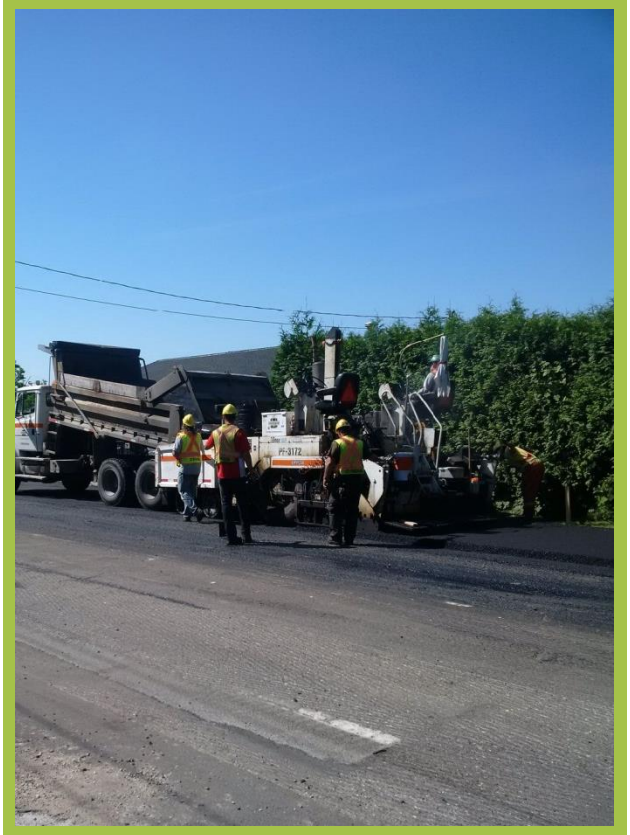
Improving Sustainability Practices by Repurposing City Construction Waste



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CITY OF VANCOUVER

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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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EXECUTIVE SUMMARY

The City of Vancouver wants to become the greenest city in the world by 2020. In order to do so the Engineering Division needs to find a way to recycle or repurpose all of their road and utility construction waste. While progress has been made towards this goal, there is still approximately 100,000 tonnes of construction waste that is not recycled each year. This project addresses this issue by exploring ways to improve current operations to increase recycling as well as investigating future opportunities for recycling the construction waste. Kent Yard's processes were at the center of this project as its facilities are the central hub for construction waste recycling in Engineering.

The first recommendations made as a result of this project focus on the asphalt production at Kent Yard. Currently, there are limitations on the recycled content that Kent Yard can incorporate into their asphalt production. The two main constraints revolve around equipment restriction and quality control and assurance measures. There needs to be improvements to the material feeding system as well as implementing a more sophisticated emission control system at the plant. There also needs to be better communication and project coordination between the various branches to help facilitate increased opportunities to use recycled materials.

Another recommendation made aims to tackle the main source of surplus construction waste, excavated soil and rubble. There is a demand for engineered soils used as a growing medium in today's market. Kent Yard could expand its current product lines to include blending an engineered landscaping soil or other similar products. This would require expansion of the current equipment as it is a completely new product for Kent Yard to produce. Also, a soil amender would need to be acquired to blend with the excavated soil in order facilitate vegetation growth. There are opportunities for synergies with both inter divisions and external companies that should be explored further.

1 INTRODUCTION

The City of Vancouver (the City) has taken initiative to make Vancouver the greenest city in the world by 2020. The Greenest City 2020 Action Plan (GCAP) sets out ten goals that will make this vision a reality. Having met several target benchmarks already and receiving 10 awards in the last year for its quality of life and sustainability efforts, Vancouver is making great strides to achieve these goals. The GCAP echoes many of the same themes set out in the City of Vancouver 2016 Corporate Plan. This document outlines ten corporate level goals with priorities to be accomplished this year. It identifies the short-term priority 3A: Green Operations Plan Priorities which states "current year focus on … reducing … construction waste rubble generated by City operations."

