ACIL ALLEN CONSULTING

DRAFT REPORT TO
NZ MINISTRY FOR THE ENVIRONMENT

OCTOBER 2013

BROMINATED FLAME RETARDANT RESEARCH

COST-BENEFIT ANALYSIS OF SORTING OPTIONS FOR E-WASTE PLASTICS

ACIL ALLEN CONSULTING PTY LTD
ABN 68 102 652 148

LEVEL FIFTEEN
127 CREEK STREET
BRISBANE QLD 4000
AUSTRALIA
T+61 7 3009 8700
F+61 7 3009 8799

LEVEL TWO
33 AINSLIE PLACE
CANBERRA ACT 2600
AUSTRALIA
T+61 2 6103 8200
F+61 2 6103 8233

LEVEL NINE
60 COLLINS STREET
MELBOURNE VIC 3000
AUSTRALIA
T+61 3 8650 6000
F+61 3 9654 6363

LEVEL ONE
50 PITT STREET
SYDNEY NSW 2000
AUSTRALIA
T+61 2 8272 5100
F+61 2 9247 2455

SUITE C2 CENTA BUILDING
118 RAILWAY STREET
WEST PERTH WA 6005
AUSTRALIA
T+61 8 9449 9600
F+61 8 9322 3955

ACILALLEN.COM.AU

CONTENTS

List of figures

List of tables

1 Introduction

ACIL Allen has been commissioned by the New Zealand Ministry for the Environment (the Ministry) to undertake a cost-benefit analysis of sorting options for Waste Electrical and Electronic Equipment (WEEE) being recycled in New Zealand that potentially contain brominated flame retardants (BFRs).

This cost-benefit analysis is part of a broader project led by ENVIRON Australia Pty Ltd and supported by Geo & Hydro – K8 Ltd to investigate the practicalities of identifying, sorting and segregating plastics in the New Zealand e-waste recycling industry, according to those components that contain BFR chemicals listed under the Stockholm Convention on Persistent Organic Pollutants (POPs), and those that are not.

1.1 Background and context

Polybrominated diphenyl ethers (PBDEs), a subset group of BFRs, have been used globally since the late 1970s for their flame-retarding properties and have been applied as an additive to a range of products including electrical and electronic equipment (EEE), furniture upholstery, automobile interiors, mattresses, carpet underlay and other items that are required to be flame retardant.

In May 2009, nine new POPs were added to the Stockholm Convention's annexes, including certain congeners contained in commercial pentabromodiphenyl ether (c-pentaBDE) and commercial octabromodiphenyl ether (c-octaBDE) and together referred to as POP-BDEs.

Based on recent studies, the Ministry believes that the most likely source of POP-BDEs in electronic products in New Zealand are those manufactured before the mid-2000s. But without affordable identification and sorting capabilities, recyclers have been forced to send plastic components of suspect e-waste to Class A landfill, on the assumption that they contain POP-BDEs and thereby eliminating their downstream recycling value, or they have been stockpiling the plastics awaiting a recycling solution.

Prior to this cost-benefit analysis, a Pilot Study of e-waste plastic scanning and sorting for BFRs using a hand-held scanner was undertaken by ENVIRON Australia Pty Ltd (and supported by Geo & Hydro – K8 Ltd) at three major e-waste recycling companies with facilities throughout New Zealand: SIMS Recycling Solutions, RCN Group and RemarkIT Solutions.

Site visits were conducted at these facilities, involving observations and WEEE article measurement on the factory floor, using a handheld X-Ray Fluorescence (XRF) analyser optimised for bromine detection.

A further round of testing was carried out through destructive laboratory analysis for the specific PBDEs and tetrabromobisphenol A (TBBPA) , plus qualitative scans for two other BFRs commonly used as replacements for the PBDEs, decabromodiphenyl ethane (DBDPE) and 1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPE). This was conducted on 15 plastic samples representative of the range of WEEE items that tested as high in bromine by XRF.

The Pilot Study resulted in the development of a series of risk-based decision tables for identifying WEEE items that have a high probability of BFR and/or POP-BDE contamination.

This cost-benefit analysis compares different sorting options for waste that potentially contains BFRs (particularly POP-BDEs) against disposal of these wastes to Class A landfills in New Zealand.

