Developing Sustainability Opportunities for the Vancouver Police Department: Uniform Disposal

Alisa Koebel, Greenest City Scholar 2016, VPD

3585 Graveley Street, Vancouver, BC, V5K 5J5

This report was produced as part of the Greenest City Scholars (GCS) Program, a partnership between the City of Vancouver and The University of British Columbia, in support of the Greenest City Action Plan.

This GCS project was conducted under the mentorship of City staff. The opinions and recommendations in this report, and any errors, are those of the author, and do not necessarily reflect the views of the City of Vancouver or The University of British Columbia.

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ACKNOWLEDGEMENTS

I would like to express my gratitude to the Greenest City Scholar program and coordinators Jennifer Wahl, Katie Dolling, and Karen Taylor, for providing this challenging and enriching opportunity. Great thanks also go to my mentor, Kimberly Jang, who provided invaluable support of all kinds throughout the project.

Kimberly Jang, Senior Budget Analyst, Financial Services Section, VPD
Dawna Marshall-Cope, Senior Director of Information Services, VPD
The Code Green Committee, VPD
Jennifer Wahl, Sustainability Specialist, Sustainability Group, City of Vancouver
Katie Dolling, Program Manager, UBC Sustainability Initiative
Karen Taylor, Program Manager, UBC Sustainability Initiative
Barbara Corcione, Police Stores Unit, VPD
Richard Kwai, Stores Worker, Police Stores Unit, VPD
Kelly Kim, Stores Keeper, Police Stores Unit, VPD
Ian Wightman, Manager, Property and Evidence Control Section, VPD
Justin Hull, Acting Supervisor, Property and Evidence Control Section, VPD
Pam Derrett, Property Office Clerk, Property and Evidence Control Section, VPD
Jim Lloyd, Consultant, Financial Services Section, VPD
Henrietta Sia, Accounting Clerk, Financial Services Section, VPD
Bruno Ambrosi, Operations Supervisor, VPD
Dr. Jennie Gill, Strategic Research and Policy Advisor, VPD
Laurel Kennedy, Communications Coordinator, Community & Public Affairs, VPD
June Yamamoto, Executive Assistant to Dawna Marshall-Cope, VPD
Krystie Babalos, Sustainability Planner, Sustainability Group, City of Vancouver
Sergeant Alvin Shum, Community Policing Services Unit, VPD
Staff Sergeant Lee Patterson, Planning, Research & Audit Section, VPD
Constable Cliff Louie, District 4, Team 9, VPD
Christa Brown, Greenest City Scholar 2014, VPD
Karen Franklin, Abbotsford Police Department
Mountain Equipment Co-Op
Pete Scott, Sales/Operations Manager, *de*·brand Services Inc.
Anthony Shackleton, Trans-Continental Textile Recycling
Patrick Jordan, Creative Embroidery
…And everyone else who supported my work and pointed me towards resources, thank you.

Executive Summary

The VPD currently generates approximately 7000 kg of police uniform waste annually. This report explores available methods for disposing of decommissioned uniforms and evaluates them for security, environmental impact, and cost-effectiveness. The project promotes the City of Vancouver's Greenest City Action Plan zero waste goals (City of Vancouver, 2015a, p. 27), and advances the VPD's Code Green initiatives (Vancouver Police Department, 2012, p. 26).

Currently, all decommissioned uniforms are disposed of at the Covanta waste-to-energy incineration facility in Burnaby at a cost of $250 per tonne. This process results in electricity, ash, air pollution, and greenhouse gas emissions. However, incineration wastes more energy than it generates, because it captures only a fraction of the energy used to manufacture the item and because more energy is needed to create a replacement good. The scientific literature shows mixed results as to whether incineration saves or emits greenhouse gases on net compared to landfilling.

Recycling is preferable over both incineration and landfill because the energy used to manufacture the goods is not wasted, and recycled goods displace some of the demand for new, "virgin" materials. This reduces energy use, pollution, and land use impacts. Neither donation nor "upcycling" are feasible on a large scale due to security concerns and low demand.

Key Recommendations

An ideal uniform disposal solution would separate the waste streams and divert them towards their optimal end-of-life destinations. Donation is the best option from an environmental perspective, but is only available for a minority of decommissioned uniforms. Recycling through shredding is the best option for processing the majority of uniform waste, but is more expensive than incineration.

Reducing the amount of uniform waste generated would result in significant cost savings, both in the cost of disposal and the cost of purchasing replacements. A simple change in process would be to expand VPD Stores' re-use program to facilitate and encourage higher rates of recirculation of wearable uniforms. This could be implemented quickly and with minimal expense.

When reuse is no longer viable, the following summarizes the primary and secondary recommendations for each component of the uniform.

- Footwear and plainclothes in good condition should continue to be provided to the Jail or, if there is excess, donated.
- Shred highly identifiable components such as shirts and jackets.
- Shred reflective vests and body armour due to legal requirements and security concerns.
- Donate trousers[1], and shred any surplus.
- Incinerate pouches and belts in order to keep down the costs of shredding the higher-value components.
- Incinerate any material suspected of contamination.

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[1] The president of Firefighters Without Borders Canada, Bob Dubbert, has expressed conditional interest in receiving excess trousers for their beneficiaries.

The components that should be shredded can be processed by two companies that specialize in this industry: *de*·brand and Trans-Continental Textile Recycling (TCTR). Both are able to shred textile material so that it is neither wearable nor recognizable as police issue.

- *de*·brand: $2454 per tonne
- TCTR: $1158 per tonne (offset by $0.10 per pound that can be sold as clothing abroad)

There may be opportunities to decrease costs in both cases. Collaborating with other agencies may allow for a volume discount. Removal of flashes prior to shredding could also reduce costs by allowing the companies to use more efficient technology and removing the need to witness destruction. Flash removal could be performed by Community Policing volunteers. Sergeant Alvin Shum has expressed his support for this initiative.

If both shredding options are too costly, incineration is the next-best alternative for shirts, jackets, reflective vests, and body armour that need to be destroyed. For pieces that cannot be donated and do not require secure destruction, incineration or landfill are both acceptable options because the relative impacts of the two are unclear.

By separating uniform waste at Stores and diverting each stream towards the optimal processing method, both environmental impacts and financial costs can be minimized. Paired with measures to reduce the creation of waste, and to repurpose ostensible "waste" as a resource, these changes will contribute to the VPD's position as a leader in law enforcement sustainability.

Table of Contents

Introduction

The Vancouver Police Department (VPD) disposes of roughly 7000 kg of decommissioned uniforms annually. Pursuant to Vancouver's Greenest City zero waste and green operations goals, the VPD is continuously seeking ways to be more environmentally responsible; for that reason, the current year's business plan includes the strategic goal of finding a sustainable and secure method for uniform disposal. The need for secure disposal arises because many police uniform components bear flashes (patches bearing the VPD crest), other insignia, the word "Police", or characteristic design elements such as epaulets that can lead to misuse and unlawful impersonation of a police officer.

True sustainability includes environmental, social, and economic dimensions. For policing, an additional and overriding concern is securing disposal of the uniform to prevent misuse, and the VPD is determined to adopt the most environmentally friendly alternative that meets that requirement. Any plan must be cost-neutral or incur minimal costs so that it can be maintained over the long term.

This report details the VPD's current practice, the research question, guiding policy context, methodology, and major findings. It assesses the impacts of the current approach based on a thorough literature review, and compares four alternative waste management options: donation, recycling, upcycling, and landfill. Finally, these findings form the basis for the recommendations and possible future opportunities.

The Goal & Guiding Principles

In 2014, Greenest City Scholar Christa Brown mapped the waste streams originating from the VPD Property Office and examined sustainable and secure alternatives to the current practice of incinerating evidence, seized property, and other materials. Her report identified decommissioned uniforms as a separate but connected waste stream not under the immediate jurisdiction of the Property Office (Brown C. , 2014, p. 17). This report focuses on the uniform waste disposal stream. The primary research question for this report can be phrased as a modification of the 2014 research question: what alternative methods to incineration exist for disposing of decommissioned uniforms that align with the Greenest City Action Plan Zero Waste goal; are operationally feasible; and ensure that safety, security, and privacy are maintained?

For the purposes of this report, a "uniform" is anything worn on the body and includes shirts, trousers, jackets, belts, boots, pouches, and body armour which are the primary elements sent for incineration. Uniform hats are excluded because none were present in the waste audit.

In keeping with the City of Vancouver's Greenest City Action Plan goals, an ideal and truly zero-waste solution would divert all waste away from both the landfill and the incinerator. The need to prevent misuse of uniforms and financial limitations may make this impossible or impractical. Any solution should at least reduce greenhouse gas (GHG) emissions and pollutants to the greatest extent possible.

This project is guided primarily by the City of Vancouver's (CoV) Greenest City Action Plan in support of the goals of Green Operations and Zero Waste. Table 1 summarizes the relevant policies at all levels of governance; the policy goals are set out in more detail in Appendix A.

Table 1: Key Policies and Goals

Level of Governance	Policy	Goal Supported by Project
Vancouver Police Department	Code Green Action Plan	Manage resources in an environmentally sustainable manner Be a law enforcement leader in environmental sustainability[2]
City of Vancouver	Greenest City Action Plan	Green Operations: divert 90% of waste from landfill (non-public-facing facilities)
		Zero Waste: reduce amount of solid waste going to landfill or incinerator by 50% from 2008 levels by 2050
		Clean Air: meet or beat the most stringent air quality guidelines for ozone, particulate matter, NO_2, and SO_2
	Renewable City Strategy	Derive 100% of Vancouver's energy from renewable sources by 2050 Reduce GHG emissions by 80% below 2007 levels by 2050
Metro Vancouver	Integrated Solid Waste and Resource Management Plan (ISWRMP)	Conserve and develop natural capital, economic capital, and social capital
Plan by Canadian Council of Ministers of the Environment; implementation by Province of British Columbia	Extended Producer Responsibility (EPR); governed by the *BC Environmental Management Act* and the associated *Recycling Regulation*.	Establish an EPR program for textiles in BC by 2017

It is significant to note that the zero waste goals set out in the Greenest City Action Plan consider incineration to be an undesirable waste management method to be limited where possible, along with landfilling (City of Vancouver, 2015a, p. 27).

In order to structure and rank efforts to achieve this vision, the City of Vancouver in its Integrated Solid Waste and Resource Management Plan adopts a 5-R hierarchy (see Table 2), which is meant to inform zero waste objectives by ranking the desirability of different waste processing and disposal options. While the "5-R" hierarchy of waste management reflected in Table 2 is accepted as a general "rule of thumb", the order of preference varies by context. Therefore, the alternatives for textiles specifically

[2] An updated Code Green Action Plan will be released soon.

must be evaluated, particularly in light of the additional considerations raised by police uniforms. Table 2 also summarizes the working definitions for the purpose of this report.

As the scope of this project focuses on disposal, this report will emphasize the options following "reduce", but will include recommendations for limiting waste.

Table 2: "5-R" Definitions

Working Definitions of the City of Vancouver's 5-R Hierarchy
Reduce waste at source: change consumption so as to generate less waste **Reuse where possible**: use of the item as such (e.g. through donation), or with minimal processing into a higher-value item (upcycling) **Recycle products at the end of their useful life**: processing into lower-value component parts such as rags, pulp, or fiber, which can then be used in the production of a new product **Recover energy or materials from the waste stream**: generating electricity through the incineration of waste and removing recyclable components such as metals **Manage Residuals in an environmentally sound manner**: components of the waste stream that cannot be reused or recycled, or are left over after these processes (such as bottom ash from incineration), are disposed of in landfill

Current Practice

New recruits to the police force are issued a new set of gear, which includes multiple shirts and pants for daily use, as well as jackets and other basics. Some of the more specialized items are not included in this initial outfitting (Barbara Corcione, personal communication, May 10, 2016; Kelly Kim, personal communication, June 7, 2016).