As part of this green initiative, Engineering Services has been charged with taking responsibility for their construction waste. Kent Yard has become a critical City operated facility in accomplishing this goal. Established in 1999, the facility has become a hub for recycling and repurposing road and utility construction waste by successfully repurposing close to 200,000 tonnes of concrete, asphalt and excavated soils every year. However, there remains room for advancement as historically over 100,000 tonnes of surplus excavated construction waste is not repurposed annually. This project aims to find new, long-term opportunities and establish best practice standards for repurposing the surplus material.

1.1 PROJECT SCOPE

As part of the Corporate Plan, Kent Yard is responsible for identifying and refining sustainable design and operation opportunities in handling the construction waste generated by the City's road and utility construction. This report will include exploring both short and long term operational modifications to processes and necessary equipment for final recommendations. All recommendations should meet the strategic objectives of the City of Vancouver and reinforce its commitment to the environment and community. These will provide guidance in the future plans for Kent Yard and its Materials Management Review.

It was the task of this project to make recommendations for the next steps in reaching a zero waste (100% repurpose and recycle) benchmark. Subject Matter Expert (SME), Jeff Markovic, estimates that for a typical year there is approximately 100,000 tonnes of surplus excavated material sent to the Vancouver Landfill without beneficial use. Therefore, the fundamental scope of this project is to establish a plan moving forward to repurpose 100,000 tonnes of excavated construction waste. This was accomplished by refining current operations and identifying new opportunities for the future of Kent Yard.

1.2 PROJECT OBJECTIVES

The project was broken down into four objectives. Each of which supported the project scope. These are defined as follows:

Objective 1: Investigate the current processes used at Kent Yard facilities

Kent Yard has been operating on an industrial scale since its founding in 1999. The intent of this objective is to establish a foundation of metrics and trends from which to base future recommendations from. Material streams and process flows were summarized in a general manner in order to keep information simplified and easily manipulated. Of primary concern in this investigation were the concrete, asphalt slab, and excavated rubble materials. It was also important to understand the flow of material streams within Kent Yard operations in case a beneficial modification to current processes was discovered.

Objective 2: Investigate other potential recycling uses

The bulk of the work for this project was spent on this objective. After establishing material flows from Objective 1, it was easier to identify the major streams of surplus construction waste and better explore their potential uses. This objective involved a literature review and meetings with other City departments to explore future opportunities and improvements to current practices.

Objective 3: Survey similar operations and supporting documents

This Objective was accomplished alongside Objective 2. Since all the branches of the City have sustainability goals it was beneficial to see if crossovers and synergies could be found. When establishing new practices and procedures, it is important to explore other similar systems' strengths and weaknesses that could offer insight on recommendations. Concepts from other systems were modified to accommodate Kent Yard's current practices and to support recycled content use for future operations.

Objective 4: Educate City staff on Kent Yard's products and services

The last Objective is intended to provide relevant City branches with a basic knowledge of Kent Yard facilities and products. It is thought that due to Kent Yard's physical separation from the core of City operations and complex hierarchy of divisions and branches, that the details of Kent Yard services may be difficult for employees to access. It is important to keep and promote a certain level of knowledge about Kent Yard in all pertinent branches so that Engineering can fully benefit from its services.

1.3 METHODS

The primary method used to develop recommendations for this project was data collection and analysis from Kent Yard's extensive data banks. Since their start in 1999, Kent Yard has kept records of material flows and processes. The most recent years have data logs of the daily inflow and outflow of material from weigh scales as well as daily processed material totals for the crushing facility and the asphalt plant. This played the largest role in Objectives 1, 2 and 4.

Literature review also was a vital task to the successful completion of this project. An investigation of other large scale projects that produced a bulk amount of concrete, asphalt or excavated soils

waste was conducted. Cases where there were mandatory benchmarks for recycling or repurposing the material were of particular interest. This was most important for completion of Objective 2.

