

# REPORT

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**To :** Alan Clifford - HSE & Q Manager  
Vector Ltd

**From :** Lani Patchett - Occupational Hygienist

**Date :** Amended report – Issued 25<sup>th</sup> November 2014

**Ref:** LP11-14

**SUBJECT :** Occupational Hygiene Assessment – Penrose Substation

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This report assesses the risk from exposure to hazardous substances for Vector staff and contractors following a fire at Transpowers Penrose Substation on 5<sup>th</sup> October 2014.

The observations for this assessment were made during a visit to the premises by Lani Patchett of Paragon Health and Safety on 6<sup>th</sup> November 2014. Analysis reports of soil samples collected by Tonkin and Taylor were provided by Alan Clifford of Vector.

The purpose of this assessment were to:

- Characterise the exposure pathways to staff and contractors working with the damaged cables.
- Determine the significance of exposures to staff and contractors in relation to occupational health before and after precautions were put in place.
- Enable recommendations to be made to assist Vector in maintaining appropriate health and safety procedures during work with the damaged cables.

## 1. Background

A fire at Transpowers Penrose substation occurred on Sunday 5<sup>th</sup> October 2014 and caused substantial damage to a number of cables. Staff and contractors worked around the clock to repair and reinstate damaged cables. During this initial period (around 1 week) there were reportedly very few precautions taken with regard to minimising exposures to hazardous substances resulting from the fire.

The cables have insulation surrounding them, the composition of which is unknown. They are contained within concrete trenches (approximately 1m wide 2m deep and lengths up to 100m) which have concrete covers. The fire melted and burnt the outer insulation layer resulting in charred residue ash and soot. From a health hazard perspective it is the charred residue ash and soot that is considered to be the main hazard for staff and contractors working with the damaged cables.

Two samples of soil from the trenches that contain the damaged cable were collected by Tonkin and Taylor and sent for analysis of heavy metals, Polycyclic Aromatic Hydrocarbons (PAH's), Polychlorinated Biphenyls (PCB's) and asbestos. The results are attached. Heavy metals and PAH's were detected in the samples; PCB's and asbestos were not detected in the samples.

It is therefore assumed that these substances are likely to be present in the soot and residue ash.

## **2. Process descriptions**

There are a number of operations where staff work/worked in close proximity to the damaged cables and therefore could potentially be exposed to the above hazardous substances. These are briefly described in the table overleaf.

### Other information:

Urine samples were collected from all staff that were potentially exposed to the damaged cables. It was reported that nothing of concern was found.

It was reported that due to the weather the soot in the trenches was slightly damp as was confirmed from the site visit. This will minimise airborne dust.



Operation	Procedure	H&S precautions in place
Period of around 1 week post-fire - repairing and reinstating damaged cables	Cutting cables at Gavin Street end only. No work on fire damaged cables.	Normal PPE
Removing concrete covers from trench <b>Carried out by Northpower Investigation team in attendance</b>	Concrete covers lifted using excavator or hiab. Covers laid with soot side exposed beside trench.	At Gavin Street end normal PPE. Used P2 respirator and then full PPE as work progressed and became aware of risks.
Removing cable samples from trenches Continuation with repairing and reinstating damaged cables <b>Carried out by Northpower Some of investigation team inside trench inspecting cables</b>	Samples of the fire damaged cable are cut using hydraulic cutters. The sample is placed inside a duct pipe and capped. Sample is taken to designated storage area ready for cleaning.	All staff working in and around the trenches containing the damaged cable were provided with PPE. When working inside trench, full PPE was worn including overalls, boots, gloves and full face P3 negative pressure respirator. Make-shift 'decontamination' area was set up – outer layer removed, bagged and disposed off. When working at top of trench, P2 respirator worn. Damaged trenches covered in plywood and polythene.
Inspection of samples in separate building <b>Investigation team and Northpower jointers</b>	Removal of samples from ducts, cleaning and inspecting damage.	All staff inspecting samples wore full PPE. Includes coveralls, boots, gloves and full face P3 respirators (as above).
Cleaning cable samples from trench in preparation for transport to UK <b>Carried out by Morecroft</b>	Three designated areas have been established: storage, dirty and clean. The dirty and clean areas are separated using a temporary polythene wall. Samples from the trench are stored in the storage area. Samples are removed and cleaned using rags, bristle brushes and scrapers inside the 'dirty' area. Once clean they are passed through to the clean area and stored inside duct pipes for transport to the UK.	All staff cleaning the cable samples are provided with full PPE. Includes coveralls, boots, gloves and full face P3 respirators (as above).
Removing damaged cable from trench and cleaning trench <b>To be carried out by Morecroft</b>	Not started	



### 3. Results of analysis

Asbestos was not detected in the trench samples; PCB's were not detected in the trench samples.

