechanical should also be issued with C0 and N02 monitors and masks so that they do not remove them from the regional teams.

The Review recommends any further C0 and N02 equipment should be fitted with the ability to download data and adjust alarm settings. **The Review recommends** institutionalising the frequency of downloading data and analysis, that is, downloading after the threshold has been exceeded.

The Review clarified that masks are PPE and have their limits as far as being able to control the hazard. They are the last line of defence after controls that attempt to eliminate or minimize the hazard have failed. The Review obtained external advice from Carol McSweeney of Air Matters, about the use of masks and monitors. Carol discussed what could trigger the alarms on the monitors. It is vital that masks and monitors are fit for purpose, and that all staff and contractors use the appropriate equipment.

8.8 Procedures

The Review team read and assessed documents relating to the tunnel, namely:

- L2 – Kaimai Tunnel Serious Incident/Emergency Procedures
- Q132 – Best Practice Working in Tunnels

The L2 "Instruction on an Emergency in the Kaimai Tunnel" is disorganized and ambiguous. No one could reasonably be expected to follow this in an emergency. Emergency situations lend themselves to simple instructions that typically sit better in the form of a flowchart. Who does what to whom would be a good start. For example, it states, "In the event of a serious incident occurring in the tunnel (i.e personal accident, train failure or fire) a Rail Incident Controller (RIC) is to be arranged and the Emergency Services advised via Fire Communication Centre."[11]

1. Who arranges the RIC?
2. The Fire Communication Centre?, if this is Train Control, who advises the emergency services if the incident isn't a fire?

In fact, it's not until the next page that you discover that the KiwiRail NCM will arrange for the RIC to be appointed.

Halfway through the second page, the person – in the middle of an emergency – is then advised to, "Follow detailed arrangements in Rail Services Controlled document Q132 re Kaimai Emergency procedures."[12]

The Review recommends that procedural documents are reviewed for applicability, ease of use, best fit for the audience and consistency across KiwiRail (that is, Freight, I&E, and so on).

The Review considered L2 and Q132 and the learner workbook for "Working in Tunnels and Gas Awareness", and found there were inconsistencies between these documents.

The Review recommends that the Q132 document be finalized by Keith Permain, and it also needs to be turned from guidance into mandatory standards.

The Review recommends that an audit is undertaken to ensure conformity between contractors' procedures and those of KiwiRail.

The Review also recommends that a gap analysis is undertaken between the hazards and KiwiRail's current and relevant documents.

Given recent changes in the Health and Safety in Employment Act and some changes resulting from MBIE, **the Review believes there needs to be someone within KiwiRail who owns these types of changes.**

8.9 Incident reporting

The Review noted that in some cases the definitions of emergency, incident and serious harm and how each should be reported were unclear. This was evident at both the 12 August 2012 incident and the 6 2013 incident where MBIE was not notified by the employer, and upon investigation it was revealed that "serious harm" injuries like this were not automatically notified to MBIE (as they are with NZTA through IRIS (Incident Management Reporting System).

The Training providers safety briefing example says, "Anyone working in the Tunnel that shows symptoms of toxic gas poisoning is required to report to the Site Supervisor as soon as symptoms appear." The briefing does not advise whether this matter ought to be communicated to IRIS by the individual or the site supervisor.

At the 19 July 2013 meeting, the Review team discovered that the local I&E Area Manager had not been informed of a recent fire in the Kaimai Tunnel.

[11] L2 – page 56
[12] L2 – page 57

The Review makes the following recommendations:

- Define and communicate definitions of emergency, incident and serious harm and how they are to be communicated.
- Remind employees (through Toolbox talks and other forums) of their responsibilities to report these cases.

In discussions with workers, it was revealed anecdotally that there had been many more incidents in the tunnel than we could find reported in IRIS. Team members suggested that people may be scared of reporting incidents and that it could be difficult to report through Train Control due to how busy Train Control typically was. **The Review recommends** a step change in incident reporting and recording for both KiwiRail and contracting staff and a culture change so that people do not feel scared to report issues.