1.2 Report structure

This report is organised as follows:

- Chapter 2 describes the options shortlisted for the cost-benefit analysis
- Chapter 3 analyses the benefits and costs of the shortlisted options
- Chapter 4 compares the costs and benefits of the shortlisted options and identifies the preferred option.

2 Options development

Based on the results of the Pilot Study conducted by ENVIRON Australia Pty Ltd and Geo & Hydro – K8 Ltd, four scanning, sorting and segregation options were identified that could in theory be implemented in the New Zealand recycling industry.

A fifth option, Handheld Scanning BFR and Laboratory Testing, was not investigated any further, due to impracticalities of very high cost, scale and time delays associated with laboratory testing.

2.1 Shortlisted options

The four shortlisted options are described below.

2.1.1 Status Quo – no scanning, sorting or segregating of BFR/ non-BFR plastics; disposal of all candidate plastics to landfill

The base case describes what currently occurs in New Zealand, based on the Ministry's guidelines (http://www.mfe.govt.nz/publications/waste/bromide-flame-retardant-waste/html/index.html). This takes a conservative approach – in the absence of sorting by BFR/ non-BFR type plastics (which is the current practice), it is assumed that items older than 2008 models, particularly CRT TVs, will contain POP-BDEs and therefore Class A landfilling is required.

2.1.2 Visual BFR - visual inspection based on risk matrix, sort and segregate for high-risk BFR-containing components

Using the "ready reckoner" approach involving risk-based decision tables for each major category of WEEE (see Section 2.2), decisions about whether to recycle plastics from a particular article or not are made simply by visual identification of the type of the article, in some cases augmented by its likely manufacturing date.

This option uses the decision table guidance for the presence of any BFRs - not just POP-BDEs - in the event that the Ministry's preference was to use a more stringent approach to ensure compliance with the Imports and Exports (Restrictions) Prohibition Order (No 2) 2004 and the Stockholm Convention itself.

2.1.3 Visual POP-BDE – visual inspection based on risk matrix, sort and segregate for high-risk POP-BDE-containing components

Using the "ready reckoner" approach involving risk-based decision tables for each major category of WEEE, decisions about whether to recycle plastics from a particular article or not are made simply by visual identification of the type of the article, in some cases augmented by its likely manufacturing date.

This option uses the decision table guidance for the presence of POP-BDEs, to manage compliance with the Imports and Exports (Restrictions) Prohibition Order (No 2) 2004 and the Stockholm Convention itself.

2.1.4 Handheld Scanning BFR – handheld XRF scan, sort and segregate for high-risk BFR-containing components

This option requires the on-site use of one or more XRF handheld scanners to physically measure at-risk items to determine the presence of BFRs, as a means of scanning, sorting and segregating into BFR and non-BFR plastic categories, with only non-BFR components processed for further recycling.

2.2 Risk matrices for visual identification

Risk-based tables were developed by ENVIRON Australia for assisting workers in the e-recycling facilities to visually determine which WEEE items are likely to contain BFRs and/or POP-BDEs.

2.2.1 Televisions

The risk-based decision table for managing TVs encountered in the New Zealand WEEE recycling market is presented in Table 1.

TABLE 1 **TVS DECISION TABLE**

WEEE Category	TVs*						
Equipment Type	CRT**					LCD	
Date of manufacture	European manufactured pre-1990***	Pre-2000		Post-2000		-	-
Plastic component	All	rim	back cover	rim	back cover	rim	back cover
BFR free[1]?	N	Y	N	N	N	N	N
PBDE free[2]?	N	Y	N	Y	Y	N	N
POP-BDE free[3]?	N	Y	Y	Y	Y	Y	Y
Class A landfill?	Y	N	N	N	N	N	N
Currently OK to recycle (Stockholm compliant)?	N	Y	Y	Y	Y	Y	Y
Likely to be OK to recycle in future[4]?	N	Y	N	Y	Y	N	N
Requires a Basel permit?	Y	N	Y	Y	Y	Y	Y

Notes:
* Plasmas not included due to low plastic content - bodies almost always metal
** includes rear projection TVs
*** Applies to CRT TVs manufactured both before 1990 AND in Europe only
[1] - likely to be <0.1% BFRs
[2] - likely to be <0.1% PBDEs (includes c-penta, c-octa and c-deca mixtures)
[3] - likely to be <0.1% POP-BDEs (includes c-penta and c-octa)
[4] - In the event that decaBDE is added to the Stockholm Convention in the future
Legend: Y = Yes, N = No
ORANGE: likely but further sampling is recommended.