Heavy metals were detected in Trench sample 1; PAH's were detected in Trench samples 1 and 2.

#### PAH's

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. There are more than 100 different PAHs. PAHs generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds. PAHs usually occur naturally, but they can be manufactured as individual compounds for research purposes; however, not as the mixtures found in combustion products. They are found throughout the environment in the air, water, and soil. They can occur in the air, either attached to dust particles or as solids in soil or sediment. The greatest sources of exposure to PAHs for most of the general population are active or passive inhalation of the compounds in tobacco smoke, wood smoke, and contaminated air, and ingestion of the compounds in foodstuffs. The general population may also be exposed to PAHs in drinking water and through skin contact with soot and tars.

The National Institute for Occupational Safety and Health (NIOSH) concluded that occupational exposure to coal products can increase the risk of lung and skin cancer in workers. NIOSH established a recommended occupational exposure limit, timeweighted average (REL-TWA) for coal tar products of 0.1 milligram of PAHs per cubic meter of air (0.1 mg/m<sup>3</sup>) for a 10-hour workday, within a 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends an occupational exposure limit for coal tar products of 0.2 mg/m<sup>3</sup> for an 8-hour workday, within a 40-hour workweek. The Occupational Safety and Health Administration (OSHA) has established a legally enforceable limit of 0.2 mg/m<sup>3</sup> averaged over an 8-hour exposure period

PAHs or their breakdown products can be measured in urine, blood, or body tissues

#### Heavy metals

Lead can be absorbed into the body by inhalation and by ingestion. The substance may have effects on the blood, bone marrow, central nervous system, peripheral nervous system and kidneys, resulting in anaemia, encephalopathy (e.g., convulsions), peripheral nerve disease, abdominal cramps and kidney impairment. Causes toxicity to human reproduction or development. This substance is a suspected human carcinogen.

Absorption of arsenic is largely dependent on the solubility and particle size. Concentrations of arsenic or its metabolites in blood, hair, nails and urine may be used as biomarkers of arsenic exposure. Since the elimination of arsenic takes place mainly via the kidneys, the concentration of arsenic in the urine is a good indication of recent exposure to inorganic arsenic.

*Health effects of acute exposure:-* Single doses of inorganic arsenic may be highly toxic by ingestion and inhalation. Both ingestion and inhalation may cause gastrointestinal effects such as nausea,



diarrhoea and abdominal pain. Multi-organ failure may occur in severe cases following ingestion. Inorganic arsenic is irritant to the eye and skin.

*Health effects of chronic exposure:-* Following chronic ingestion a range of non-specific symptoms of the respiratory tract, CNS, endocrine system, liver, kidneys or gastrointestinal system may occur. Chronic inhalation of arsenic may cause irritation of the mucous membranes leading to conjunctivitis, pharyngitis and rhinitis. Inorganic arsenic compounds have mutagenic potential. Inorganic arsenic is a known human carcinogen.

#### 4. Routes of Exposure

The likely exposures would originate from the residue ash and soot. This being the case the exposures can be characterised as follows:

- Skin contact with residue ash and soot (which can lead to ingestion)
- Inhalation of residue ash and soot carrying heavy metals and PAH's.

##### 4.1 Inhalation exposures

In order to interpret the metals and PAH results and understand their significance they must be converted to an airborne concentration, since in the scenario under consideration, inhalation, is considered to be a potential route of exposure.