Following this, VPD members are provided with an annual allotment of points, which can be redeemed for replacement uniforms and other equipment at Stores (Barbara Corcione, personal communication, May 10, 2016).

Collection and Re-Use

The VPD has two offices, one on Cambie Street and the other on Graveley Street. The Graveley office contains Stores, where VPD members obtain new uniforms and equipment and can also drop off used uniforms, garments, and other supplies. Members are expected to remove their name and ID number badges, but not the flashes, when dropping off old uniforms (Barbara Corcione, personal communication, May 10, 2016). Uniforms that are returned in good condition due to retirement, reassignment, or a change of clothing size, are available at no cost to any member in need of another uniform component (Barbara Corcione, personal communication, May 10, 2016). This re-use program is well known among the VPD members, and new recruits are made aware of it. The re-usable uniforms and supplies are located beside the fitting rooms in Stores; overall, it is a well-known and popular program (Kelly Kim, personal communication, June 7, 2016).

Members can also drop off used uniforms at the Cambie office, where they are bagged and then delivered to Graveley Stores. However, due to the high volume of waste delivered from the Cambie location, the Stores staff does not sort these (Richard Kwai and Kelly Kim, personal communication, July 18, 2016). Instituting a similar re-use program at the Cambie office would require an investment in space and staffing, as there is no Stores office at that location (Bruno Ambrosi, personal communication, July 25, 2016).

Reasons for Waste

One reason provided for uniform waste, and which disqualifies uniforms for re-use, is wear and tear. Where possible, uniforms are mended and patched at Shirtland, with whom the VPD has a laundering contract (Barbara Corcione, personal communication, May 10, 2016). At VPD and other policing agencies, it is important that officers and their uniforms maintain a clean and professional appearance, so unacceptable damage can include pilling, discoloration, and thinning of fabric as well as more severe, un-mendable damage such as large tears. Discoloration may result from staining, or the disinfectants used to clean biohazardous materials such as blood may leave a faded area or a hole in the weakened fabric. The Velcro patches used to secure body armour can also accelerate wear and thinning (Const. Clifton Louie, personal communication, May 4, 2016). Contamination with biohazardous or other materials is another reason for disposal.

However, during the waste audit and related discussions, it was suggested that the quantity of uniform waste has been increasing, and that this may be due to a new uniform design and member preferences[3]. The VPD changed their uniform supplier in 2013, and the new polyester/cotton blend uniforms are lighter and more comfortable than the older polyester/wool blend (Richard Kwai, personal communication, July 18, 2016). As a result, members may be "upgrading" their uniforms before the end of the previous uniform's useful life[4].

Additionally, the limited size and capacity of the "Used" area means that Stores workers select only the very best items for re-use when sorting through bags of returned goods and discard many more that are in good condition (Kelly Kim, personal communication, July 19, 2016).

Disposal: Covanta Energy

Every 4-8 weeks (Pam Derrett, personal communication, July 21, 2016; Ian Wightman, personal communication, July 21, 2016), a City of Vancouver Sanitation Services vehicle attends the Property Office. After Property Office staff load the truck with seized and abandoned property, the truck is escorted to the Graveley office, where that location's waste, primarily composed of decommissioned uniform pieces, is loaded into the truck. Waste is then taken to the Covanta waste-to-energy (WtE) facility in Burnaby, where it is dumped into a 3-storey deep pit for storage before being incinerated. Covanta charges $250 per tonne of waste disposed at their facility. Incineration results in heat used for electricity production; valuable ferrous and, increasingly, non-ferrous metals are removed from the waste stream and sent away to be recycled into new products (Covanta, 2014d).

A current exception to this practice is the disposal of boots and plainclothes. Officers are provided a list of boots that are acceptable for the uniform; these styles are publicly available and not designed for the

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[3] It was unclear whether the amount of uniform waste has been increasing over a period of months or of years. The change in supplier is more likely to be the primary causal factor if the increase in waste began in 2013/14. If that increase has been accelerating over a period of months, then there are likely additional factors at play.

[4] Significant changes in design that require old styles to be taken out of use are uncommon (Barbara Corcione, personal communication, May 10, 2016); minor changes in design associated with new suppliers or new lines, such as a change in pocket location, do not generally necessitate disposal, and many brands and styles of uniform are in circulation simultaneously (Richard Kwai, personal communication, May 4, 2016). An historical example of disruptive design change was the switch from medium blue to the navy blue currently used; a small number uniforms in the former colour are still being collected. All uniform design and sourcing decisions are handled by the VPD Uniform Committee (Kimberly Jang, personal communication, July 20, 2016).

police (Richard Kwai, personal communication, May 4, 2016). As such, they lack any identifying marks or characteristics and can be donated when in wearable condition. Officers are individually responsible for disposing of both, and in some cases choose to return them to Stores. When used boots are given to Stores, they are sometimes donated to the Vancouver Jail to be provided to inmates upon release. The same is true of plainclothes; if an inmate comes into custody without suitable clothing, they will be provided with used plainclothes at the end of their time in custody (Kelly Kim, personal communication, June 7, 2016).

Methodology

Interviews

Interviews with VPD staff were generally informal. In some cases, a list of questions was prepared prior to the meeting, and an organic conversation developed based on them. In other cases, impromptu conversations yielded insight.

Communications with business were conducted primarily by email, and once by telephone.

Survey

SurveyMonkey was used to develop a questionnaire about police uniform disposal methods, alternatives explored, and the benefits and challenges encountered by other police agencies. The URL was distributed by email to 49 police agencies: 34 in Canada, 5 in the United States, and 9 abroad. Europol distributed the questionnaire to their member states, 2 of whom responded. One of the European responses was deleted because they answered only 2 of 9 questions. 23 agencies responded, resulting in a sample size of n=22; 17 from Canada, 1 from the United States, 1 from Australia, 1 from New Zealand, 1 from continental Europe, and 1 from the United Kingdom. None of the questions were made mandatory, so the response rate varies for each question.

The questionnaire was not intended to be descriptive of general police practice, but was instead intended to elicit ideas for further research and to identify common challenges, so the sample need not be representative. The questionnaire is reproduced in Appendix B.

Literature Review

Scholarly sources were located through the UBC Library online database. News articles, policy documents, business practices, and business opportunities were identified using Google.

Waste Audit

Due to the quantity of waste, it was not possible to sort all of the waste in the time available; instead, a sample was conducted. There were 5 bins filled with a number of bags of waste at the Graveley office. There were an additional 59 bags that had been delivered from the Cambie location; these were not contained in a bin. One-third of the bags in each bin, and one-third of the loose bags, were selected for sorting. The contents of the sampled bags were separated by type, counted, and weighed using the scale provided by Stores. All weight measurements include the plastic bags into which the components were sorted by type.

The report assumes sample representativeness on two levels; first, that the sampled bags were representative of this load of collected waste; and second, that this load is representative of all uniform waste generated by the VPD throughout the year. In order to improve the chances of obtaining a representative sample, the audit was conducted just prior to the waste being sent for incineration.

Findings

Survey Results

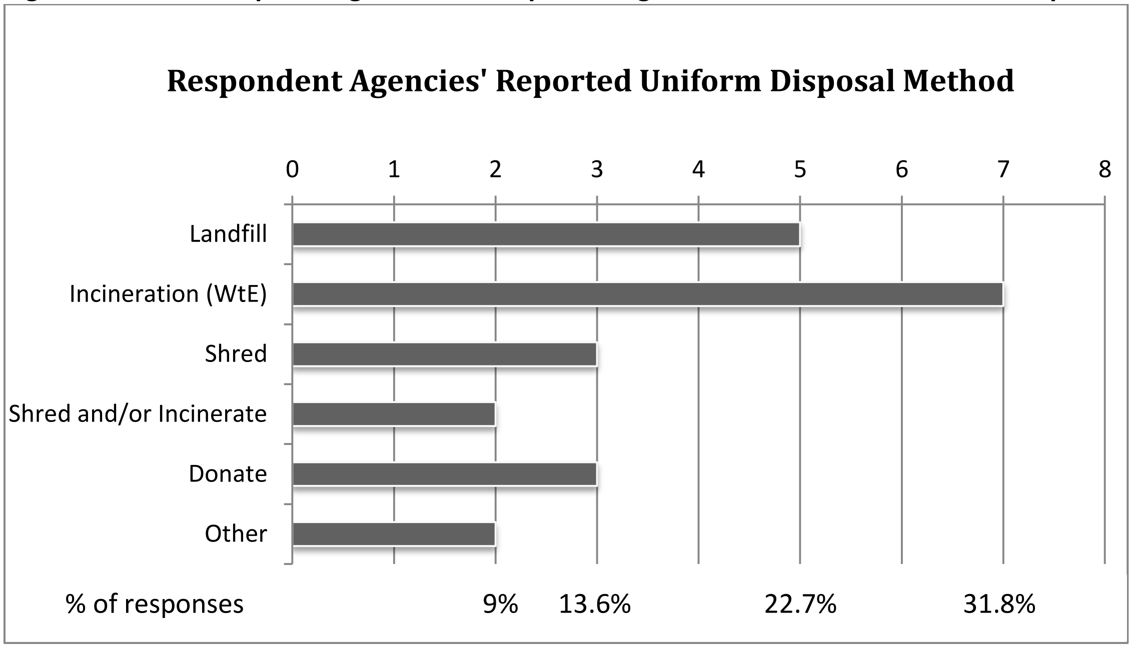
The agencies varied in size and amount of waste generated, and their solutions reflected that diversity. Of the 22 total respondents, 2 reported having changed their disposal method in the last five years. One police services used to incinerate its uniforms, but now donates them to volunteer firefighter cadets. It is unknown how the uniforms are ultimately disposed of following use by the cadets. A police department overseas currently disposes of their uniforms through a secure shredding contract which provides secure transportation and proof of destruction; their former disposal method is also unknown.

Of the 20 agencies who have not recently changed their disposal method, eight incinerate them, six put them in the landfill after some type of destruction or removal of flashes (shredding, cutting up, bulldozing), and two shred them without later incineration. One agency donates them locally at the discretion of the officers, and another removes the flashes and "recycles" them – surrounding language suggests that this "recycling" is really re-use, possibly through donation. Of the agencies who employ incineration, two agencies also utilize the Covanta facility in Burnaby and thereby contribute to electricity generation.

Other agencies make their members responsible for the disposal of uniforms. One small agency requires members to cut up their old uniforms and dispose of them in the garbage. A province-wide agency, because of their wide geographic coverage, requires members to remove all insignia and identification and dispose of it "in an environmentally friendly manner" of their choosing. Three others remove flashes and throw away the rest – it is unclear whether this is an individual responsibility or centralized.

Only three of 21 respondents reported that, in the past five years, they had explored other disposal options. One is looking into collaboration with other services around the province of Ontario. Another reports an intention to improve internal re-use of items such as badges and holsters, and anticipates centralization of uniform disposal across Canada through a third party. The third hopes to work with a local non-profit who will remove flashes and donate clothes to the needy; if this is unsuccessful, they intend to contract with a secure shredding company.