SOURCE: ENVIRON AUSTRALIA,

2.2.2 Copiers and printers

The risk-based decision table for managing copiers and computer printers encountered in the New Zealand WEEE recycling market is presented in Table 2.

TABLE 2 **COPIERS/PRINTERS DECISION TABLE**

WEEE Category	Copiers/ Printers/faxes		
Equipment Type	**Business Machine (large)**	**Home use machines (small)**	**Toner cartridges**
Date of manufacture	**Post-2005***	**-**	-
BFR free[1]?	N	N	Y**
PBDE free[2]?	Y	Y	Y
POP-BDE free[3]?	Y	Y	Y
Class A landfill?	N	N	N
Currently OK to recycle (Stockholm compliant)?	Y	Y	Y
Likely to be OK to recycle in the future[4]?	Y	Y	Y
Requires a Basel permit?	Y	Y	N

Notes:
* - no items pre-2005 tested. Assume pre-2005 equipment >0.1% POP-BDE in the absence of other data
** - One out of approx. 20 toner cartridges was found to be >0.1% Br, which was confirmed by laboratory analysis to be DBDPE.
[1] - likely to be <0.1% BFRs
[2] - likely to be <0.1% PBDEs (includes c-penta, c-octa and c-deca mixtures)
[3] - likely to be <0.1% POP-BDEs (includes c-penta and c-octa)
[4] - In the event that decaBDE is added to the Stockholm Convention in the future
Legend: Y = Yes, N = No

SOURCE: ENVIRON AUSTRALIA,

2.2.3 Computers and peripherals

The risk-based decision table for managing computers and peripherals (excluding printers and monitors) encountered in the New Zealand WEEE recycling market is presented in Table 3.

TABLE 3 **COMPUTERS AND PERIPHERALS DECISION TABLE**

WEEE Category	Computers & peripherals							
Equipment Type	CRT Monitors	LCD Monitors	Desktop computers*	Computer internal drives**, fans etc.		Laptops	Keyboards/ mice	Modems
Date of manufacture				Pre 2005	Post 2005			
BFR free[1]?	N	Y	Y**	N	N	Y	Y	Y
PBDE free[2]?	N	Y	Y**	N	N	Y	Y	Y
POP-BDE free[3]?	N	Y	Y**	N	Y	Y	Y	Y
Class A landfill?	Y	N	N	Y	N	N	N	N
Currently OK to recycle (Stockholm compliant)?	N	Y	Y**	N	Y	Y	Y	Y
Likely to be OK to recycle in future[4]?	N	Y	Y**	N	N	Y	Y	Y
Requires a Basel permit?	Y	N	N	Y	Y	N	N	N

Notes:

* - Only one Apple desktop computer found. This included plastic components high in BFRs

** - CD, DVD & floppy drives in one test item (2001) found to contain high BFR, while remaining plastic components in item BFR free. Drives should be separated.

[1] - likely to be <0.1% BFRs

[2] - likely to be <0.1% PBDEs (includes c-penta, c-octa and c-deca mixtures)

[3] - likely to be <0.1% POP-BDEs (includes c-penta and c-octa)

[4] - In the event that decaBDE is added to the Stockholm Convention in the future

Legend: Y = Yes, N = No

ORANGE: likely but further sampling is recommended.

SOURCE: ENVIRON AUSTRALIA,

2.2.4 Refrigerators

The risk-based decision table for managing refrigerators encountered in the New Zealand WEEE recycling market is presented in Table 4.

TABLE 4 **REFRIGERATORS DECISION TABLE**

WEEE Category	Refrigerators	
Equipment Type	**Plastic skin**	**Electrical cover (small)***
BFR free[1]?	Y	N
PBDE free[2]?	Y	Y
POP-BDE free[3]?	Y	Y
Class A landfill?	N	N
Currently OK to recycle (Stockholm compliant)?	Y	Y
Likely to be OK to recycle in future?	Y	Y
Requires a Basel permit?	N	Y

Notes:

* - Small (~10x20cm) piece on back of item used to cover electrical wiring. Should be removed and separated from remaining fridge plastics

[1] - likely to be <0.1% BFRs

[2] - likely to be <0.1% PBDEs (includes c-penta, c-octa and c-deca mixtures)