The following table shows the additional data used in the calculations:-

General dust WES 8hr TWA mg/m <sup>3</sup>	10
50% of WES 8hr TWA mg/m <sup>3</sup>	5
Volume of air breathed in a working day m <sup>3</sup>	10

WES = New Zealand Workplace Exposure Standards

Volume of air breathed in an 8 hour working shift generally taken as 10m<sup>3</sup>

	1	2	3		4		5		6		7	8
	mg/kg	mg/mg	Assume Dust Concentration of 5 mg/m <sup>3</sup>		Assume Dust Concentration of 10 mg/m <sup>3</sup>						WES 8hr mg/m <sup>3</sup>	Daily intake @ WES 8hr exposure mg
			total mg breathed	% daily WES intake	total mg breathed	% daily WES intake						
Arsenic	196	0.00020	0.01	2	0.020	4					0.050	0.5
Cadmium	2.2	0.000002	0.0001	0.1	0.0002	0.2					0.010	0.10
Chromium	73	0.00007	0.0035	0.07	0.007	0.14					0.500	5
Copper	3,800	0.0038	0.19	1.9	0.38	3.8					1.000	10
Lead	8,600	0.0086	0.43	43	0.86	86					0.100	1
Nickel	7	0.000007	0.0035	0.035	0.007	0.07					1.000	10
Zinc	11,800	0.011	0.55	0.55	1.1	1.1					10.000	100
Total PAH's (trench 2)	2757	0.0028	0.14	7	0.28	14					0.2 (US ACGIH)	2



1. Step 1 is to take the analysis results (*column 1*) and convert them to the number of mg of metal per mg of sample dust (*column 2*)
2. Step 2 makes the assumption that the concentration of dust in the air is at 50% of the WES for general dust (5 mg/m<sup>3</sup>). At this concentration there would be a “perceptible” amount of dust in the atmosphere.
3. Step 3 uses the average amount of air breathed in an 8 hour working shift (10m<sup>3</sup>) and calculates the amount of metal breathed in if there were 5 mg/m<sup>3</sup> dust in the air for 8 hours i.e. for arsenic 10m<sup>3</sup> x 5mg/m<sup>3</sup> x 0.0002mg = 0.01mg (*column 3*)
4. Step 4 calculates the amount of metal breathed in over an 8 hour period if the air concentration of the metal were at its WES i.e for arsenic 0.05mg/m<sup>3</sup> (*column 7*) x 10m<sup>3</sup> with the result of 0.5mg (*column 8*) . The rationale here is that, at and below the WES it is expected that most people will not experience any adverse health effects.
5. Step 5 compares the amount of metal breathed in at a nominal 5mg/m<sup>3</sup> of dust (*column 3*) with that breathed in if the airborne metal concentration was at the WES (*column 8*) and shows that as a percentage of the amount breathed in at the WES (*column 4*).
6. The steps are repeated for the individual metals and at two Workplace Exposure Standards concentrations (5mg/m<sup>3</sup> and 10mg/m<sup>3</sup>). The 10mg/m<sup>3</sup> WES (*columns 5 & 6*) has been chosen as a dust concentration such as this would be seen as a dense fog which people would find difficult to tolerate without some form of respiratory protection, except for brief periods.

Based upon the results and calculations it is unlikely that Workplace Exposure Standards for the individual metals and PAH's (total) would be exceeded and hence adverse health effects would not be expected.

#### 4.2 Skin contact/Ingestion exposures

It is reasonable to predict that under some circumstances oral ingestion could occur through poor hygiene practices. While there are no occupational standards set out for skin contact and ingestion, it is helpful to compare the concentrations found in the soil against the oral Rfd (reference dose) where established for some of the toxic substances found. A RfD is an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive sub-populations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. It is important to note that they represent intake for a lifetime. They are not so precise that they cannot be exceeded for short periods of time. Short term exposure exceeding the RfD is not a cause of concern provided the individuals intake over time does not appreciably exceed the level set. The large uncertainty factors generally involved in establishing RfD serve to provide assurance that exposures for short periods are unlikely to have any deleterious effects on human health.



Substance detected in soil sample and amount detected	Oral reference dose (RfD)*	Oral reference dose for 80 kg man	Amount of contaminated soil/soot that would need to be ingested to exceed RfD
Arsenic (196 mg/kg)	0.0003 mg/kg/day	0.024 mg/day	0.1 g/day
Benzo(a)pyrene (42 mg/kg)	7.3 mg/kg/day (cancer potency)	584 mg/day	13,000 g/day
Napthalene (1140 mg/kg)	0.004 mg/kg/day	0.32 mg/day	0.3 g/day
Pyrene (168 mg/kg)	0.03 mg/kg/day	2.4 mg/day	14 g/day

\*Source: MfE Guidelines for the Assessment and Management of Petroleum Hydrocarbon Contaminated Sites in New Zealand - Appendix 4L - Toxicity Assessment

## 5. Conclusions of risk to health

Based upon the information supplied to us and observations made the following conclusions are made:

There is a low risk to short or long term health from inhalation of contaminated residue ash and soot during repairing and reinstating damaged cables in the week following the fire.