Figure 1: Number of police agencies that report using various methods for uniform disposal



Waste Audit Results

The sample consisted of 568.2 pounds, or 262.3 kg, of waste (one-third of the total). Based on this, the total weight of the disposed uniforms in this period is estimated to be 786.9 kg, or 18.5% of the 4260 kg destroyed. Assuming an average pickup period of 6 weeks results in an estimated annual output of 37,062 kg of waste in total, of which approximately 6846 kg is uniform waste.

Of the 262.3 kg of uniform waste, half was polyester in a textile blend (124.8 kg). There was an additional 16.8 kg of 100% polyester, mostly from Polartec fleece jackets. This is significant because 100% polyester can be fully recycled, separately from textile blends.

Wool and cotton were found in similar amounts, at 30 kg and 29.5 kg respectively. Nearly all of this was found in blends; a negligible amount of 100% cotton was disposed of, in the form of plain grey tee-shirts (0.09 kg). 6 kg of nylon and 0.7 kg of elastane (in some cases branded Lycra or Spandex) were also present in the sample. There were 35.3 kg of boots, most of which were unpaired, though their counterparts may have been present in an unsampled bag.

There were 54.3 kg of unknown or other fabrics, including a small amount of olefin in one jacket, acrylic lining on two VPD-branded toques, and the polytetrafluoroethylene membrane of the Gore-Tex jackets. However, a large majority of the unidentified materials are likely to be of a similar proportion of the measured components, as these were largely very similar garments that had lost their tags. The quantities of each textile are presented in Table 3.

The most common components of the waste stream were shirts and trousers of the Genius and Flying Cross brands, with a smaller number of Omega and SWAT.

The weight of an average load has been increasing annually from 3.55 tonnes in 2013 to 4.16 tonnes in 2015; the sampled load in July 2016 weighed 4.26 tonnes; about 18.5%, or 786 kg of this is uniform. The average weight of a 2016 load is 5.55 tonnes, but this overstates the increase of waste because the period between pickups has increased from 4-6 weeks to 8 weeks. The Property Office reported lower than usual quantities of waste because personnel resources had been diverted to conducting annual inventory, so uniforms probably made up a larger percentage of the waste than usual. If an average load of waste is 4.5 tonnes, 17.5% of which is uniforms (0.7875 tonnes), at an average collection frequency of 6 weeks, the VPD disposes of about 6.825 tonnes (1 tonne = 1000 kg) of uniform per year, at an estimated cost to the VPD of about $1,700.

Table 3: Textile quantities of the waste sample, by weight and percentage

Material		Weight in Kilograms	Percentage of Total
All		262.27	100
Polyester (total)		141.6	54
	Polyester (in blend)	124.8	47.6
	Polyester (pure)	16.8	6.4
Cotton (total)		29.5	11.3
	Cotton (in blend)	29.4	11.2
	Cotton (pure)	0.09	0.03
Wool		30	11.4
Lycra/Spandex/Elastane		0.74	0.3
Nylon		6	2.3
Other/unknown		54.3	20.7
Leather		2.6	1.0
Shoes		35.3	13.5

Common and Best Practices

While the 5R hierarchy purports to rank the environmental impacts of various disposal methods, other contextual factors are highly relevant in determining the best option. For police departments, the primary concern is security (Jim Lloyd, personal communication, May 10, 2016; Barbara Corcione, personal communication, May 10, 2016). 67% of police agencies surveyed (14/21) identified security concerns as a barrier preventing more environmentally sustainable uniform disposal methods.

While both incineration and landfilling are popular among police agencies, an online search for textile recycling and disposal, particularly focused on secure destruction and handling of uniforms, reveals that a large majority of businesses in the sector utilize shredding. There are some exceptions. One company specializing in destruction of sensitive material advertised its use of incineration "to be totally secure" (ID Secured, n.d.); at the other extreme, three companies worked on mending uniforms and covering logos so that they could be reused (WRAP; Reseau CFER Inc, n.d.; Green Reparation, n.d.), and one provided corporate uniforms to inmates for skills training in creating upcycled goods such as tote bags (Environment Times, 2016). It was unclear whether identifying marks were removed by the inmates or prior to delivery.

While this may not reflect the industry consensus, UK company Uniform Reuse has a database of fabrics and preferred handling options for each. Recycling – mechanical or chemical, though mechanical is much more widely available e.g. in the form of shredding - is the recommended option for wool/synthetic, wool/polyester, cotton/polyester, and cotton/lyocell blends (Uniform Reuse, n.d.; Uniform Reuse, n.d.; Uniform Reuse, n.d.; Uniform Reuse, n.d.). Incineration is a recommended alternative for cotton/polyester and cotton/lyocell blends (Uniform Reuse, n.d.; Uniform Reuse, n.d.). They recommend incineration for Lycra, but acknowledge that this material is present in small amounts (up to 2%) in fabric blends (Uniform Reuse, n.d.). Lycra is UV resistant and should not be composted (Uniform Reuse, n.d.).

Disposal Methods

This section presents the findings of the literature review and compares the various end-of-life disposal options in terms of security, environmental impact, and practicality. Implementation opportunities and local partners are also identified and evaluated for each alternative.

A note of caution is warranted in interpreting the quantitative results provided. Many of the carbon and energy footprint estimates used in this report are derived from life cycle analyses (LCAs) or similar methodology. Although life cycle analyses share a standardized set of guidelines and are in that regard rigorous, their results vary greatly depending on the assumptions made (Glew, Stringer, Acquaye, & McQueen-Mason, 2012, p. 123). Therefore, LCAs cannot be directly compared without a careful consideration of the assumptions and scope used. This also emphasizes the point that the preferable treatment option is context-specific; aspects such as the material being handled, the energy source that would be displaced by WtE-generated electricity, and the rate at which reused clothing displaces consumption of new goods all affect the outcome. The numbers presented for each method should not be taken as the known result of a particular treatment, but instead used to supplement claims of the superiority or inferiority of one method compared to another on environmental metrics of energy use and greenhouse gas emissions.

Current Practice: Waste-to-Energy Incineration

Benefits:

- **High degree of security**
- **Recovers energy and metals**
- **Logistics known to be practicable**

Challenges:

- **Studies on GHG emissions/avoidance and energy use/savings may give contradictory findings**
- **Loses most of the "embodied energy"[5] in the object, as well as the material**
- **Incinerated object must be replaced by new, resource-intensive production**

Cost:

- **$250/tonne**

Impacts

Metro Vancouver's WtE facility is operated by Covanta. It employs mass burn technology, in which waste is received and incinerated with little or no pre-processing (Brereton, 1996, pp. 227-228). Energy is produced through heating water with the thermal energy released by incineration, which then powers turbines. Most of the water used in the process is for cooling the steam; Covanta is increasing their use of non-potable and reclaimed wastewater for their cooling systems, and recycle their cooling water to reduce consumption and avoid introducing warm water into aquatic ecosystems (Covanta, 2014b).

According to the waste balance published by Metro Vancouver, an input of 1 tonne of waste results in an output of 590 kWh of electricity, 28 kg of metals, 161 kg of bottom ash, 42 kg of fly ash, 5.8 kg of phosphoric acid, and 2.9 kg of other trace air emissions (Metro Vancouver, n.d.). This amounts to 8,500 tonnes of ferrous metal per year, which is used to manufacture reinforcing steel (Metro Vancouver, 2015).

Because WtE facilities do emit GHGs and other pollutants, decisions regarding the extent of their use will impact the City's ability to meet their clean air and climate change targets, as well as the immediate goal of reducing waste.

[5] Embodied energy refers to all the energy used in the production of a good. Only a fraction of this is energy that can be harnessed from the object, as most is used in the production process.

Is Waste Renewable Energy?

Covanta claims that its product meets the International Energy Agency definition of renewable energy as energy "derived from natural processes that are replenished constantly" (Covanta, n.d.). Some European nations classify WtE facilities as a source of renewable energy (Kasper, 2013). If this designation is appropriate in the local context, then the continued use of WtE incineration would help the City of Vancouver meet its sustainable energy target under the *Renewable City Strategy*. However, the City of Vancouver has explicitly excluded WtE incineration as a solution under the Zero Waste goals of the *Greenest City Action Plan*, and is therefore unlikely to favour it under the complementary *Renewable City* plan.

Other levels of government have made it clear that WtE is accepted as a low-priority waste-mitigation strategy. The Province, in the ISWRMP, has adopted the European Union's standard for a WtE's minimum energy efficiency to be classified under "Recovery" (Metro Vancouver, 2010, p. 24). Metro Vancouver has given WtE ash residue an exemption under their landfill reduction strategy, and do not count it towards the total quantity of landfill waste to be reduced (Metro Vancouver, 2010, p. 27).

Energy Generation

Incineration of polyester yields 33 MJ of energy per kilogram of polyester; for the same quantity, incineration of cotton yields 7 MJ (Rana, Pichandi, Parveen, & Fangueiro, 2014, p. 18). A report from a professor at Columbia suggests that at its most efficient, a WtE facility can generate up to 1000 kWh of energy per ton of waste (Themelis) – while the author does not specify which type of "ton" is used, it can be assumed that it is the US "short ton", equivalent to 2000 pounds, or about 0.91 metric tonnes. Metro Vancouver estimates that the Covanta facility produces 590 kWh of electricity per tonne of waste (Metro Vancouver, n.d.).

Greenhouse Gas Emissions

Covanta and others have stated that for each tonne of waste incinerated at a WtE facility, a tonne of carbon dioxide equivalent (CO_2e) emissions are avoided, citing a US Environmental Protection Agency (EPA) study (Covanta, 2014c; Kasper, 2013). Unfortunately, this tonne-per-tonne claim cannot be verified because the EPA website has since been updated, and many of its older reports removed. A seemingly related claim that each tonne of waste processed in this way avoids the need for one barrel of oil or a quarter-ton of coal (Covanta, 2014c) also could not be verified.

More generally, the claim that WtE facilities, while emitting some GHGs, mitigate emissions on net, is supported by some available studies (see Themelis; U.S. Environmental Protection Agency, 2006). An EPA study in 2009 predicted that for each ton (probably an American short ton) of mixed municipal waste diverted from landfill to WtE incineration, there would be a GHG saving of 0.5 tonnes of CO_2e (U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response, 2009, p. A-36). Whatever emissions are avoided are due to displacing fossil fuel-generated electricity which has higher GHG emissions, avoiding methane emissions from landfill, and energy saved by recovering metals (Covanta, 2014c).

Opposing studies go as far as to say that, when considering GHG emissions per unit of energy produced, WtE facilities are worse than even coal-powered plants (Lee, Legg, Maxwell, & Rees, 2013, p. 6). A study commissioned by Metro Vancouver found that about 244 kg CO_2e are produced per tonne of waste incinerated (Morris, Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver, British Columbia, 2009, p. 23). This discrepancy appears to be primarily caused by differences in what types of emissions are counted in the respective studies.

Biogenic Emissions

A significant problem with quantifying greenhouse gas emissions from WtE is whether emissions from incinerating organic waste – biogenic emissions – should be counted. This includes natural fibers such as cotton and wool, each of which account for just over 11% of the total material sampled in this study. In most official reports, biogenic emissions are excluded under the assumption that the carbon cycle of organic systems is balanced and would have been emitted anyway through natural decomposition (U.S. Environmental Protection Agency, 2006), or that it is taken up by new growth which balances the emissions (U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2015, p. 1-15). Environmental and anti-incineration groups have criticized this practice, saying that materials of this type are fairly stable in landfill and would act as a carbon sink if not incinerated (Lee, Legg, Maxwell, & Rees, 2013, p. 18); they estimate that including biogenic emissions triples the total GHG contribution of WtE (Lee, Legg, Maxwell, & Rees, 2013, p. 19). The estimate of 244 kg CO_2e per tonne of incinerated waste comes from a study which assigned carbon credits to biogenic materials in landfill (Morris, Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver, British Columbia, 2009, p. 23).