Several meetings, interviews and a webinar were attended throughout the project. Information was gathered and opportunities for collaboration and synergies were discovered between Kent Yard and several other areas of the City of Vancouver. The webinar was particularly informative on the processes and standards other municipalities set in order to create their own green and sustainable cities.

2 BACKGROUND STUDY

The intent of the background study is to understand the goals and initiatives set out by the City that provided the motivation for this project. There are two main documents of reference for this review: the Greenest City 2020 Action Plan (GCAP) and the 2016 Corporate Plan for the City.

2.1 GREEN CITY 2020 ACTION PLAN

The initial release of the GCAP in 2012 laid out the goals for the City in order to become the greenest city in the world by 2020. In development of this plan, the public was engaged on several levels. One of the critical points that came from public engagement is that the City needs to be an example for the initiatives they set. As part of this the City aims to divert surplus waste from the Vancouver Landfill (VLF) including the waste produced through construction operations in its branches.

In the 2015 publishing of the GCAP Part Two: 2015-2020, the City states the goal to reach "zero waste". This means that City facilities and City-owned or operated facilities will need to divert a large portion of their waste away from the VLF. Currently, a waste reduction target for all City operations is still under development. Once established, it will place an aggressive benchmark on the amount of construction waste that needs to be recycled and repurposed from City operations in Streets, Water and Sewers. This is done to minimize the environmental impacts that come from large scale construction projects.

2.2 CORPORATE BUSINESS GOALS

The 2016 Corporate Plan is the latest public document from the City which outlines its overarching green goals and business initiatives. It gives perspective for City staff and departments to understand how their individual actions play a part in the larger City strategy. The Corporate Plan outlines 10 long-term goals with unique initiatives to meet by the close of 2016. Public opinion took high priority in developing this document as well as it offers a more wholistic approach to green business operations. This project directly addresses goal 3A which states the need to reduce waste from City contruction projects. This directly affects Kent Yard as it is currently the central hub for processing road and utility constructruction waste.

3 OBJECTIVE 1: INVESTIGATE THE CURRENT PROCESSES USED AT KENT YARD FACILITIES

To see how Kent Yard operations may function in the future it is important to see what it has done in the past and what it is currently doing today. This objective was intended to provide a glimpse into the past and present operations at Kent Yard facilities. The flow of various materials was of greatest interest as there was a need to identify which materials are in surplus and which materials are in shortage, if any. This will create a point of focus for further investigation and facilitate the conversation surrounding recycled material use.

3.1 INTRODUCTION TO KENT YARD

Kent Yard was commissioned in 1999 in order to help Engineering manage internally produced road and utility construction waste. Today, it is a 12.5 acre facility that manages construction waste in the form of recycling and repurposing material in a beneficial way. Located in Vancouver proper, on the north bank of the Fraser River, Kent Yard is ideally situated to provide service for City operations. Its proximity reduces trucking distances from projects thereby lowering transportation costs and greenhouse gas emissions associated with hauling material. Coupled with bulk material purchasing, this allows Kent Yard to provide competitive pricing on construction materials.

Through years of strategic expansion, Kent Yard now includes an asphalt plant, barge and aggregate conveyor system, materials testing lab, trucking scales, water retention and treatment facility, ready-mix concrete plant and rubble sorting and crushing facilities. This allows Kent Yard the capacity to accept and process three dominant types of construction waste material commonly referred to as rubble, slab and millings. These are defined as native excavated soils, concrete and asphalt slabs, and ground up pavement respectively, which are recycled as a portion of new construction materials for the City's projects.

The cycle of taking old construction materials and using them as a resource for future needs is referred to as urban mining. This follows Engineering's green philosophy because it not only reduces the amount of waste sent to the landfill without benefit but also decreases the demand for virgin, or new, construction materials such as gravel and sand. By reducing the demand for natural resources, Kent Yard helps Engineering Services promote lower capital and life-cycle costs, energy use, carbon and organic emissions while promoting the extension of infrastructure life cycle and satisfying public interest.