There is a low risk to short or long term health from ingestion of contaminated residue ash and soot during repairing and reinstating damaged cables in the week following the fire.

There is a very low risk to short or long term health from inhalation of contaminated residue ash and soot during cable sample collection and cleaning of cable samples.

There is a very low risk to short or long term health from ingestion of contaminated residue ash and soot during cable sample collection and cleaning of cable samples.

### Rationale for conclusion on risk to health

The above conclusions are based on the information made available to us and the following:

1. The dampness of the soot in the trenches means that significant amounts of airborne dust would be unlikely. Also the methods used for taking a cable sample and cleaning the samples would not generate significant levels of airborne dust. Even if airborne dust was created, the results and calculations indicate it is unlikely that Workplace Exposure Standards for the individual metals and PAH's would be exceeded and hence adverse health effects would not be expected.
2. The oral reference doses are based on lifetime exposures so even if some staff inadvertently ingested some of the contaminated soot and ash through poor personal hygiene the



unprotected exposure time was relatively short (<1week) and hence long term adverse health effects would not be expected.

3. The use of personal protective equipment during sample collection and sample cleaning was appropriate and would further reduce exposures.
4. Urine samples collected showed nothing of concern.

## 6. Recommendations

1. Going forward, unless significant levels of airborne dust are being generated, respiratory protective equipment is unlikely to be necessary from a health perspective. Alternatively a P1 disposable mask would be appropriate. If worn correctly this respirator provides a protection factor of 10 which is more than adequate for the tasks being carried out. The level of protection provided by a P3 respirator is not necessary.
2. Measures should be taken to avoid raising significant dust clouds, e.g. damping down with light mist of water spray. This will be important when Morecroft are cleaning out the trenches.
3. Skin contact with the contaminated soot is likely to be a significant route of exposure which can lead to ingestion. Lead for example can be easily absorbed through ingestion. **A high standard of personal hygiene is very important** to minimise the risk of exposure through accidental ingestion (hand to mouth). Hands must be thoroughly washed before eating, drinking and smoking. Gloves and overalls as currently worn are appropriate. It would also be appropriate to take measures that avoid clothing becoming soaked in the liquid that results from the dampened dust. Suitable risk assessments should be made to address this issue.

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This independent assessment report has been prepared by Paragon Health & Safety Ltd for Vector. The report reflects the position concerning exposures to hazardous substances arising from work with damaged cables following a fire at the Penrose Substation.

This report is issued under the authority of



Authorised electronic signature

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Lani Patchett  
Occupational Hygienist  
25<sup>th</sup> November 2014

Peer Reviewed by Ian Bartlett.



Authorised electronic signature

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Ian Bartlett. BSc. DipOH. CMFOH.  
Chartered Occupational Hygienist  
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**ANALYSIS REPORT** Page 1 of 3

<b>Client:</b> Tonkin & Taylor	<b>Lab No:</b> 1337917	SPv2
<b>Contact:</b> J Scarrow	<b>Date Registered:</b> 11-Oct-2014	
C/- Tonkin & Taylor	<b>Date Reported:</b> 20-Oct-2014	
PO Box 5271	<b>Quote No:</b>	
AUCKLAND 1141	<b>Order No:</b>	
	<b>Client Reference:</b> 29752.2041	
	<b>Submitted By:</b> J Scarrow	