[3] - likely to be <0.1% POP-BDEs (includes c-penta and c-octa)

Legend: Y = Yes, N = No

SOURCE: ENVIRON AUSTRALIA,

2.2.5 Implications of risk-based decision tables

Extrapolation of the recommendations from the above risk-based decision tables (which were derived from the findings of the Pilot Study) on annual volume data supplied by the recyclers participating in the Pilot Study suggests the following:

- All categories of WEEE items are likely to be POP-BDE free except for the plastics from computer monitor casings, of which 90 per cent are likely to be POP-BDE free
- Computers and peripherals (other than internal drives and fans, monitors and printers) are likely to be BFR free, while 90 per cent of computer monitors are likely to be BFR free, 54 per cent of TVs are likely to be BFR free, 5 per cent of printers/copiers are likely to be BFR free and 99 per cent of white ware are likely to be BFR free.

The annual weight of WEEE plastics that are currently handled by the three major recyclers in New Zealand participating in the Pilot Study is estimated to be: Computers – 122,268 kg; Monitors – 47,515 kg; TVs – 174,992 kg; Printers/copiers – 210,594 kg, White ware – 151,200 kg; and Other computer peripherals – 6,400 kg.

3 Benefits and costs of shortlisted options

3.1 Qualitative overview of potential benefits of shortlisted options

3.1.1 Visual BFR options

The benefit of the Visual BFR option, compared with the Visual POP-BDE option, is that it would give the Ministry greater certainty that current and future domestic and international obligations regarding BFRs will be met.

3.1.2 Visual POP-BDE option

As POP-BDEs are a subset of BFRs, the Visual POP-BDE option would enable more items to be recovered and recycled than the Visual BFR option.

3.1.3 Handheld Scanning BRF option

Compared with the Visual BFR and Visual POP-BDE options, the Handheld Scanning BFR option would give the Ministry additional comfort that no BFR-containing items will slip through and that no non-BFR items will be inadvertently prevented from being recycled.

3.2 Quantification of potential benefits of shortlisted options

Based on the risk-based decision tables shown previously in Section 2.2, the weight of WEEE plastics that can be recycled each year by the three major recyclers in New Zealand participating in the Pilot Study under the shortlisted options are:

- Status Quo: 555,478 kg recycled (with 157,493 kg of plastics from CRT TVs landfilled or stockpiled)
- Visual BFR: 369,899 kg recycled (with 343,072 kg of plastics from *some* TVs, computer monitors and other peripherals, and white ware and *all* printers and copiers landfilled)
- Visual POP-BDE: 708,219 kg (with 4,752 kg of plastics from CRT monitors landfilled)
- Handheld Scanning BFR: 369,899 kg recycled (with 343,072 kg of plastics from *some* TVs, computer monitors and other peripherals, and white ware and *all* printers and copiers landfilled).

The weight of WEEE plastics that can be recycled under each option is shown in Table 5.

TABLE 5 **WEIGHT OF WEEE PLASTICS RECYCLED ANNUALLY, BY OPTION**

	Weight of WEEE recycled (kg)	Weight of plastic in WEEE recycled (kg)	Weight of plastic recycled under Status Quo (kg)	Weight of plastic recycled under Visual BFR option (kg)	Weight of plastic recycled under Visual POP-BDE option (kg)	Weight of plastic recycled under Handheld Scanning BFR option (kg)
Desktop computers	205,677	86,384	86,384	86,384	86,384	86,384
Computer servers	35,970	15,107	15,107	15,107	15,107	15,107
Laptop computers	49,470	20,777	20,777	20,777	20,777	20,777
Monitors	158,384	47,515	47,515	42,764	42,764	42,764
TVs	833,296	174,992	17,499	38,248	174,992	38,248
Printers/copiers	501,415	210,594	210,594	10,530	210,594	10,530
White ware	360,000	151,200	151,200	149,688	151,200	149,688
Other computer peripherals	8,000	6,400	6,400	6,400	6,400	6,400
Total	**2,152,212**	**712,971**	**555,478**	**369,899**	**708,219**	**369,899**

SOURCE: ENVIRON AUSTRALIA

The value of plastic that can be recycled under the Status Quo and the Visual POP-BDE options is assumed to be $0.80 per kg, based on information provided by one of the recyclers in the Pilot Study. This consists of 40 cents per kg for the recycled plastic and 40 per cents per kg in avoided landfilling cost. Based on a 2011 study by Toxics Link in India, it is assumed that there is a 10 per cent price premium for BFR-free plastic. The value of plastic that can be recycled under the Visual BFR and Handheld Scanning BFR options is therefore assumed to be $0.84 per kg.