3.2 OPERATIONS AND STATISTICS

3.2.1 INBOUND MATERIAL

The City upgrades approximately 1% of Vancouver's infrastructure annually in order to keep systems and roads in proper working condition. In 2015, Kent Yard received over 330,000 tonnes of City construction waste from such projects. This material is generated primarily from three City branches: Streets, Water, and Sewers. Kent Yard also accepts roughly 50,000 tonnes of concrete and

asphalt slab from private contractors annually. Despite steady improvements in recycling construction waste, Engineering Services has a significant surplus of material that is not being recycled or repurposed.

All three branches, Sewers, Streets and Water, produce excavated rubble and slab as a construction waste product. Streets is the only branch to produce road millings. A grand total of 388,000 tonnes of construction waste was processed by Kent Yard in 2015. Figure 1 shows the material flow paths taken by construction waste. From left to right it identifies the origin of the material, how much of each material is received by Kent Yard, amount of each material after Kent Yard processes them, and the final destinations for the material. It is important to note that nearly 33% of construction waste materials are not being put to beneficial use.

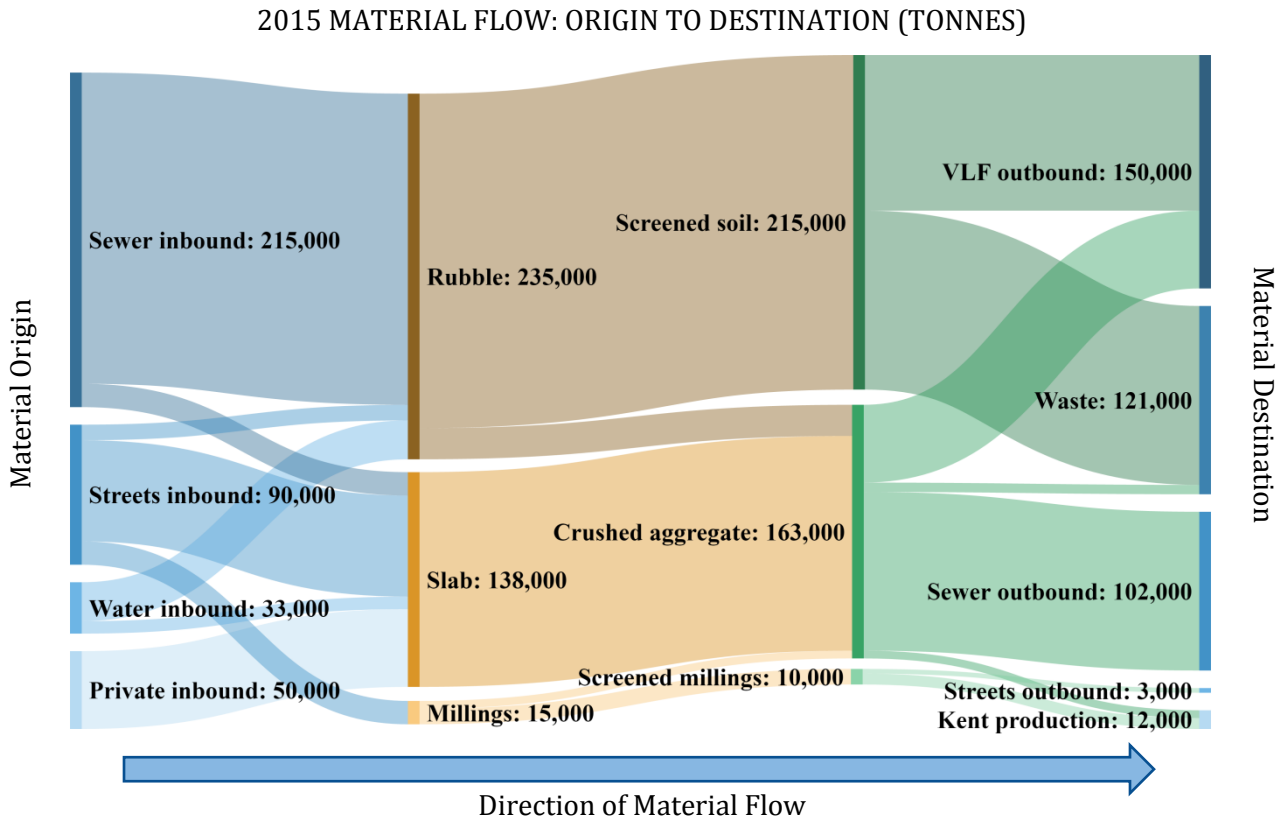


Figure 1: Construction waste flow from origin to destination

This figure clearly shows that excavated rubble has the highest volume with 235,000 tonnes being produced in 2015. Also worth noting, is that Sewers Operations is the largest producer of construction waste. They produced 215,000 tonnes of total combined construction waste in 2015, which is more than the combined total of Streets, Water and private sector waste. This is largely because the city sewers are gravity systems and therefore often require excavating at a greater depth in order to achieve positive drainage in the sewer pipes. A summary of Kent Yard's inbound material streams are provided in Table 1. Not shown in Table 1 is the 215,000 tonnes of virgin mineral aggregate that are imported to Kent Yard.