8.10 Emergencies

At the outset and throughout the Review, it was unclear just what was the relationship with, and responsibility of, Mines Rescue. The Area Manager Hamilton East has trained Mines Rescue staff so they are able to enter the tunnel with all the appropriate qualifications. With Mines Rescue being the lead agency (L2 ROP section 7.4) in an event, **the Review determined** that more active engagement should be sought with them and that there should be a codified regular desktop emergency scenario to ensure all agencies (not only Mines Rescue) are aware of what is expected from them in an emergency.

The Review also recommends that an audible alarm is instituted or codified (from existing equipment) for use in emergencies and that all emergency equipment in the tunnel is verified as functioning, with particular reference to the training safety briefing that states oxygen is located at the northern and southern portals.

8.11 Asset Management Plan

Figure 10: Slab cracking

The slab track condition can be summarized as follows:

- 1% of tunnel length is 1 (best)
- 67% of tunnel length is 2
- 25% of tunnel length is 3
- 5% of tunnel length is 4
- 1% of tunnel length is 5 (worst).

Areas of poor condition are being addressed by grooving beneath the rail foot and maintenance of side drains to ensure they do not overflow and divert beneath the base slab.

The tunnel lining is between 35 and 45 years old. Some areas are opening up and significant groundwater flows are evident.

Figure 11: Groundwater flow in tunnel

The following maintenance activities will manage the tunnel lining in future:

- Crack sealing/waterproofing
- Crack grouting
- Crack stitching
- Spalling repair.

The Review recommends that this is monitored by the KTFG.

The Review recommends monitoring of the:

- Progress of improvements in the slab track performance
- Effectiveness of the current intervention
- Progress of the proposed fix for the telephones, the performance of the current communications system in the tunnel and its subsequent renewal
- Incidents of obstacles and blockages in the tunnel and why.

The Review is aware that metrage markers have been placed in the tunnel as illustrated below.

Figure 12: Metrage Markers

9. Conclusion

This Review considered the incident that occurred in the Kaimai Tunnel on 25 August 2012, and its broader context. We consulted widely within KiwiRail and with relevant experts, and we took note of the Otira Tunnel Review of Safe Working Procedures, and subsequent related developments.

As a result of our considerations, we have made a large number of recommendations for change that are specific to the Kaimai Tunnel. However, many of these recommendations are also relevant to tunnel safety in the wider KiwiRail network.

KiwiRail

Kaimai Tunnel
Review of Safe Working Procedures Project

TERMS OF REFERENCE
May 2013

1. **Introduction & Purpose**

1.1. The purpose of this project is to:

- review the current practices and working procedures for the Kaimai tunnel with a focus on infrastructure work; and
- consider the hazards and risks of working within, trains stopped and travelling through the tunnel environment; and,
- recommend safety improvements that minimise, isolate or eliminate hazards and prevent harm to employees and contractors; and
- oversee the implementation of the recommendations arising from the review.

1.2. The Kaimai Rail Tunnel is on the East Coast Main Trunk line which links the Waikato with the Bay of Plenty. It is 8.879 km long, the longest rail tunnel in NZ.

1.3. The tunnel is straight and is constructed to a continuous 1 in 324 gradient which rises with the kilometrage (ie. uphill towards Tauranga).

1.4. The Tunnel passes through a volcanic and seismic geological area with volcanic gases, heat and ground water exhausting into the tunnel.

1.5. All trains through the tunnel are diesel electric locomotive hauled.

1.6. The current key traffics on the line are IMEX containers, forestry products,coal steel and general freight. There are up to 25 scheduled train movements through the tunnel per day. The line is a key traffic corridor for the company.