Under these assumptions, the value of WEEE plastics that can be recycled in New Zealand each year under the shortlisted options are estimated to be:

- Status Quo: $444,382
- Visual BFR: $301,715
- Visual POP-BDE: $566,575
- Handheld Scanning BFR: $301,715.

The incremental value of recycled WEEE plastics under the Visual BFR, Visual POP-BDE and Handheld Scanning BFR options relative to the Status Quo (Base Case) is therefore estimated to be:

- Visual BFR: -$133,667
- Visual POP-BDE: $122,193
- Handheld Scanning BFR: -$133,667.

3.3 Costs of shortlisted options

3.3.1 Status Quo, Visual BFR and Visual POP-BDE options

The operational costs of the Status Quo, Visual BFR and Visual POP-BDE options are assumed to be identical. This is because a quick visual inspection of all recycled items is required under all three options. In the case of the Status Quo, a visual inspection of each TV is required to determine if it is likely to have been manufactured prior to 2008.

However, it is assumed that the Visual BFR and Visual POP-BDE options will require a Quality Assurance (QA) testing regime to ensure adherence to the decision tables during the sorting process. It is assumed that tests would be conducted every six months, with a rolling testing program across each of the major recycling facilities in turn or with samples taken from a number of recyclers and analysed collectively. Each test is assumed to cost $10,000.

The incremental costs of the Visual BFR and Visual POP-BDE options are therefore $20,000 per annum.

3.3.2 Handheld Scanning BFR option

The assumptions pertaining to the capital and maintenance costs of handheld XRF scanners that underpin the costing of the Handheld Scanning BFR option and their sources are shown in Table 6.

TABLE 6 **COSTING ASSUMPTIONS AND SOURCES REGARDING THE CAPITAL AND MAINTENANCE COSTS OF HANDHELD XRF SCANNERS**

Assumption	Assumed value	Source / notes
Cost of a handheld XRF scanner	$57,600 (USD 40,000 – 50,000)	UNEP, 2010. "Draft Technical Review of the Implications of Recycling Commercial Pentabromodiphenyl Ether and Octabromodiphenyl Ether", Table 5
Useful life of a handheld XRF scanner	2 years	Geo & Hydro – K8 Ltd
Annual cost of running and maintaining scanner	$333	Geo & Hydro – K8 Ltd
Number of XRF scanners required	4	Geo & Hydro – K8 Ltd

SOURCE: VARIOUS,

The human resource assumptions that underpin the costing of the Handheld Scanning BFR option and their sources are shown in Table 7.

TABLE 7 **HUMAN RESOURCE ASSUMPTIONS AND SOURCES UNDERPINNING COSTING OF HANDHELD SCANNING BFR OPTION**

Assumption	Assumed value	Source / notes
Training and accreditation		
Duration of XRF training	3 days	Geo & Hydro – K8 Ltd
Cost of XRF training per employee	$10,000	Geo & Hydro – K8 Ltd
Annual cost of XRF accreditation per employee	$800	Geo & Hydro – K8 Ltd $300 licence fee plus site visit to audit internal handbook and safety procedures every 4 years ($2,000 per visit)
Operations		
Time taken to test an item by XRF scanning	5 minutes	ENVIRON Australia Pilot Study
Annual salary of employees performing XRF scanning	$50,000	ACIL Allen estimate
Annual salary of existing employees	$34,500	Major recyclers in New Zealand
On-costs to employers as proportion of salaries	25 per cent	ACIL Allen estimate
Annual hours worked per worker	1,740	OECD statistics (2012)[1]
Number of employees operating the scanners	8	2 per recycling facility with XRF scanners
Average tenure of employees operating scanners	5 years	ACIL Allen estimate

SOURCE: VARIOUS,

The annual costs of the Handheld Scanning BFR option, calculated under the above assumptions, are shown in Table 8.