If only non-biogenic emissions sources are counted, then only synthetic textiles such as polyester (which makes up over 54% of the total materials sampled) would contribute to the CO_2e emissions output, as they are manufactured from petrochemicals. The textile content of various uniform pieces varies, and many pieces are created from a blend of synthetic and natural fibers; the current uniform supplier makes their products from a cotton/polyester blend, while many of the older uniforms are a wool/polyester blend. The 54.3 kg of other and unknown textiles (see Table 4) is probably also over 50% polyester; adding the other synthetic fibres nylon and elastane, as well as the rubber from boots, reveals that well over half of the uniform weight is made of synthetic materials, whose GHG emissions would be counted as non-biogenic. Therefore, quantifying the climate impact of WtE facilities depends on which materials will be included, and which excluded, when measuring GHG emissions. The estimates generated from different assumptions could be of such magnitude as to change the ranking of WtE relative to other disposal methods such as landfill (see below).

Bottom Ash

Covanta estimates that the volume of the ash is reduced to 10% of the input waste (Covanta, 2014d); other estimates suggest it is closer to 30%, and that the volume of ash is only 45% less than the volume of landfill waste, which is compacted (Greenpeace UK, p. 5; Brown C. , 2014, p. 9). In either case, this is a significant reduction of the volume deposited in landfills, thus reducing the need to expand landfill capacity.

While the City of Vancouver's zero waste goal entails diversion away from incinerators as well as from landfill, Metro Vancouver excludes the quantity of residual ash created by WtE from its own goal to reduce the quantity of waste going to landfill (Metro Vancouver, 2010, p. 27). This suggests a more favourable view on Metro Vancouver's part about the potential of WtE to help meet sustainability goals.

Bottom Ash: Toxicity

"Bottom ash", the ash that results from incineration but is not contained in gaseous emissions, contains heavy metals and soluble salts that can leach into water and soil (Tang, Florea, Spiesz, & Brouwers, 2015). Nonetheless, it is considered non-hazardous, as leaching concentrations are generally below regulatory cut-offs (Phoungthong, Xia, Zhang, Shao, & He, 2016; Covanta, 2014d). Some studies have found that lead, copper (Phoungthong, Xia, Zhang, Shao, & He, 2016), antimony, chloride, and sulphate

(Tang, Florea, Spiesz, & Brouwers, 2015) sometimes exceed the legal limit. The City of Vancouver's testing records support that the Covanta facility in Burnaby has consistently kept its emissions at or below regulatory limits (Metro Vancouver, n.d.; Allan, 2014). Nonetheless, Brereton, in his study of the Burnaby facility, finds the leaching concentrations of bottom ash to be of "environmental concern" (Brereton, 1996, p. 255). Testing of bottom ash occurs weekly (Metro Vancouver, n.d.).

Bottom Ash: Uses

Among Covanta's sites in general, 1/3 of the ash generated can be used as landfill cover (Covanta, n.d.; Covanta, 2014d), and replacing the need for "virgin soils" is touted as a benefit (Covanta, 2014d). This benefit is less significant in Vancouver, however, as all landfill cover is sourced from construction waste (Sydnie Koch, personal communication, July 28, 2016). Ash also has potential use as a building substrate, for example in the construction of roads (Covanta, 2014d). It is unknown whether such an application is being considered or piloted locally.

Fly Ash and Air Pollutants

"Fly ash", the portion of ash that is airborne, is subject to continuous emissions monitoring as well as periodic tests of the stack and of ambient air quality around Metro Vancouver – one in Burnaby, one in North Delta, and one in Richmond (Allan, 2014, p. ZWC-10).

Again, air emissions have been well below regulatory limits since the facility began operations in 1988; NOx regulations were first introduced in 1997, and although emissions were above the new limit before that time, they were at compliance levels by the time the regulation was implemented (Allan, 2014, p. ZWC-15). However, carbon monoxide (CO) emissions briefly exceeded permitted levels on two occasions in 2014 (Allan, 2014, p. ZWC-11) due to unusually wet garbage.

The Covanta facility employs several levels of pollution abatement technology. Ammonia or urea converts NOx to gaseous nitrogen, the main component of our breathable air, while still inside the furnace[6]. Activated carbon pulls air pollutants like dioxin and mercury out of the gas emitted from the facility – the addition of this practice has significantly increased mercury removal to 84% (Brereton, 1996). More than 95% of acidic sulfur dioxide and hydrochloric acid, which are strongly acidic gases, and over 99% of particulate matter is removed from the gas (Covanta, 2014a). High temperatures destroy other toxins and pathogens already present in waste (Metro Vancouver, 2015).

The health risks of mercury and particulate matter (creating smog) are commonly known, as are the environmental dangers of acid gases. Dioxins have been linked to numerous deleterious health effects including liver (Committee on the Implications of Dioxin in the Food Supply, 2003, p. 23) and other cancers as a tumor promoter (Schwab, 2009, pp. 873-876), birth weight, infant neurodevelopment and immune system development, and skin problems (Committee on the Implications of Dioxin in the Food Supply, 2003, pp. 23-24). On the other hand, a meta-analysis of studies exploring links between waste management practices and human health did not find a clear positive correlation between WtE and adverse health effects (Giusti, 2009).

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[6] Covanta reduced their NOx emissions by half when they upgraded their abatement technology in late 2014 (Allan, 2014; Simet, 2015), so earlier figures overstate the current polluting impact of this facility.

Other Incineration Methods

The foregoing information pertains to mass burn incinerators of the type employed by Covanta Energy in Burnaby. Alternatively, pyrolysis or gasification-based incinerators also exist, as does technology for creating refuse-derived fuel. Strictly speaking, only mass burn facilities are properly described by the term “incineration” (Metro Vancouver, 2015); what these technologies share is the ability to recover energy from waste.

These alternatives were not explored further because preliminary research suggests that they may have a larger footprint than mass burn facilities because they may need additional energy input (Platt, Ciplet, Bailey, & Lombardi, 2008, p. 6), and gasification facilities release more nitrogen oxides and dioxins than mass burn facilities (Pembina Institute). Moreover, they are not available in the Lower Mainland.

Criticisms of Incineration

A common concern amongst critics of WtE plants is that they “lock in” a certain amount of disposal, incentivizing the creation of waste in order to keep the plant viable or else risk a shortfall of electricity (Lee, Legg, Maxwell, & Rees, 2013, p. 19; Greenpeace UK, p. 21). However, in its Integrated Solid Waste and Resource Management Plan, Metro Vancouver is prepared to progressively shut down or convert the plant’s three furnaces to use alternate fuel sources in the event that waste flows fall below 780,000 tonnes per year (Metro Vancouver, 2010, p. 15).

Connected to the concern of “locking in” demand for waste and undermining recycling efforts, critics also point out that the two most calorie-dense inputs, paper and plastics, are also those that can and should be diverted into a recycling stream (Lee, Legg, Maxwell, & Rees, 2013, p. 19; Greenpeace UK, p. 21). Without these high-calorie waste inputs, WtE plants may have difficulty reaching optimum burn temperature, potentially leading to increased air pollution and toxicity (Lee, Legg, Maxwell, & Rees, 2013, p. 19), but lower GHG emissions (because plastic is a petrochemical). Because of these concerns, opponents of incineration claim that it is incompatible with recycling and zero waste (Lee, Legg, Maxwell, & Rees, 2013, p. 41). However, case studies show that some of the European countries who use WtE technology also have the highest recycling rates (Kasper, 2013).

Opponents of WtE are also concerned about the human and environmental impacts of air pollution and ash residue, as previously discussed.

Finally, critics have proposed that WtE is not only undesirable, but unnecessary. They propose improving the landfill by using “mechanical and biological treatment”, or MBT, so that garbage is cleaner and safer to bury. This is done by separating waste streams and removing toxic, recyclable, and organic components so that the landfilled components are stable and non-toxic (Greenpeace UK, p. 20). Similar logic of source-separation can be applied to minimize both landfill and incineration, without abolishing either.

Concerns that WtE incineration captures only a portion of the energy “embodied” in a product, wasting most of it, are valid. Because incineration destroys the material, most of the energy it took to create the product is lost, and more resources will be required to create “virgin” material to replace it (Lee, Legg, Maxwell, & Rees, 2013, pp. 6, 19; Morris, Recycling versus incineration: an energy conservation analysis, 1996, pp. 277-278). One estimate suggests that WtE facilities capture about 15% of the possible heat value (Morris, Recycling versus incineration: an energy conservation analysis, 1996, p. 277). Therefore, recycling is almost always preferred over incineration when possible (Morris, Recycling versus incineration: an energy conservation analysis, 1996).

Landfill

Benefits:

Landfill may sequester carbon and reduce GHG and toxic emissions

Challenges:

Lack of consensus on methodology obscures relative impacts

Disposal in landfill without prior destruction may not offer adequate security

Cost:

≤$112 per tonne for landfill disposal

This section will examine the impacts of landfilling, particularly as compared to WtE incineration. While recycling is generally better than either incineration or landfilling from an environmental and resource use perspective, the order of preference between the latter two is still the subject of research and debate. Two methodological decisions - whether or not to include biogenic emissions and whether to grant "credits" to landfills for sequestering carbon – result in conflicting findings.

A study in Sweden found that, for energy use, recycling was the best option, followed by WtE and then landfilling (Finnveden, Johannson, Lind, & Moberg, 2005, p. 221) the same order held true when looking exclusively at global warming (p. 221). Landfilling was preferred to WtE for non-renewable energy use in that study, but was highly sensitive to the assumptions (p. 221). When these impact categories are combined, WtE was found to be preferable to landfilling (p. 222).

On the other hand, a life-cycle assessment commissioned by Metro Vancouver for their zero-waste objectives found that landfilling was preferable to WtE for each of greenhouse gas emissions, emissions relevant to human health[7], and emissions with toxic effects on ecosystems (Morris, Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver, British Columbia, 2009). Landfilling was found to prevent each of these emissions, while WtE generated them. Figures from this study are presented in Table 4.

Table 4: Emissions Reported by Jeffrey Morris, 2009: Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver

	Landfill	WtE
GHG Emissions	-140,000 – 174,500 tonnes	+231,700
Human Health Emissions	-1,100 – 3,900 tonnes	+56,600
Ecosystem Toxicity Emissions	-50 tonnes	+800

Methane Capture

There is significant disagreement, too, about the efficiency of landfill methane gas capture. Assumptions about this could significantly affect the results of a comparative study, especially as landfills are the third biggest contributor of anthropogenic methane emissions (Kasper, 2013).

[7] This study excluded dioxins and furans due to inadequate records

Reported 2015 figures state that 71% (based on site-specific conditions – another, more generic method of estimation puts this at 60%) of methane generated by the Vancouver Landfill was collected, of which 54% was used for energy and heat, while the other 44% was flared. This means that about 38% of total methane emissions were used to generate energy. In 2014, 62% of the collected methane was beneficially used, but there were technological limitations in 2015 that the City is looking to overcome (Transfer & Landfill Operations Branch, City of Vancouver Engineering Services, 2015, p. 25). This agrees with the EPA's model which estimates 34% of landfill-generated methane is used in electricity generation, while 38% is flared, and 28% is lost (Kasper, 2013).