1.7. There are no scheduled passenger trains through the tunnel, but there are occasional passenger charter trains.

1.8. KiwiRail has documented safe working procedures for the Kaimai Tunnel developed in conjunction with employees and their representatives the RMTU, emergency services and Mines Rescue. These include the Local Network Instructions L2 sections 7.4 – 7.11, the Kaimai Tunnel Emergency Procedures document Q132, and KRNI SA-0006 Working in Tunnels and Gas Safety Instructions and Track Safety Rules and Rail Operating Rule 90(j).

2.16. Arrange for occupational hygiene testing to be undertaken to identify hazards, and

2.17. Consider Kaimai tunnel safe working procedures against the recommendations from the recent Otira tunnel review, and

2.18. Prepare a report on the findings and make any recommendations for safety improvements (including monitoring, supervision, training and on-going assessment requirements) for consideration by the Project Steering Committee by 30 August 2013.

2.19. Participate in the implementation of recommendations.

3. Management

3.1. The project sponsor is the KiwiRail General Manager Safety & People.

3.2. The project Steering Committee is Steve Collett (KiwiRail), Ian Cotton (KiwiRail) and Wayne Butson (RMTU).

3.3. The project working group will consist of KiwiRail employees who will provide operational and technical support and RMTU national office nominated representation.

3.4. The Project Manager has been appointed by the Steering Committee.

Bernie Snook..

Hazel Armstrong ....

Bryden Klink ....

Jeanine Benson..

Mason Erueti..

William Lanigan..

Shane McNae ..... S. McNae ....

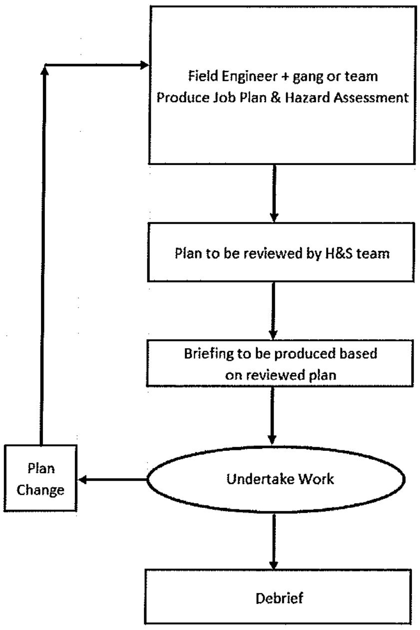
Campbell McNee ....

Karen Fletcher..

Peter Dix

Appendix 2: Example Process for Tunnel Work, December 2013

Example process for tunnel work



Hazard Assessment to consider Principle Hazards:
- Fire (fuelling of plant, electrical risks, fuel types, etc.)
- Roads and Traffic (vehicle checks, rail protection type, direction of travel)
- Air quality (Gas training currency, proof of competence, briefing of actions at alarm levels, calibration tests)
- Electrical/Mechanical/Ventilation/Worker Health
- Emergency response (communication protocols, TARP's, Etc.)

Appendix 3: Kaimai Tunnel Investigation report

Incident Investigation Report

Title: Kaimai Tunnel Incident

Incident date: 25th August 2012

Incident location: Approx. 4Km from Whatakao end portal

Lead Investigator: Mark Taylor, Impac Services

Peer Review: Mike Cosman, Managing Director, Impac Services

Final Report Date: 19th September 2013

impac

Risk & Safety Management Solutions

Contents

Executive Summary

On 25th August 2012, several Kiwi Rail contractors were exposed to elevated levels of carbon monoxide, whilst working in the Kaimai Railway Tunnel. The nature of the work and the inherent conditions made this a hazardous situation similar to that of a confined space. The controls framework in place to protect these workers did not reflect the risks involved and allowed a potentially dangerous situation to develop. This was not a one off event, as various witnesses have commented that gas detectors were regularly going off in the tunnel due to limited air flow and high levels of contaminants.