TABLE 8 **ANNUAL COSTS ASSOCIATED WITH HANDHELD SCANNING BFR OPTION**

Cost item	Estimated cost
Capital cost of handheld XRF scanners	$115,200
XRF training and accreditation costs	$22,400
Operational labour costs	$232,893
Total incremental costs relative to Status Quo	**$370,493**

SOURCE: VARIOUS

[1] http://stats.oecd.org/Index.aspx?DatasetCode=ANHRS, accessed on 3 September 2013

3.4 Net quantified benefits of shortlisted options

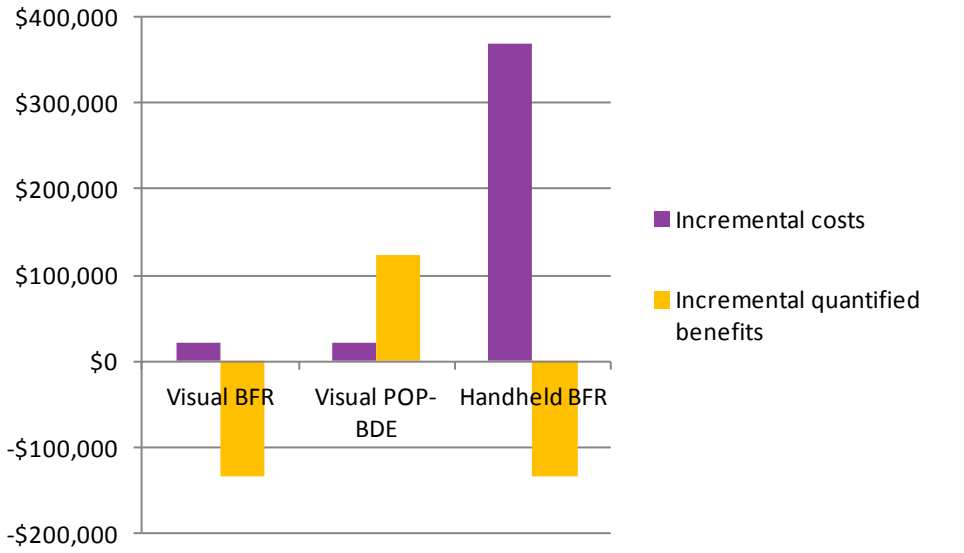
Combining the incremental value of recycled WEEE plastics under the Visual BFR, Visual POP-BDE and Handheld Scanning BFR options relative to the Status Quo shown in Section 3.2 and the incremental costs of the options shown in Section 3.3, the incremental net quantified benefits of the three options (relative to the Status Quo) are estimated to be:

- Visual BFR: -$153,667 per annum
- Visual POP-BDE: $102,193 per annum
- Handheld Scanning BFR: -$504,160 per annum.

The annual net quantified benefit of the Visual POP-BDE option is thus $255,800 higher than that of the Visual BFR option and $606,353 higher than that of the Handheld Scanning BFR option.

The annual incremental costs and incremental quantified benefits of the three options (relative to the Status Quo) are shown in Figure 1.

FIGURE 1 **INCREMENTAL COSTS AND QUANTIFIED BENEFITS OF VISUAL BFR, VISUAL POP-BDE AND HANDHELD SCANNING BFR OPTIONS**



SOURCE: ACIL ALLEN

3.5 Sensitivity analysis

If the useful life of a handheld XRF scanner is assumed to be three years instead of two years, the incremental net quantified benefit of the Handheld Scanning BFR option (relative to the Status Quo) increases from -$504,160 per annum to -$465,760 per annum.

If the average time taken to XRF test an item increases from 5 minutes to 10 minutes, the incremental net quantified benefit of the Handheld Scanning BFR option (relative to the Status Quo) decreases from -$504,160 per annum to -$737,054 per annum.

4 Conclusion

4.1 Impracticality and high cost of the Handheld Scanning BFR option

In addition to the very high cost of the Handheld Scanning BFR option, there is a lack of sufficiently compelling benefits as well as operational and practical complexities that calls into questions its feasibility.

In the context of a recycling facility, this option is an impractical and potentially unreliable way to balance proper management of environmental hazard with a facility's goal of maximising legal recycling of plastics.

While a handheld XRF scanner is highly reliable for bromine detection, the combination of operator skills and its inability to distinguish between POP-BDEs and other more acceptable BFR alternatives means that the use of XRF screening as a surrogate for POP-BDE plastic separation would result in large numbers of false positives.