Table 1: Inbound construction waste streams by City branch, 2015

2015 CONSTRUCTION AGGREGATES INBOUND (TONNES)					
MATERIAL	**BRANCH**				
	SEWERS	STREETS	WATER	PRIVATE	TOTAL
Excavated Rubble	200,000	10,000	25,000	0	235,000
Slab	15,000	65,000	8,000	50,000	138,000
Millings	0	15,000	0	0	15,000
Total	215,000	90,000	33,000	50,000	388,000
% of inbound per branch	55%	23%	9%	13%	100%

3.2.2 KENT YARD PROCESSES

The raw construction waste materials, once brought into Kent Yard, are sorted and processed for recycling and repurposing. For the contents of this paper, recycling will refer to the modification of raw construction waste that is then blended with new construction materials to produce a "new" construction product. Repurposing of construction waste material will refer to materials that are not modified in any substantial way and reused "as is". An example of a recycled product produced at Kent Yard would be warm-mix asphalt with recycled asphalt pavement (RAP) content while a repurposed product would be the rubble that is used without substantial modification.

When the material is delivered to Kent Yard it is weighed and sorted into an appropriate stockpile. The two main piles are slab and excavated rubble. Oversized rocks and boulders from the rubble are placed in a different pile to be treated with the slab. The slab and boulders are then crushed by a private contractor on site. The crushed product is made to specifications set out by contract and stockpiled once more to be reused in new projects.

The mineral aggregate is barged into Kent Yard along the Fraser River, offloaded and stockpiled until needed. These various mineral aggregates are then used in the production of asphalt, concrete or as road construction material. These can be anything from recycled slab, to mineral aggregates, to binders and other cementitious materials. The finish product will go out to construction sites to be put to use. Figure 2 shows part of Kent Yard production process. The left shows the slab stockpile being fed to the crusher at the center. In the right forefront is a crushed product stockpile that is ready for blending.