In any incident there are usually a number of contributory factors and this one is no different. No single factor was more prevalent than another but a lack of planning, contractor management, poor use and control of documentation, ineffective training, insufficient equipment, supervision, communication and human error all played their part to some degree.

It has to be acknowledged that the contractors involved did not take full responsibility for their own health and safety; however these failures need to be seen in the context of KiwiRail's role as the principal and how its systems and processes allowed the contractors to begin work without the necessary people, equipment and process' in place to keep them safe. The recommendations are therefore focussed on KiwiRail's systems as they are the organisation commissioning this report.

We have attempted to make this report as factual as possible, based on the information provided about an event that happened almost a year ago. We believe the majority of the evidence given was open and honest, but cannot say all of it is 100% accurate, due to some conflicting replies and statements that we were unable to reconcile.

In a significant incident such as this, lots of people are fallible and make mistakes which we can all learn from. This report highlights the major causes of the incident and makes some fundamental recommendations, which will hopefully prevent reoccurrence.

Mark Taylor

Mike Cosman

Impac Services Ltd

13th August 2013

1. Recommendations

The following recommendations are based on the findings of the investigation and are aimed at embedding learning from this incident to improve overall safety performance.

1.1. Absent/failed defences

1.1.1. Ensure all contractors are trained, have access to, and wear a suitable gas mask when evacuating a tunnel in an emergency as specified in section 3.1 of the Working in Tunnels and Gas Safety Instructions 'Best Practice Guidelines"

1.1.2. Ensure multiple work groups in the tunnel have sufficient gas monitors so that each crew is able to monitor the atmosphere in the local area where they are working at all times.

1.1.3. Set the alarm points on the gas monitors to go off earlier to give advanced warning to evacuate in long tunnels.

1.1.4. Measure oxygen levels as well as CO and NO2.

1.1.5. If possible use a heavy duty battery pack to supply the grinders and auxiliary lighting. Section 3.2 of the Working in Tunnels and Gas Safety Instructions 'Best Practice Guidelines", states elimination is the best form of control.

1.1.6. If 1.1.5 is not possible, use a 20 KVA diesel powered generator and 100m of cable, so that fumes can be kept clear of the worksite. Ensure all internal combustion engines have scrubbers or catalytic converters fitted.

1.1.7. Ensure that there are sufficient number and capacity of fans to extract or blow the fumes and dust away from the working area.

1.1.8. Ensure post incident drug and alcohol testing of all parties is undertaken.

1.2. Organisational factors

1.2.1. Prestart and annual health checks to be carried prior to workers working in tunnels. This is specified in section 9 of the Working in Tunnels and Gas Safety Instructions 'Best Practice Guidelines"

1.2.2. Develop a system to ensure all contractors complete the contractor induction, tunnel awareness and refresher training before being allowed to enter the tunnel.

1.2.3. Ensure that a Site Specific Job and Evacuation Plan is written for each operation and reviewed daily before commencement of any work. Although tunnels don't necessarily come under the definition of a confined space, all the same elements exist, so we recommend that AS 2865:2009 is followed and a permit to work issued and authorised for any work in long tunnels.

1.2.4. Working in Tunnel and Gas Awareness training has been improved, but some of the wording in the new learner workbook needs reviewing such as:

- Page 19 (last paragraph). "If you are working on the infrastructure in a tunnel, there is **usually** one set of monitors for each work group". Replace the word usually with **must**.
- We recommend that only one occupational exposure standard is included in the learner workbook (50ppm over 60 minutes), which is identical to the secondary alarm point on the gas monitor, to avoid confusion.

1.2.5. Ensure there are clear procedures and timelines for reporting and investigating incidents (including near misses) based on the likelihood and severity of the incident. All major incident investigation teams should include an independent person[1]

1.2.6. Include Pre Hospital Emergency Care first aid training (to enable oxygen to be administered) as one of the requirements in the tunnel emergency response plan.

1.2.7. Ensure all similar work high risk work is either supervised by a Kiwi Rail employee or can be delegated to a main contractor who has all the prerequisite qualifications, training and experience.