On the other hand, one study found that about 60%-85% of methane "leaks" out – meaning that capture efficiency is only 15%-40% (Kaplan, DeCarolis, & Thorneloe, 2009). One environmental group's report stated that methane capture could be "as low as 20%" (Platt, Ciplet, Bailey, & Lombardi, 2008, p. 29).

While many have mentioned it in passing, one study explicitly noted that the ranking of disposal options change based on important assumptions such as the scope of the system modeled, the time period used, and whether or not biogenic carbon is treated as an emission or part of a complete carbon cycle (Moberg, Finnveden, Johannson, & Lind, 2005).

Biogenic Emissions

Polyester is not biodegradable, so it could be counted as a carbon sink when deposited in the landfill. Because it is made from fossil fuels, the quantity of greenhouse gases emitted from burning it is significant. Unlike polyester, cotton is biodegradable and releases GHGs from landfill (5.5 kg of CO_2 per kg of cotton) (Rana, Pichandi, Parveen, & Fangueiro, 2014, p. 18), some of which are caught by the methane capture systems of modern landfills.

Even though landfills sequester carbon in plastics, the fact that they emit methane (which has a global warming potential 21 times that of CO_2[8]) (American Society of Mechanical Engineers, p. 4) could mean that they contribute more to global warming than WtE (Kaplan, DeCarolis, & Thorneloe, 2009), which releases CO_2 as its primary greenhouse gas (Kaplan, DeCarolis, & Thorneloe, 2009).

Overall, the literature suggests that whether landfill or WtE is environmentally preferable depends on the material being processed and assumptions made about the system – but recycling is always better than either and should be prioritized.

Opportunities

Vancouver Landfill

Security

Disposing of uniforms, especially shirts, in the landfill without prior destruction may not offer adequate security against misappropriation and misuse. If uniforms cannot be thrown away intact, then incineration should be pursued; it would not make sense to shred the uniforms before landfilling because once shredded, they can be recycled. Another option would be to adopt the practice of police agencies such as the Delta Police Department, London Police Service, and Royal Newfoundland Constabulary, and cut off one or both sleeves on the shirts and jackets, and one leg off the pants, and

[8] The exact global warming potential varies depending on the time frame used in the estimate

landfill them in that condition. This work could be conducted by Stores staff or volunteers with the community policing service.

Financial Implications

The Vancouver Landfill has a 3-tier fee system, with the cost per tonne decreasing as quantity increases. At the middle range, the fee is $112/tonne, with a maximum charge of $720 total, for loads between 1-9 tonnes. If the VPD takes all 7 tonnes of annual uniform waste once per year, the cost estimate would be only $720, compared to the estimated cost to the VPD of $1750 charged by Covanta. Diverting all waste from Covanta to the landfill would reduce disposal fees by 59%. The cap of $720 reduces costs by $64; if waste reduction measures successfully reduce the mass of waste to less than 6.4 tonnes per year, then the VPD would pay the unit cost of $112 per tonne, reducing disposal costs by 55.2%.

Recycle

This section looks at secure shredding and fiber-pulling services provided by "rag dealers", as well as future opportunities for fiber separation.

Benefits:

Save between 5.7 tonnes CO_2e and 93 GJ primary energy (chemical recycling) and 8 tonnes CO_2e and 141 GJ (reuse)

Save almost 2000 kg CO_2e per tonne of textile recycled (unknown method; projection under Metro Vancouver Zero Waste 2029 scenario)

Challenges:

Additional GHG emissions if shipping

Advanced technologies not yet commercially available

Cost:

$2454/tonne – varies with volume and complexity (*de·*brand)

$1158/tonne (TCTR)

$661/tonne when combined with donation (TCTR)

Where destruction is required, garments can be cut into wiping rags, turned into pulp, or have the fibers pulled to create new yarn. Only textiles containing a high proportion of cotton can be turned into wiping rags; no component of VPD uniforms meets that requirement. Therefore, fabric sent to any of these companies would be fully shredded or pulled into new thread.

Recycling is widely acknowledged to be preferable to incineration from a climate perspective. Fletcher (qtd. in Porse, 2013, pp. 14-15) found that even the most energy-intensive recycling methods used less energy than what would be required to produce replacement "virgin" material, resulting in a net gain (Porse, 2013, pp. 14-15). As with reuse, this means less land, water, pesticides, herbicides, and fossil fuels are needed to produce textiles. However, the savings are smaller because of the energy and inputs used in the recycling process. Therefore, energy savings are positive, but less than 141 GJ of energy and 8 tonnes of CO_2e per tonne that is reused. One study found that, for 1 tonne of cotton t-shirts, one would emit 0.2 tonnes of CO_2e by landfilling, save 0.3 tonnes CO_2e by WtE incineration, and save 0.84-1.2 tonnes CO_2e through material recycling, here defined as cutting into industrial wipers (Laitala & Klepp, 2015, p. 346). These numbers are over the entire lifecycle, but as only the disposal method changes, it can be inferred that, under that study's assumptions, recycling could save 0.5-0.9 tonnes of CO_2e compared to WtE. It must be noted with caution that a cotton t-shirt is not representative of the VPD's textile waste, much of which is synthetic and most of which is blended. A report commissioned by Metro Vancouver to evaluate the impacts of zero-waste policies estimated that up to 2 tonnes of CO_2e could be avoided by recycling 1 tonne of mixed textiles; the type of recycling was, however, unspecified

(Morris, Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver, British Columbia, 2009).

Depending on the type of material, savings can extend beyond energy to oil and gas (of which polyester is made), land use (natural fibers such as cotton and wool), and water use (especially cotton). Use of pesticides and herbicides, and associated ecosystem and human health effects, are also minimized by reducing the need for new materials (Porse, 2013). An estimate provided by the recycling industry suggests that per kilogram of reused clothing of mixed types, 3.6 kg of CO_2 emissions are saved, as well as 6000 litres of water, 0.3 kg of fertilizers, and 0.2 kg of pesticides (Bureau of International Recycling, n.d.).

Recycling – Mechanical (Shredding and Pulling)

Blends

Blended fabrics are common, but methods to separate them are not commercially available, which limits the use to which recycled fibers can be put. In most cases, fabric is shredded, resulting in "shoddy" fiber, a fluffy aggregate used in applications like automotive insulation and furniture stuffing, where it can displace foam and other filling materials. Alternatively, fabric can be pulled apart, separated into filaments, and cleaned before being spun it to create thread. This approach shortens the fibers, decreasing their quality and eventual lifespan; as a result, recycled fibers are sometimes blended with virgin fibers during spinning to create yarn with better properties. Chemical methods are also in development.

No carbon footprint was located for mechanical recycling (shredding and pulling), but these methods are less energy-intensive than chemical techniques (Fletcher, 2008, ctd. in Porse, 2013, p. 14). The same Swedish study that provided the estimated energy and carbon savings of incineration and donation estimates that chemical separation using the ionic liquid NMMO as a solvent (see "Emerging Technologies" below) would result in saving 5.5 tonnes CO_2e and 116 GJ of primary energy per tonne of fabric compared to primary production, or 5.7 tonnes CO_2e and 93 GJ of energy compared to incineration (Zamani, Svanstrom, Peters, & Rydberg, 2015). While the study does not offer an estimate for mechanical recycling, other sources suggest that mechanical recycling is less energy-intensive than chemical, though with a tradeoff of producing lower quality fibers with a shorter total lifespan (Porse, 2013, p. 14). An estimate of the energy saved by the improved quality and durability of chemically separated fibers and whether it outweighs the energy savings of mechanical shredding and pulling could not be located.

Opportunities

TCTR (TexShred)

TexShred is the branch of TCTR that deals with secure disposal. Through TCTR, they sell the components that do not require destruction. Where destruction is necessary, they turn clothing into wiping cloths or shred them, as required. Only fabrics with a cotton content of at least 65% can be used for industrial wiping cloths (Anthony Shackleton, personal communication, July 26, 2016) so based on the findings of the waste audit, nearly all of VPD's textile waste would have to be either donated/sold or shredded. All destruction and basic processing is done in Canada, and the shoddy or pulled fibers that result from the mechanical destruction processes are sent to factories in India and Pakistan for further processing including fiber pulling and spinning (Trans-Continental Textile Recycling Ltd, n.d.).

TCTR can perform both shredding and pulling; it is unaware of any thread pulling facilities in North America, so this stage is conducted overseas. However, they prefer textiles with a high natural fiber content for fiber pulling, so most of all of the VPD waste would likely be shredded and used as shoddy fiber (Anthony Shackleton, personal communication, July 26, 2016).

TexShred does not have the capability to separately recycle 100% polyester components such as the VPD's Polartec fleece jackets.

Security

TCTR employees would cut the uniforms manually in order to ensure that all identifying marks and flashes are destroyed; their machine renders clothing unusable but there is a risk that insignia could slip between the blades.

No time estimate was provided for this process, but as destruction would be carried out by hand, it is likely to take longer than mechanical destruction (which *de*·brand offers at an estimate of 1.5 hours). They will accommodate witnessed destruction, either by having VPD present or, acknowledging that it is a lengthy process, by providing photo or video (Anthony Shackleton, personal communication, July 19, 2016).

Logistics

Upon request, a bin could be installed in Stores; TCTR would pick it up periodically or on request.

Financial Implications

TCTR charges $0.50 per pound to shred clothing. If there are saleable components, this could offset the cost by $0.10 per pound of wearable clothing.

Assuming that 100% of the material must be destroyed, this method would cost $1157.43 per tonne – 4.6 times as much as disposal at Covanta. Cargo-style trousers accounted for a little over a third of the weight of the disposed uniforms, most of which were in wearable condition. If these are provided to TCTR for sale overseas, at 33% of the uniform weight, this offsets the cost of disposal to an average of $0.30 per pound or $661.39 per tonne, only 2.65 times as much as Covanta.

de·brand

de·brand Services Ltd would mechanically shred all components and reclaim the resulting shoddy fiber for use in a variety of applications including automotive and furniture stuffing, insulation, geo-textiles, and consumer goods such as stuffed animals and boxing gloves (Peter Scott, personal communication, July 20, 2016). Pulling to create new yarn, and recycling clothing into new clothing, is still in development, is very expensive, and not a viable option in North America at this time. A research centre in the Netherlands is pioneering that technology.

de·brand does not have the capability to separately recycle 100% polyester in the form of polyethylene terephthalate (PET), nor do they offer fiber pulling. All textiles would be reclaimed through shredding.

Security

de·brand would provide record checks on employees as needed. All identifying marks including flashes and insignia will be destroyed while a supervising VPD representative is on-site, and no partially-destroyed material will be stored. All identifiable materials will be mulched and rendered unidentifiable.

Logistics

The VPD would call or email *de*·brand to set up a witnessed destruction as needed, with one week of advance notice, and would carry out delivery. *de*·brand estimates 800-1000 pounds (363-454 kg, or <0.5 tonnes) per delivery, and that destruction of this quantity would take approximately 1.5 hours.

de·brand will request information from Ford and Chrysler about the quantity of shoddy fiber used in the vehicle models that make up the VPD fleet, creating an interesting opportunity to demonstrate a partially closed-loop system.

Financial Implications

de·brand quoted $1.06 plus GST per pound for a test project destruction, and promises no extra fees. This comes to $2,453.75/tonne, almost 10 times the current cost paid to Covanta. This is based on an estimate of 800-1000 pounds, but they would consider a volume discount if the quantity is larger.