Sample Type: Soil						
Sample Name:	Trench 1 10-Oct-2014	Trench 2 10-Oct-2014				
Lab Number:	1337917.1	1337917.2				
Individual Tests						
Dry Matter	g/100g as rcvd	49	55	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	196	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	2.2	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	73	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	3,800	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	6,600	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	7	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	11,800	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening In Soil						
Acenaphthene	mg/kg dry wt	15.1	39	-	-	-
Acenaphthylene	mg/kg dry wt	134	340	-	-	-
Anthracene	mg/kg dry wt	95	123	-	-	-
Benzo[a]anthracene	mg/kg dry wt	43	60	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	27	42	-	-	-
Benzo[b]fluoranthene + Benzo[k]fluoranthene	mg/kg dry wt	36	50	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	18.8	34	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	11.8	15	-	-	-
Chrysene	mg/kg dry wt	41	56	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	2.4	< 5	-	-	-
Fluoranthene	mg/kg dry wt	120	129	-	-	-
Fluorene	mg/kg dry wt	66	122	-	-	-
Indeno[1,2,3-c,d]pyrene	mg/kg dry wt	16.3	29	-	-	-
Naphthalene	mg/kg dry wt	490	1,140	-	-	-
Phenanthrene	mg/kg dry wt	440	410	-	-	-
Pyrene	mg/kg dry wt	154	168	-	-	-
Polychlorinated Biphenyls Screening In Soil						
PCB-18	mg/kg dry wt	< 0.10	-	-	-	-
PCB-28	mg/kg dry wt	< 0.10	-	-	-	-
PCB-31	mg/kg dry wt	< 0.10	-	-	-	-
PCB-44	mg/kg dry wt	< 0.10	-	-	-	-
PCB-49	mg/kg dry wt	< 0.10	-	-	-	-
PCB-52	mg/kg dry wt	< 0.10	-	-	-	-
PCB-60	mg/kg dry wt	< 0.10	-	-	-	-
PCB-77	mg/kg dry wt	< 0.10	-	-	-	-
PCB-81	mg/kg dry wt	< 0.10	-	-	-	-



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.  
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked \*, which are not accredited.



Sample Type: Soil						
Sample Name:		Trench 1 10-Oct-2014	Trench 2 10-Oct-2014			
Lab Number:		1337917.1	1337917.2			
Polychlorinated Biphenyls Screening in Soil						
PCB-86	mg/kg dry wt	< 0.10	-	-	-	-
PCB-101	mg/kg dry wt	< 0.10	-	-	-	-
PCB-105	mg/kg dry wt	< 0.10	-	-	-	-
PCB-110	mg/kg dry wt	< 0.10	-	-	-	-
PCB-114	mg/kg dry wt	< 0.10	-	-	-	-
PCB-118	mg/kg dry wt	< 0.10	-	-	-	-
PCB-121	mg/kg dry wt	< 0.10	-	-	-	-
PCB-123	mg/kg dry wt	< 0.10	-	-	-	-
PCB-126	mg/kg dry wt	< 0.10	-	-	-	-
PCB-128	mg/kg dry wt	< 0.10	-	-	-	-
PCB-138	mg/kg dry wt	< 0.10	-	-	-	-
PCB-141	mg/kg dry wt	< 0.10	-	-	-	-
PCB-149	mg/kg dry wt	< 0.10	-	-	-	-
PCB-151	mg/kg dry wt	< 0.10	-	-	-	-
PCB-153	mg/kg dry wt	< 0.10	-	-	-	-
PCB-156	mg/kg dry wt	< 0.10	-	-	-	-
PCB-157	mg/kg dry wt	< 0.10	-	-	-	-
PCB-159	mg/kg dry wt	< 0.10	-	-	-	-
PCB-167	mg/kg dry wt	< 0.10	-	-	-	-
PCB-169	mg/kg dry wt	< 0.10	-	-	-	-
PCB-170	mg/kg dry wt	< 0.10	-	-	-	-
PCB-180	mg/kg dry wt	< 0.10	-	-	-	-
PCB-189	mg/kg dry wt	< 0.10	-	-	-	-
PCB-194	mg/kg dry wt	< 0.10	-	-	-	-
PCB-206	mg/kg dry wt	< 0.10	-	-	-	-
PCB-209	mg/kg dry wt	< 0.10	-	-	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 4	-	-	-	-

## SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil			
Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	1
Polycyclic Aromatic Hydrocarbons Screening In Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample. [KBIs:5786,2805,2695]	0.010 - 0.05 mg/kg dry wt	1-2
Polychlorinated Biphenyls Screening In Soil	Sonication extraction, SPE cleanup, GC-MS analysis. Tested on dried sample	0.005 - 0.2 mg/kg dry wt	1
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1