[1] Outside the particular business unit or external to KiwiRail

2. Incident details

Date: 25.8.2012.

Time: 8.51am

Business Unit: Kiwi Rail

Site: Kaimai Rail Tunnel

Location of incident: Approx 4km from Whatakao portal

Personnel injured/affected: Abernethy Civil Limited & Concrete Solutions Ltd employees

Other persons involved: Graham Broome – Kiwi Rail Employee

Responsible Manager: Peter Dix.

Date investigated: 24th June to 29th July 2013

Incident summary: 13th August 2013

3. Incident description

3.1. Background

On 25th August 2012 a working party consisting of five Abernethy and five Concrete Solutions workers were contracted to carry out repairs to a section of concrete pad in the Kaimai Tunnel. The damaged sections of the pad had been caused by the oscillating/vibrating effect of the track as locomotives passed over it on a regular basis. The track had previously been supported by a rubber/cork pad, which had deteriorated over time and had been removed allowing the track to sit directly on the concrete.

The repair involved removing a section of the track to allow cracks to be either filled or ground out using angle grinders and filled using a two pack grouting agent. This work had been done previously on several occasions by the contractors under similar conditions and with the same plant and materials.

3.2. Pre-Incident Information

All of the Abernethy workers had completed a Tunnel and Gas Awareness course prior to the work being undertaken, but none of the Concrete Solutions had attended this course and only two employees had completed the Contractor Induction.

The training itself was not conducted in conjunction with an approved document and there were a number of anomalies as follows:

- The initial training was carried out using a PowerPoint which read “Tunnel and Gas Awareness – Revalidation 2011 to 2013”.
- The document reads “A 15 minute exposure that applies to any 15 minute period during the working day no more than 4 times”. The maximum STEL (short term exposure limit) is only for a 15 minute period and the Workplace Exposure Standards make no reference to the number of times a person may enter at or above this level. This could have been potentially confusing to the workers carrying out the work.

3.3. The incident

07.00am - The work commenced with a safety briefing (see appendix doc1) and the workers then gathered their materials and plant onto the Hi Rail Vehicle before entering the tunnel.

The safety briefing failed to identify many of the hazards associated with the work such as silica dust, gas emissions, slips and trips, use of electrical machinery and abrasive wheels, lighting requirements, ventilation, communication methods, emergency details and medical care.

Insufficient PPE was specified, such as the use of gas masks for evacuation, respirators for grinding and hearing protection when using loud equipment.

Please note: No Site Specific Safety Plan or Evacuation Plan was completed for the job on the day or prior to the work being undertaken. This should have been undertaken, as it is specified in the KiwiRail general procedures.

It was reported that a loco had entered the tunnel not long before the commencement of the works, but no actual time was established. There appear to be no rules on the specific time required for the tunnel to self purge before a work party can enter.

07.54 A calibration test was undertaken on both the Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) Gas Detectors. This was supposed to be done outside the portal at the Whatakao end, but the initial detector report indicated a reading of 2ppm, so this may be due to the after effects of the loco smoke or perhaps the test was done some way inside the tunnel.

Inside the tunnel the Abernethy workers removed a section of the rail and laid it at the side of the track for the Concrete Solution employees to commence repairing the concrete pad (see appendix doc 2 for a sketch of the works).

At 08.06am the carbon monoxide (CO) gas detector alarm went off. This was probably due to the start-up of the diesel generators and quickly returned to normal when the fans were switched on. The gas monitors are designed to first activate when the levels exceed the time weighted average (TWA). This is a level of 25ppm for carbon monoxide and 3ppm for Nitrogen Dioxide (NO2). The first alarm was deactivated and the workers continued with their work.