Christa Brown's research on the topic in 2014 showed $1.06/pound as the minimum cost, which could increase to $1.50 depending on the level of security (p. 33). While their fee structure may have changed, we should be prepared for the cost to potentially increase following the test project, if this option is pursued. The complexity and creativity of recycling solutions is associated with higher fees, so costs can be kept to a minimum by continuing to send difficult and small items like pouches and belts to Covanta. This can be done through *de*·brand for a lower WtE rate, or by source separation at the VPD.

de·brand would collaborate with the VPD to find value-recovery options for Kevlar/Twaron components, and no project would be acted upon without the VPD's express consent.

Comparing *de*·brand and TCTR

Between the two secure textile recyclers, *de*·brand and TCTR, there is a trade-off between cost and efficiency. TCTR charges less, but their process is more time-consuming as they would destroy uniforms by hand in order to ensure that no insignia are left intact. They offer fiber-pulling, which is a higher quality of recycling than shredding and creates higher quality and higher value goods, but this part of their operation is conducted overseas in India and Pakistan. They will pay for the wearable uniform portions such as trousers because it can sell these abroad, but this has mixed effects on local economies. They were less thorough and professional in their correspondence.

de·brand's services are more costly, but their system is more efficient, as they can ensure that their mechanized process will destroy all components. They do not have explicit cost-recovery methods such as payment for wearable garments, but they have expressed interest in collaborating with the VPD to find creative uses for shredded Kevlar with the VPD's approval, and to trace the uniforms through shredding back to the automotive stuffing used in the VPD's fleet. They have expressed eagerness to set up a test destruction and have been very professional and informative.

I:CO Blue

Certain manufacturers and retailers are organized in a network to provide services similar to an extended producer responsibility (EPR) program. H&M, for example, will collect used clothing and textiles regardless of their origin, which are then processed and recirculated by I:CO (I:Collect), a company which describes itself as a "service provider for clothing and shoes reuse and recycling". I:CO also has a division, I:CO blue, which provides "confidential handling". They could not be contacted for enquiries; email delivery failed. An attempt to email them through the parent company I:CO yielded no response. No other contact information was provided.

Recycling – Emerging Technologies

Traditionally, blended fabrics have been regarded as less sustainable because there was no existing technology readily able to separate them for recycling. New technologies such as improved fiber pulling and chemical separation of textile blends are being explored; if and when these techniques become commercially viable, this could change the opportunities and incentives in the textile recycling industry.

Increased viability of fiber-pulling technologies could save even more energy and raw material than shredding, because recycled thread displaces virgin material at a higher level and quality than shoddy fiber, and creates products of a higher value and with a longer lifespan.

As noted above, chemical separation of polyester/cotton blend textile waste could save 5.5 tonnes CO_2e and 116 GJ of primary energy per tonne of fabric, whereas WtE was found to save only 23 GJ of primary energy production and to produce 0.23 tonnes of CO_2e. These savings are primarily due to displacing primary production of polyester and cotton (Zamani, Svanstrom, Peters, & Rydberg, 2015). However, dissolving cellulose requires high levels of thermal energy. While this estimate assumed 75% of cellulose fibers could be reconstituted, the authors recognized the role of potential impurities and found that the reduction in CO_2e and primary energy use was not sensitive to changes in efficiency at this stage (Zamani, Svanstrom, Peters, & Rydberg, 2015).

In the literature, ionic liquids emerge as a promising and comparatively well-studied method for separating fiber types from a blended fabric. The ionic liquid selectively dissolves one of the components, and the solution is forced through spinners, creating new thread. The second component of the blend is unaffected by the ionic liquid and is left behind in nearly 100% purity (Zamani, Svanstrom, Peters, & Rydberg, 2015). Studies have shown minimal loss of fiber and near-100% reusability of the solvent in a closed system (Zamani, Svanstrom, Peters, & Rydberg, 2015), and better fibre quality compared to acidic or caustic solvents (De Silva, Wang, & Byrne, 2014). The effectiveness of this method has been demonstrated with blends of cotton/polyester (Zamani, Svanstrom, Peters, & Rydberg, 2015; De Silva, Wang, & Byrne, 2014; Sun, Lu, Zhang, Tian, & Zhang, 2013; Sankauskaite, et al., 2014; Kwon, 1997), cotton/nylon (Lv, Wang, Zhu, & Zhang, 2015), nylon/spandex (Yin, Yao, Wang, & Wang, 2014; Lv, et al., 2015). No studies examining blends of three or more fiber types. However, in one study, cotton was used as an input and lyocell was generated; it may be that the method applies to all cellulosic fibers (including cotton, lyocell, and rayon/viscose, among others).

Less research has been conducted on the separation of wool from textile blends. Wool is a significant component of the uniform. Wool can be dissolved in an ionic liquid, but this could not be used to separate wool and cotton, as cellulose is also soluble. In fact, ionic liquids were used to blend wool and cotton (Hameed & Guo, 2010; Xie, Li, & Zhang, 2005).

Other exploratory methods of recycling are the transformation of PET waste into dye (Shukla, Harad, & Jawale, 2009), the creation of new blended fabrics incorporating finished leather waste (Senthil, Inbasekaran, Gobi, Das, & Sastry, 2015) and the production of biofuel from cellulose extracted from blended-fiber waste textiles (Jeihanipour, Karimi, Niklasson, & Taherzadeh, 2010).

Recycling – 100% Polyester

Chemical recycling for synthetic fibers is available and results in higher-quality fabrics but is more energy-intensive (Porse, 2013). Recycling of polyester can reduce energy use by 76% and CO_2 emissions by 71% by one estimate (Zamani, Svanstrom, Peters, & Rydberg, 2015); another study found that it would save 0.9 tonnes of CO_2e and 26 GJ of energy per tonne of polyester recycled – that is 3 GJ/tonne more than WtE incineration, but assumes that the residues of this process are still incinerated (Zamani, Svanstrom, Peters, & Rydberg, 2015, p. 682), and 1.03 tonnes of CO_2e avoided compared to WtE, which emits 0.23 tonnes of CO_2e on net.

A common problem is that polyester garments are rarely completely pure – fasteners and adornments can contaminate a pure PET source. For the VPD, one of the main 100% polyester garments is a Polartec fleece; however, the embroidery thread used to brand it as police wear is 100% nylon, which renders most or all of the polyester garments unsuitable for this form of recycling.

Flash Removal

The above assumes that all flashes and insignia are still present on the uniforms when disposed. While some pieces have embroidery and others, such as windbreakers, have the word "Police" printed on them, these are readily destroyed by mechanical means. On the other hand, flashes, ID number patches, and other insignia that are attached to the garment are the elements that may survive mechanical destruction. If the flashes were removed prior to delivery, the VPD could take advantage of TCTR's lower fees and destruction could be completed more quickly by mechanizing the process. Cost and time savings may also be available at *de*·brand if flashes can be removed prior to shredding.

Opportunities

The Community Policing volunteers are likely the best group to take responsibility for the task of flash removal. These individuals have already been vetted and security-cleared. A change in how used uniforms are handled will likely result in additional labour for Stores staff; using the community policing volunteers where possible minimizes this burden.

Shirts could be transported from Stores to a community policing office, but this may be logistically undesirable. When volunteers attend a community policing office, they generally have a particular activity planned such as a patrol (Sergeant Alvin Shum, personal communication, July 28, 2016). In addition, although CPCs are trusted locations, transportation takes up time and introduces an added element of risk. It may be preferable to bring volunteers into Stores to perform the work of flash removal (Sergeant Alvin Shum, personal communication, July 28, 2016).

Sergeant Shum has indicated his support of the idea and would be interested in discussing logistics if this plan is considered.

Reuse: Donation and Upcycling

As described above, the VPD has an extensive and popular internal reuse program. This section will examine opportunities for reuse outside of the VPD that require minimal processing – donation for use as clothes, or as material for "upcycling".

Donation

Benefits:

- **Saves 8 tonnes CO_2 and 141 GJ of energy per tonne (before export)**
- **Reduces water, land, pesticide, herbicide, and fossil fuel use and associated toxicity**
- **Provides affordable clothing for low-income communities[9]**

Challenges:

- **Security risk**
- **Labour-intensive to mitigate risk**
- **GHG emissions from shipping[9]**
- **May contribute to the decline of local industry in developing economies[9]**

Impacts – General

A study in Sweden found that material reuse could save almost 8 tonnes of CO_2 equivalents and 141 GJ of energy per tonne of textile waste, compared to incineration with electricity generation, which is the current practice in Sweden for solid waste treatment (Zamani, Svanstrom, Peters, & Rydberg, 2015). This is primarily because re-use of material means that less new material needs to be produced (Zamani, Svanstrom, Peters, & Rydberg, 2015). For synthetic textiles like polyester and nylon, this means that less oil and gas is needed to extract the petroleum of which these fabrics are made. Less land, water, fertilizer, herbicides and pesticides are needed to grow the crops for natural fibers. These benefits are addressed in more detail in the section on Recycling.

Impacts – Local

Reuse of shirts by external parties as clothing raises the greatest security risk of the options explored. The shirts' epaulets are distinctive as a police design, and genuine "collectible" flashes are publicly available on sites such as EBay and could be sewn on. Jackets and blazers, as well as any gear marked "Police" or with insignia, are of similar concern for their ability to be used illegally to impersonate a police officer, contrary to section 130 of the *Criminal Code*. The Department of Homeland Security (DHS) and the FBI have both issues statements warning of the risk of police impersonation using stolen or fake uniforms

The other side of this concern is the fear of "blue-on-blue" violence (where one police officer mistakenly shoots another). If an officer is second-guessing the affiliation of an individual wearing police-styled clothing, this could create hesitation and disrupt an officer's ability to do their job in an often high-pressure and fast-paced situation (Jim Lloyd, personal communication, May 10, 2016). The concern is not entirely hypothetical. One member recounted the story of an Inspector (a senior rank with supervisory responsibilities) who, at a distance of less than a block, mistook two armoured car drivers for police officers based on the similarity of their uniform (Kelly Kim, personal communication, June 7).

These concerns make it dangerous and undesirable to reuse any branded parts of the uniform. These must be destroyed. Some unmarked elements may be suitable for donation. Boots are currently provided to the jail, as are plainclothes.

Trousers do not bear any insignia and so may be suitable for donation; however, considering that 142 pants and shorts were present in the waste audit sample, suggesting over 400 pants in a 6-week period,

[9] Impacts relevant to overseas donation

local demand is unlikely to exhaust this resource. Export may be a suitable alternative or supplementary solution.

Impacts – Export

Companies such as Trans-Continental Textile Recycling (TCTR) grade, bale, and ship clothes on a large scale, primarily to African markets. Financially, this option is attractive, as TCTR offers free pickup and will pay $0.10/pound for any reusable items (Brown C. , 2014, p. 33). This could offset the costs of disposing of waste streams that cannot be donated, or the costs of removing the flashes prior to delivery.

Delta PD and Abbotsford PD have both investigated the possibility of export to developing countries, and found it to be cost prohibitive (Dawna Marshall-Cope, personal communication, May 10, 2016). Abbotsford PD found that shipping directly to Africa was cost-prohibitive, and has not looked into collaborating with TCTR (Karen Franklin, personal communication, July 20, 2016). They currently partner with the Mennonite Community Centre, whose members remove and return the flashes and ship the uniforms. Delta PD did not respond to an email requesting insight into the barriers they encountered.