The X-rays emitted by a handheld XRF scanner penetrate to 5-10mm of depth of the sample, so erroneous readings often result when other bromine sources are nearby, such as printed circuit boards or cooling fans underneath equipment casings. An experienced XRF scanner operator who is cognisant of these risks would conduct measurements with the scanner angled to the plastic surface, or finely locating the device on the edge of an item. However, even an experienced operator could make mistakes from time to time – the difference between an accurate and spurious result can be 1000-fold.

Other practical issues associated with the Handheld BFE option are discussed in Section 6.4.1 of the ENVIRON Australia Pilot Study report, *Brominated Flame Retardant Research: A Pilot Study of E-waste Plastic Sorting in New Zealand*.

The advantage of the Handheld Scanning BFR option is that it could potentially give the Ministry additional comfort that no BFR-containing items will slip through and that no non-BFR items will be inadvertently prevented from being recycled.

However, while a little under half of the items tested in the Pilot Study were BFR-free (and therefore POP-BDE free), no POP-BDEs were found in any of the 15 high BFR samples selected to best represent those samples likely to contain POP-BDEs. Therefore, the Pilot Study data indicate a low likelihood of the presence of POP-BDEs above the RoHS limit of 0.1 per cent across all of the WEEE category plastics observed (TVs, copiers/ printers, computers and peripherals and fridges).

This means that handheld XRF scanning is unlikely to confer much advantage in terms of identifying items containing POP-BDEs that would otherwise have slipped through the system under the Visual POP-BDE option.

4.2 Weighing the costs and benefits of the Visual BFR and Visual POP-BDE options

The costs of the Visual BFR and Visual POP-BDE options are similar but the Visual POP-BDE option would enable more items to be recovered and recycled. The net

benefit of the Visual POP-BDE option is therefore much higher than that of the Visual BFR option, from the recyclers' perspective.

However, the Visual BFR option would give the Ministry greater certainty that current and future domestic and international obligations regarding BFRs will be met. ACIL Allen believes that it is unlikely this will translate into a significant premium on the price that recyclers in New Zealand will receive for their WEEE plastics, as the recommended QA testing regime should give their customers sufficient confidence that the plastics will be POP-BDE free under the Visual POP-BDE option.

According to ACIL Allen's modelling, the annual net quantified benefit of the Visual POP-BDE option is $255,860 higher than that of the Visual BFR option. Therefore, the Visual POP-BDE option would be the preferred option unless the Ministry deems the greater certainty that current and future domestic and international obligations regarding BFRs would be met under the Visual BFR option to be worth more than $255,860 per annum.

It should be noted that the risk-based decision tables developed by ENVIRON Australia allow the Ministry to adopt the Visual POP-BDE option now and switch to the Visual BFR option in the future as New Zealand's international obligations regarding BFR become progressively clarified.

5 References

ENVIRON Australia, 2013. *Brominated Flame Retardant Research: A Pilot Study of E-waste Plastic Sorting in New Zealand*, August.

OECD. StatExtracts, http://stats.oecd.org/Index.aspx?DatasetCode=ANHRS, accessed on 3 September 2013.

Toxics Link, 2011. Brominated *Flame Retardants Spreading the Fire: A Report on the Recycling of Brominated Flame Retardant Contaminated Plastic*.

UNEP, 2010. *Draft Technical Review of the Implications of Recycling Commercial Pentabromodiphenyl Ether and Octabromodiphenyl Ether*.

ACIL ALLEN CONSULTING PTY LTD
ABN 68 102 652 148

LEVEL FIFTEEN
127 CREEK STREET
BRISBANE QLD 4000
AUSTRALIA
T+61 7 3009 8700
F+61 7 3009 8799

LEVEL TWO
33 AINSLIE PLACE
CANBERRA ACT 2600
AUSTRALIA
T+61 2 6103 8200
F+61 2 6103 8233

LEVEL NINE
60 COLLINS STREET
MELBOURNE VIC 3000
AUSTRALIA
T+61 3 8650 6000
F+61 3 9654 6363

LEVEL ONE
50 PITT STREET
SYDNEY NSW 2000
AUSTRALIA
T+61 2 8272 5100
F+61 2 9247 2455

SUITE C2 CENTA BUILDING
118 RAILWAY STREET
WEST PERTH WA 6005
AUSTRALIA
T+61 8 9449 9600
F+61 8 9322 3955

ACILALLEN.COM.AU