Upon commencement of this part of the work the Abernethy crew left the tunnel to commence some housekeeping work outside the Whatakao portal end. This crew was told to revisit the worksite every hour as no effective radio communication was available in the tunnel. No safety watch was posted outside the tunnel and no records were kept of who was inside at any particular time. This crew was not issued with a second set of gas monitors to measure for CO and NO2 during re-entry.

Because the rail clamps were left in situ, this reduced the amount of room for grinding the concrete pad and the grinder shrouds had to be removed to facilitate this. The removal of the shrouds and subsequent extraction created plumes of dust, which should have been controlled by the portable fan.

At 08.54 the CO Gas detector secondary alarm went off. Instead of evacuating the Person in Charge (PIC) tried to relocate the fan to divert the dust and fumes away from the worksite, but to no avail.

The second alarm triggers when the STEL of 50ppm is exceeded.

Thereafter the CO gas detector secondary alarm went off on numerous occasions, until the crews decided to evacuate the tunnel. The exact time of the evacuation could not be established, but was delayed due to equipment and gear having to be removed from the front of the Hi-Rail vehicle before departure. This is something a site specific evacuation plan should have covered, but one wasn't written for the job.

During the evacuation it is reported that the Abernethy employees wore the KiwiRail gas masks but the Concrete Solutions staff only wore their dust respirators, which would have provided no protection against CO.

An evacuation was not possible upwind through the Whakatao portal because the Abernethy crew had already left to do the auxiliary works outside the tunnel. The evacuation therefore involved driving through the fumes for some distance, until the group exited the tunnel at the Hemopo end.

Once outside the tunnel the Kiwi Rail Area Manager was notified and workers gathered around outside the portal to recover. The crew outside the Whatakao end were also notified and told to await further instructions.

Approximately one and a half hours after exiting the tunnel two workers, a Kiwi Rail worker and the PIC re-entered the tunnel to take gas readings to see if it was safe to remove the remaining gear and replace the track so that trains could pass through the tunnel.

Due to conflicting reports, we are unable to confirm if they were told to re-enter by the Area Manager or if they went in off their own accord.

Also, we are unable to determine if the personnel wore/carried gas masks during re-entry.

On the first occasion the gas levels were too high so they exited the tunnel to fresh air. On the second occasion the levels were reported as acceptable, below the TWA and STEL, so a decision was made to re-enter and re-install the track. This was carried out by the PIC and two of the Concrete Solutions staff and the Abernethy crew who re-entered from the Whakatao portal end. The gas monitors were running continuously, so there wasn't any further fresh air recalibration prior to re-entry.

Approximately two hours after the incident the Area Manager arrived onsite to carry out an investigation and deal with the three Concrete Solutions workers, who had been exposed the most to the fumes. They complained of having headaches, feeling dizzy and nauseous.

The three Concrete Solutions employees were taken to Waharoa, where they were given drinks and food to allow additional recovery time.

Due to the absence of any medical input or assessment at the time, the significance of the symptoms reported in terms of possible harmful effects cannot be ascertained. As far as we are aware no long term damage has occurred.

3.4. Post-incident

When the track had been reinstated all the Concrete Solutions workers were sent home whilst the Abernethy crew remained onsite to finish some other work outside the tunnel for the remainder of the day.

The worksite was re-opened that day to allow trains to recommence using the tunnel. No evidence in the form of photographs or sketches was gathered from the worksite, so the information for this report has been gathered from one-to-one interviews with the personnel involved.

No post incident drug or alcohol testing was carried out for contractors. It was not established if Abernathy or Concrete Solution knew to do this at the time of the incident.

In addition to this report an accident investigation was completed by Abernethy Civil and Concrete Solutions. This was appended to the original KiwiRail report completed by the Area Manager.