Security

Abroad, as domestically, there is concern that uniforms giving the illusion of authority could be intercepted by criminal gangs, paramilitary groups, or lone criminals. The risk is particularly serious for body armour. Local governments do not always want donated body armour, in part because it is politically embarrassing to rely on donations, and also because VPD armour may not provide adequate protection in areas of the world experiencing conflict (Jim Lloyd, personal communication, May 10, 2016). The VPD uses soft armour, which is rated for protection from handguns but not rifles (National Institute of Justice, 2013; James, 2016, p. 9), which are more common in conflict zones (Jim Lloyd, personal communication, May 10, 2016). Therefore, there are clear limits on what could be donated abroad.

Environmental Impact

Maritime shipping is the least carbon-intensive form of transportation (Siegle, 2014; World Shipping Council, n.d.) , but nonetheless increases the climate and pollution impacts of clothing disposal relative to similar local solutions (Scott, 2014). It is unclear whether transportation emissions fully annul the climate and energy benefits of material reuse, or if it only reduces them. Therefore, less than 8 tonnes of CO_2e and 141 GJ of energy per tonne would be saved by exporting donated uniforms.

Like incinerators, cargo ships also emit SO2, NOx, and particulate matter (Transport & Environment, n.d.). Whether the quantity is greater or lesser than the emissions caused by incineration is unknown, but the human health effects caused by shipping are likely to be less due to distance from residential areas. Sailors, however, may be heavily impacted. Ecosystems can be harmed by physical damage from the ships, wave disturbances, and anchors, and by the release of toxic oil and other chemicals or introduction of invasive species (WWF, n.d.). Sound pollution (Brown E. , 2015) and collisions also harm marine species – for example, collisions are the leading cause of death for right whales (Ward-Geiger, Silber, Baumstark, & Pulfer, 2005, p. 266; The IUCN Red List of Threatened Species, n.d.).

Economy

TCTR claims that the export of secondhand clothing to African communities is beneficial in that it employs many individuals in the markets and provides affordable clothing without which people would be "in rags" due to low wages and competing demands on scarce resources. Additionally, they state that there is no impact on local clothing manufacturing in recipient countries, which is export-oriented (Trans-Continental Textile Recycling Ltd, n.d.).

Others, however, see the global used clothing business as a barrier to economic development, because the influx of cheap imported goods to markets in, especially, sub-Saharan Africa - which receives a third of global charitable clothing donations (Rodgers, 2015) - decreases demand for locally-made clothes. Critics say that not only does this impede the growth of a strong local textile and clothing industry, it has eroded the industry that was built during a period of import substitution, which ended in the 1980s-90s (Kermellotis & Cumow, 2013; Traub-Merz & Jauch, p. 13). Ghana, for example, lost 80% of textile and clothing employment between 1975-2000; Nigeria's employment in that sector, previously 200,000 workers, has also shrunk dramatically (Rodgers, 2015). However, commentators recognize that trade liberalization has also resulted in the increased availability of cheap clothes from Asia, which may have also contributed to the decline of the textile industry. In fact, Oxfam released a report finding that even if donations were completely ceased, it is unlikely that the industry would recover due to these other pressures. In their assessment, donations had a net benefit by providing affordable clothing (Baden & Barber, 2005).

Opportunities

Any articles, such as trousers, that are not distinctive as former police gear and are of adequate quality should be distributed locally where possible to avoid the environmental impacts of shipping. Export may be the next best option for all the wearable trousers (or only for the surplus that cannot be used locally) in order to minimize any concerns about being identifiable as a former domestic police uniform.

TCTR

Trans-Continental Textile Recycling (TCTR) is a local company that processes donated clothes and sends those that are still wearable overseas, particularly to Africa, and pays "donors" $0.10 per pound of garments that can be sold abroad in the local markets of recipient countries (Brown C. , 2014, p. 33; Trans-Continental Textile Recycling Ltd, n.d.). If supply exceeds local demand, the surplus could be delivered through TCTR, which would partially offset the costs of shredding more sensitive items.

All processing is done in Canada, and part of the proceeds benefit local charities, who hire TCTR to set up donation bins around the city. See the section on "TCTR (TexShred)" under "Recycling" above.

Firefighters Without Borders Canada

Central Stores (which serves the City of Vancouver) and Vancouver Fire and Rescue Service Stores sometimes donate surplus items to Firefighters Without Borders Canada (FWBC). Their President, Bob Dubbert, has expressed interest and has offered to contact the countries and groups in FWBC's network to find parties that are interested in using these decommissioned pants. He requests further information about the number of trousers and how they will be packaged, as FWBC recently received a very large donation of uniform items from Vancouver Fire and Rescue Service and found it very labour-intensive to sort and count them. This opportunity should be pursued further, with preference over TCTR.

Upcycling

Benefits:

Saves 8 tonnes CO_2e and 141 GJ of energy per tonne (before new production)

Support local enterprise

Challenges:

Security risk

Labour-intensive to mitigate risk

Insufficient demand to be sole solution; could supplement primary method

Impacts

Upcycling, also known as repurposing or material reuse, is valued for both thriftiness and creativity. Like "downcycling", or recycling items so that their raw materials can be used in new production, upcycling can reduce environmental impacts by displacing consumption of "virgin" goods and the effects of resource production, and is less energy-intensive than traditional recycling.

While environmentally desirable, "upcycling" or "material reuse" is not likely to be a viable option for the VPD. First, and most significant, is the issue of security. The VPD would have to disassemble the uniforms prior to providing them to artisans and producers of upcycled goods, which would be a very time-consuming process given the large quantity of uniforms that are decommissioned each year. Alternatively, the staff at all receiving locations would need to be security cleared.

The significant quantity of textile waste also poses another difficult in that it significantly exceeds demand. Upcycling remains a niche market with a limited range of goods being produced and consumed. If recipients can be identified and the problem of secure insignia removal and uniform disassembly overcome, "upcycling" can only address a fraction of the problem and additional methods must be identified.

Opportunities

None of the local textile non-profits and social enterprises identified – Our Social Fabric, Common Thread, and Craftworks Society - would be a suitable recipient for decommissioned uniform fabric[10]. The types of fabric which the VPD can supply are very unlikely to be desired by these local enterprises.

If it is decided that the security risks can be adequately addressed and that the benefits of diverting a fraction of the uniform waste stream outweigh the costs of doing so, other potentially interested parties could be contacted such as fashion schools, local designers, and the fashion/home economics programs at secondary schools.

Recommendations

Multiple opportunities are available to the VPD to reduce the environmental impact of its uniform disposal that also ensure that sensitive materials are not misused in a manner contrary to public safety. These methods must be considered alongside the limited financial means available to realize sustainability goals at this time.

[10] Our Social Fabric accepts only unused fabric. Common Thread exclusively uses old street banners and similar fabrics for an artistic effect. The composition of the uniforms does not lend itself to the projects that Common Thread pursues. Similarly, Craftworks Society, which employs adults with disabilities, mostly creates toys and ornaments on a small scale.

An ideal uniform disposal solution would separate the waste streams and divert them towards their optimal end-of-life destinations. Wearable uniforms should be returned to circulation in higher numbers through an expanded Stores re-use program. Footwear and plainclothes in good condition should continue to be provided to the Jail or, if there excess, donated. Highly identifiable components such as shirts and jackets should be shredded, after Community Policing volunteers remove flashes that can be re-used. Reflective vests and body armour should also be shredded for legal reasons. Trousers should be donated, and any surplus should be shredded. Pouches and belts should be incinerated in order to keep down the costs of shredding the higher-value components, as should any material suspected of contamination.

If both shredding options are too costly, incineration is the next-best alternative for shirts, jackets, reflective vests, and body armour that need to be destroyed. For pieces that cannot be donated but do not need to be destroyed, incineration or landfill are both acceptable options because the relative impacts of the two are unclear.

Table 5 summarizes the recommendations. Flashes, trousers, body armour, and reflective vests are elaborated on below.

Table 5: Recommendations

Primary Recommendations		
	Recommendations (ranked)	**Notes/Implementation**
Separate the waste streams at Stores	1) Install separate bins for a) trousers b) jackets and shirts c) boots and plainclothes and d) other gear 2) Separate the components either as uniforms are returned to Stores, or periodically before a disposal	Re-usable pieces should be organized in the re-use area according to type and size (see below). Since different materials have different optimal end-of-life disposal/processing options, these should be separated at Stores. Separating the waste streams is likely to require significant additional labour; recommend increasing the part-time Stores worker position to full-time.
Expand the re-use program	1) Add another clothing rack for shirts, jackets, trousers, and vests 2) Install shelving and bins to organize other re-usable uniform pieces	Expanding the re-use area and keeping it organized may require significant additional labour; consider increasing the part-time Stores worker position to full-time.
Shred sensitive items	1) Correspond with Pete Scott of *de*·brand and Anthony Shackleton of Trans-Continental Textile Recycling to set up tests of their facilities and procedures	Contacts: Peter Scott: pete@debrand.ca 604-638-8998 Anthony Shackleton: anthonys@transtextile.com

Incentivize continued use of older uniform components	1) Increase the costs of new uniforms 2) Implement an awareness campaign and challenge to encourage use of older uniforms	
Remove flashes	1) Have Community Policing volunteers come to Stores to remove flashes	Collaborate with Sergeant Alvin Shum to develop procedures to allow Community Policing volunteers to remove flashes from shirts that cannot be reused.
Secondary Recommendations		
	Recommendations (ranked)	**Notes/Implementation**
Reduce - Reflective Vest	1) Preferentially supply used reflective vests 2) Assign a small or nominal points value to reflective vests	Waive the points value if an officer has insufficient points, or if there are no used vests available.
Upcycling – Seek Opportunities	1) Reach out to fashion schools, secondary school home economics programs, and local designers	
Component-Specific Recommendations		
Component	**Recommendations (ranked)**	**Notes/Implementation**
Flashes	1) Removal by Community Policing volunteers 2) Removal by members or Stores employees 3) Shred	Removal of flashes could reduce costs and increase options for disposing of the shirts to which they are attached. If not, then they must be securely disposed; shredding is preferred. Incineration is acceptable if shredding cannot be used for financial or logistical reasons.
Shirts	1) Shred 2) Incinerate	Due to the potential for misuse, all shirts should be securely destroyed, with or without insignia attached. Shredding should be prioritized, whether through *de*·brand or TCTR; the second-best option would be to continue disposal at Covanta.

Trousers	1) Donate 2) Shred 3) Landfill or Incinerate	These should be donated if the risk of doing so is judged to minimal. Donation overseas may be appropriate, especially as local demand is likely to be smaller than supply. Firefighters Without Borders has expressed interest; contact Bob Dubbert (President) at bobvfd@gmail.com or 604-999-5188 to follow up with an estimate of the quantity of pants, whether they will be counted before donation, frequency of donation, and how they will be packaged. Because of their limited potential for misuse, destruction is not necessary, so landfilling can be employed rather than incineration.
Boots and Plainclothes	1) Send to Jail 2) Incinerate or Shred	Footwear and plainclothes in wearable condition should continue to be provided to the jail for inmates to use upon release. Those in bad condition should continue to be sent to Covanta, due to the chance of contamination. If a garment is known to be clean, it can be shredded.
Jackets	1) Shred 2) Incinerate	Jackets should, like shirts, be destroyed, as they are generally branded. Shredding is preferable, but should this prove cost-prohibitive, incineration is also appropriate. 100% polyester jackets without embroidery could be separately recycled, but due to the small quantity, it is more efficient to recycle them with the mixed textiles.
Body Armour	1) Shred 2) Incinerate	Body armour must be securely destroyed for legal reasons (see below).
Reflective Vests	1) Shred 2) Incinerate	Reflective vests are proprietary and must be destroyed for legal reasons (see below).
Belts and Pouches	1) Incinerate	Because of their small size, shredding these would be more difficult and increase the unit cost. They should continue to be sent to Covanta.
	Other	
Component	**Recommendations**	**Notes/Implementation**
Outreach	Contact the organizers of Vancouver Eco Fashion Week (EFW) to propose a partnership similar to the 2016 "Chic Sheets" challenge.	The VPD could provide worn-out uniform pieces to a small group of designers to create unique designs for the 2017 fashion show. EFW would be a good opportunity to raise the profile of the VPD's sustainability efforts, and connect with other resources in the sustainable textile community.