4. Analysis

4.1. Absent or failed defences

Code	Absent/ failed	Sub-category	Description
DF1 Awareness	Failed	Gas Emissions	All personnel heard the alarms but failed to react quickly enough to the potential danger
DF2 Detection	Failed	Gas Detection.	Only one set of gas monitors was issued to the two work groups.
DF3 Control and Interim Recovery	Failed	Respiratory Protection.	Several workers were untrained in use of RPE and therefore not competent to commence work. The respiratory equipment was correct for the grinding work and dust, but not suitable for evacuating in a gas emergency. The training documentation was uncontrolled and insufficient. Procedures were inadequate for the work being undertaken. No Job Safety Plan was written and communicated for the task.
DF4 Protection and Containment	Failed	Extraction Ventilation.	The fans were not powerful enough to force the fumes away from the work site. No extraction could be used because the grinder shrouds had been removed to allow access for grinding between the clamps. This probably led to the CO gas being suspended in the dust particles, which could have been breathed in through the respirators, which were not suitable for gas. The generator was quite small and therefore low in power, which led to it being sited near to the grinding process. This resulted in the fumes being concentrated nearer to the working area. In addition, the generator and grinders were not fitted

			with scrubbers or catalytic converters as specified in section 3.2 of the Working in Tunnels and Gas Safety Instructions 'Best Practice Guidelines"
DF5 Escape and Rescue	Failed	Systems.	No Site Specific Safety or Emergency Plan was written or communicated to the workers
		Vehicles and Equipment	The second Hi Rail vehicle was not available for emergency evacuation, due to part of the original group leaving the tunnel. Evacuation plans should specify taking the shortest path to fresh air Area control was not notified of the incident when it happen and there was no communication between the two parties inside and outside the tunnel. No Standby person was appointed outside the tunnel. Gas Masks were not used by all people during the evacuation. Workers were not given access to medical advice when exposed to high CO levels and allowed to drive home

4.2. Individual/team actions

Error/Violation	Error/Violation type	Description
Failure to wear PPE	Routine Violation	Some workers didn't use suitable gas masks for the evacuation.
Failure to evacuate	Routine Violation	Workers failed to immediately evacuate when secondary alarm sounded continuously
Failure to offer medical assistance	Routine Violation	No medical assessment offered to all people affected
Failure to complete safety documentation.	Routine Violation	PIC didn't complete and communicate a site specific safety plan for the works

4.3. Task/environmental conditions

4.3.1. Human factors

Human factors	Promotes error, violation or both	Description
Lack of collaboration	Error	PIC failed to ensure the work groups operated as a team. Both groups were quite new to each other and therefore weren't that familiar with each company's working style.

4.3.2. Workplace factors

Workplace factors	Promotes error, violation or both	Description
Insufficient Extraction/Ventilation	Error	The extraction fan wasn't powerful enough for the operation. There was no extraction fitted to the angle grinders to control concrete dust emissions
Insufficient gas monitoring equipment	Error	Only one set of gas monitors was issued and used.
Insufficient communication equipment	Error	There was no method for staying in contact with the different working parties whilst in the tunnel

4.4. Organisational factors

Code	Org. factor	Root cause	Description
HW	Hardware	YES	Insufficient extraction, gas monitoring, PPE
TR	Training	YES	Training wasn't undertaken for several workers and the guidance material wasn't controlled through the use of an effective document management system. No control to ensure only trained workers were allowed in the tunnel
OR	Organisation	YES	A lack of planning for the operation was made worse by multiple work groups being separated for long periods without effective communication

			channels.
CO	Communication	YES	Communication methods were inadequate considering the noise generated from the grinding operation, which would have made it difficult to hear the gas monitor alarms sounding. No communication method had been established for an emergency evacuation
IG	Incompatible goals	NO	We couldn't find any information that led us to believe there was an issue with the insufficient time or budget (costs) associated with the operation.
MC	Mgmt of change	YES	There was no clear procedure for what to do in an emergency situation. Who would sound the alarm, call the emergency services, treat injured people etc? Several of the Kiwi Rail procedures don't have a reference number or date, and therefore no way of telling if a document was current at the time.
PR	Procedures	YES	No Job Safety & Evacuation Plan was written and communicated. No means of ensuring this is done prior to work starting if no KR supervision
MM	Maintenance mgmt	NO	This could not be established for the equipment used. However, the company had no formal procedure or programme for plant or equipment maintenance tests.
RM	Risk mgmt	YES	Not all hazards were identified or controlled
DE	Design	YES	Air flow not monitored to calculate min purge rate required by the extractor fans.
CM	Contractor mgmt	YES	The contractor approval process wasn't fully adhered to when reviewing Abernethy's initial documentation. Abernethy had no formalised plant maintenance procedures, No system to ensure safety inductions are provided for new and existing employees and no formal procedure for communicating safety information to its employees on a regular basis. In addition, at the time of the incident, Abernathy had an inadequate system for investigating incidents and no drugs and alcohol policy.
OC	Organisational culture	YES	The gas monitor alarms were ignored on several previous occasions indicating a lack of

			understanding of the expected response. This in turn is indicative of a poor safety culture where warnings are not treated seriously
RI	Regulatory influence	NO	Consideration should have been given as to whether the incident was notifiable to MBIE as serious harm – "*Loss of consciousness, or acute illness requiring treatment by a registered medical practitioner, from absorption, inhalation or ingestion of any substance".*[2]
OL	Organisational learning	NO	Click here to enter text.
VM	Vehicle mgmt.	YES	Two Hi Rail vehicles should have been used and permanently available on site, to evacuate up wind in an emergency
MS	Mgmt systems	YES	Several of the Kiwi Rail general procedures didn't tally with the local area documents, possibly making it confusing for some contractors/workers.

[2] Note the incident was reported to NZTA as the rail regulator

4.5. ICAM Model

Organisational Factors	Task / Environmental Conditions	Individual /Team Actions	Absent or Failed Defences	Incident
Insufficient Systems or Procedures Contractor Management/Authority to Work procedure ineffective Training either omitted or uncontrolled	Still day (little natural ventilation) Crew allowed to separate without the necessary controls for each workgroup Poor communication between working groups during the operation and evacuation	No Site Specific Job or Emergency Plan written and communicated Gas monitor alarms ignored Teams possibly re-entered without permission No medical assistance offered to affected workers	Ineffective extraction/ventilation Gas masks unsuitable/not worn during evacuation or re-entry Ineffective rescue (route downwind into the fumes) Drug and alcohol testing not undertaken	Workers exposed to Carbon Monoxide fumes at a concentration exceeding TWA and STEL

5. Appendices

Persons seen

- Peter Dix – KiwiRail
- Graham Broome – KiwiRail
- Phil McQueen – KiwiRail
- Marcus Vize - Abernethy
- Karl Waitapu – Abernethy
- Lynden Bowman – Abernethy
- Ryan Cudby - Concrete Solutions
- Rohan Walsh - Concrete Solutions
- John Wilkinson - Concrete Solutions
- Olenn Ordena – Concrete Solutions
- Emit Thorne - Concrete Solutions
- Curtis Wittington - Concrete Solutions

Documents referenced

Date		Subject
19/11/2012	Memo from Rick Van Barneveld to all Regional/Area Managers and KiwiRail approved Contractors	Management of Working Hours / Competency & Supervision
24/12/2012	IRIS Reporting	
September 2012	Safety Investigation Report	Health & Safety Concerns, Media Coverage – Infrastructure & Engineering & Contractors Hamilton
28/12/2012	Email from Rick Van Barneveld to Phil McQueen	Draft Safety Investigation Report
September 2012	Draft Safety Investigation Report	Health & Safety Concerns, Media Coverage – Infrastructure & Engineering & Contractors Hamilton
28 August 2012	Email from Matt Ballard to Phil McQueen	Investigation of allegations relating to H&S concerns in Hamilton
	Letters from various staff members re above email	
	Police complaint acknowledgement	

	Notes re investigations	
	Train Control Graphs	