Flashes

The presence of the flashes (patches bearing the VPD crest) poses the greatest security risk because they are a clear symbol of police authority and increase the ease and credibility of illegal police impersonation. Flashes are attached to the shoulder of shirts and jackets, and are made of polyester (Patrick Jordan, personal communication, July 22, 2016). While attached, disposal must be witnessed by the VPD, which logistically limits the disposal options available and is costly in terms of labour hours (Jim Lloyd, personal communication, May 10, 2016). Because flashes are currently sewn onto the uniform, it is labour-intensive and time-consuming to remove them. An affordable and secure flash removal method could reduce recycling costs and expand available disposal options.

As noted under "Current Practice", when a uniform is brought to Stores, the officer is expected to have removed their name or ID number badge, to be re-used on their next uniform. They are not expected to remove the flashes. Both the name badge and the flashes are sewn on[11].

One solution would be to require all members to remove the flashes, in addition to their name badges, from uniforms that Stores staff have judged to be unusable. Uniforms in wearable condition would only have the name badges and ID numbers removed and would re-enter circulation through the re-use program. In this way, garments and flashes would be collected separately and Stores could re-issue the flashes that are in good condition; because officers would still be responsible for returning all pieces, there would not be a concern about flashes being misappropriated.

Another option would be to have Community Policing volunteers remove the flashes. This could take place at the Graveley Stores office to minimize transportation.

In either case, flashes could be used for a longer period, and recycling costs could be reduced because destruction would no longer need to be witnessed. TCTR would be able to switch from manual to mechanical destruction, which would also likely reduce costs. *de*·brand's shredding costs may also decrease if it allows them to use different machinery.

Body Armour

Body armour is controlled by the *BC Body Armour Control Act* and the associated *Body Armour Control Regulation*. The *Act* requires all persons in possession of body armour to have a valid license, with certain class exceptions. S 2(2)(a) of the *Regulation* exempts peace officers from the requirement of holding a body armour permit under s 2(3)(c) of the *Act*.
Therefore, body armour must be destroyed at the end of its useful life so as not to come into the possession of unlicensed civilians (Kelly Kim, personal communication, June 7, 2016). Kevlar body armour has a lifespan of about 5 years (Kelly Kim, personal communication, June 7, 2016) based on manufacturer's warranties; this may not reflect the armour's performance, which is less affected by age than by how and how often it is used and cared for (James, 2016, p. 5).

Although no statutory interpretation of the term "body armour" was located, and specifically whether it includes helmets, a plain reading of s 1(2) of the BC *Body Armour Control Regulation* suggests that helmets are likely to come under the definition of "body armour". Internally, the VPD has not considered helmets to be a prohibited item, but their practice has been to destroy them along with weapons that are not prohibited items. This practice should continue for the sake of public safety and the loss of public confidence should such objects be used in the commission of a crime.

[11] Some of the older designs have Velcro ID number badges

In the past, worn-out body armour was sent to Kelowna for recycling, where it was made into products such as work-boot insoles and blast blankets for NASA. Unfortunately, the plant relocated to Ottawa, and it became cost-prohibitive to ship the armour in part because of the weight of the material.

The armour used by the VPD is made of Kevlar or Twaron (Jim Lloyd, personal communication, July 15, 2016), two very similar synthetic para-aramid fibers common in protective gear. Both are flame-resistant and do not burn well (Jim Lloyd, personal communication, May 10, 2016), though they are currently being incinerated at Covanta. *de*·brand is able to shred it and would work with the VPD to find uses for the resulting Kevlar chips (Peter Scott, personal communication, July 20, 2016).

Reflective Vests

The reflective vests are a unique, patented design exclusive to first responders. Unlike commercially available vests, the back does not display an "X" pattern. The checkerboard pattern edging the reflective strips are colour-coded for the class of first responder; for police, they are black and grey (Kelly Kim, personal communication, June 7, 2016). As such, they must be destroyed, both because there is a prohibition on civilian use, and because the design does not meet WorkSafeBC requirements (WorkSafe BC). Incineration or shredding are acceptable disposal options for this class of material.

Before that stage, however, incentives should be considered to reduce waste resulting from carelessness engendered by its being costless to members. A nominal cost of 5 or 10 points could be assessed, with exemptions for those whose points balance is lower. Alternatively, Stores could preferentially supply used reflective vests, at least to those who had recently received another.

Future

Opportunities and incentives may change in the next several years as Metro Vancouver continues to implement the ISWRMP. Among the initiatives contemplated in that Plan is expanding Extended Producer Responsibility (EPR) programs to include textiles by 2017, which could increase the opportunities for centralized textile collection. The upcoming Zero Waste 2040 plan, which is currently under development and expected to be finalized by April 2017 (Krystie Babalos, personal communication, June 21, 2016), may provide further insight into the City's waste management goals, particularly the envisioned role of WtE incineration in a zero-waste future.

In addition, recycling technologies such as the use of ionic liquids for separating blended textiles are being investigated, and may someday become commercially viable and available. If fiber pulling becomes more commonplace and accessible, that would be environmentally preferable to each of the alternatives examined here, including shredding; if a contract with *de*·brand is pursued, interest in fiber pulling should be communicated in case *de*·brand should adopt the technology.

Future research could investigate member behaviour and attitudes toward uniforms, and develop incentives to reduce disposal rates. Another research project could also expand the analysis to identify "greening" measures across the uniform life cycle, including procurement of sustainable fabrics, eco-friendly laundering methods, and garment maintenance to prolong life.

Conclusion

By separating uniform waste at Stores and diverting each stream towards the optimal processing method, both environmental impacts and financial costs can be minimized. Paired with measures to reduce the creation of waste, and to repurpose ostensible “waste” as a resource, these changes will contribute to the VPD’s position as a leader in law enforcement sustainability.

Appendix A: Policy

Departmental

Code Green Action Plan

The Vancouver Police Department prides itself on being the first in the City to implement the new Zero Waste sorting stations and currently experiences a 65% diversion rate. It has mentored Greenest City Scholars since at least 2011, and implemented anti-idling technology during its latest fleet upgrade pursuant to a GC Scholar project. The Code Green committee continues to look for ways to fulfill the VPD's pledge "to Manage resources in an environmentally sustainable manner" and to be "a law enforcement leader in environmental sustainability" (Vancouver Police Department, 2012, p. 26).

Municipal

Greenest City Action Plan

This project aims to fulfill the Green Operations goal by reducing the greenhouse gas, pollutant, and land-use impacts associated with disposal of uniforms, and meeting the Zero Waste goal for City operations of 70% diversion for public-facing facilities and 90% for others (City of Vancouver, 2015a, p. 69).

More broadly, the project seeks also to further the Zero Waste goal of reducing solid waste going to the landfill or incinerator by 50% from 2008 levels by 2050 (City of Vancouver, 2015a, p. 27), and ultimately, a fully closed-loop or "cradle-to-cradle" economy in which all "waste" outputs are used as resources (City of Vancouver, 2015a, p. 30). The City has limited jurisdictional control over the regional waste management system, but intends to continue advocating that the provincial government continue to expand its Extended Producer Responsibility programs (City of Vancouver, 2015a, p. 29) (see Extended Producer Responsibility below).

The VPD's decision could also impact the City's Clean Air goal to meet or beat the most stringent air quality guidelines for ozone, particulate matter, NO_2 and SO_2 (City of Vancouver, 2015a, p. 51), as the current practice of incineration does create emissions of direct and indirect GHGs as well as other pollutants.

Renewable City Strategy

The Renewable City Strategy aims to derive 100% of Vancouver's energy from renewable sources by 2050, and reduce GHG emissions by 80% below 2007 levels by 2050 (City of Vancouver, 2015b, p. 6). The Strategy defines renewable energy as "energy that is naturally replenished as it is used", and extends to City-owned or operated facilities outside the City limits (City of Vancouver, 2015b, p. 20), such as the City-owned Covanta energy facility in Burnaby.

Metro Vancouver

Integrated Solid Waste and Resource Management Plan (ISWRMP)

The ISWRMP refers to the Metro Vancouver Sustainability Framework and its three "overarching principles" of decision making:

- Have regard for both local and global consequences, and long-term impacts
- Recognize and reflect the interconnectedness and interdependence of systems
- Be collaborative

The three “operating principles” (to “conserve and develop” each of natural capital, economic capital, and social capital) (Metro Vancouver, 2010, p. 6) reflect the “3 pillars” approach of environmental, economic, and social sustainability.

Provincial

Extended Producer Responsibility

The Canadian Council of Ministers of the Environment (CCME) defines Extended Producer Responsibility as “a policy approach in which a producer’s responsibility for a product is extended to the postconsumer stage of a product’s life cycle”. This is adapted from the OECD definition, which adds that this responsibility is “physical and/or financial” (Canadian Council of Ministers of the Environment, 2009, p. 3). CCME passed the Canada-Wide Action Plan for Extended Producer Responsibility (CAP-EPR) in 2009, setting an intention to have an EPR system in place for textiles (and other “Phase 2” product categories) by 2017 (Canadian Council of Ministers of the Environment, 2009, p. 12; City of Vancouver, 2015a, p. 31). EPR programs in the province are governed by the *Recycling Regulation* of the *BC Environmental Management Act*, and product categories for which an EPR exists are listed under the definition of “Product Category” in that Regulation. An EPR program for textiles could create new waste collection opportunities, similar to the Return-It depots for empty beverage containers which were developed as an early EPR program.

The Greenest City Action Plan contemplates the BC provincial government fulfilling this obligation under the CAP-EPR and adding textiles as a new product category under the *Recycling Regulation* (City of Vancouver, 2015a, p. 31). While no details are yet available, new opportunities for secure disposal could become available after 2017.

Appendix B: Questionnaire

Current Practice

1. What is the name of your agency?

2. How does your agency currently dispose of decommissioned uniforms?

3. Has your agency changed their disposal method in the past 5 years?

- Yes
- No

4. If so, what method was formerly used, and why did you change?

Alternatives Explored

5. Has your agency recently explored (in the past 5 years), or is it currently exploring, more sustainable uniform disposal methods? If so, which?

Future Plans

6. Does your agency intend to change its uniform disposal method?

- Yes
- No

7. If so, what new method(s) do you intend to implement and why?

8. If not, what factor(s) impede change?

- ☐ Security Concerns
- ☐ Disposal Fees
- ☐ Logistics/Practicality
- ☐ Labour Intensive to Remove Flashes
- ☐ Satisfied with Sustainability of Current Practice

Other (please specify):

<u>Final Comments</u>

9. Is there anything you would like to add?

Thank you!

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