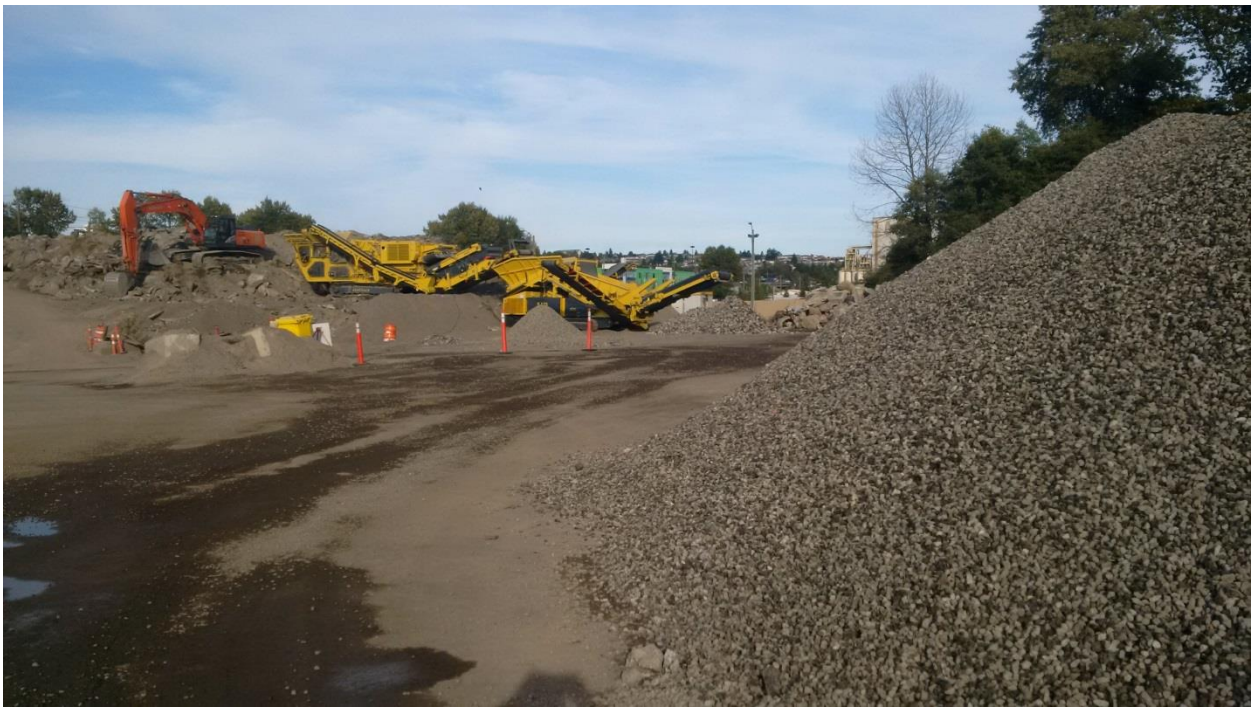


Figure 2: Kent Yard recycled aggregate production (Photo Courtesy of Kent Yard)

3.2.3 OUTBOUND MATERIAL

The use of recycled product is variable by City branch. Table 2 shows the use by branch of both mineral and recycled aggregate, which does not include excavated rubble. Sewers Operations is the most significant user of recycled aggregate. With over 100,000 tonnes of recycled aggregate used in 2015, they account for 61% of all recycled aggregates, more than all other branches combined.

The VLF is also a large recipient of recycled aggregate. They use the material to build temporary roads to access landfill piles and for use in permanently closing garbage cells. Around 60% of material used by Sewers is recycled. This is a significant volume when comparing use by Kent, Streets and Water Operations, which have 7%, 2% and 0% of material use being recycled aggregate respectively. One reason for these low recycled material rates is concerns over potential contamination of the aggregate being placed around or above the city water pipes. This would restrict the use of crushed slab as it potentially contains motor oil, petrol and other chemicals found on roadways and in asphalt and concrete.

Table 2: Material outbound by City branch, 2015

2015 CONSTRUCTION AGGREGATES OUTBOUND (TONNES)							
MATERIAL	**BRANCH**						
	SEWERS	STREETS	WATER	MISC.	VLF	KENT	TOTAL
Mineral Aggregate	67,000	25,000	40,000	3,000	0	80,000	215,000
Recycled Aggregates	102,000	3,000	<100	100	50,000	12,000	167,100
Branch Total Aggregate Material Usage	169,000	28,000	40,000	3,100	50,000	92,000	382,100
Branch % of Recycled Aggregate Usage	60%	11%	0%	3%	100%	13%	44%
% of All Recycled Aggregates	61%	2%	0%	0%	30%	7%	

3.2.4 Long-Term Trends

Kent Yard's production requirements are highly irregular. They depend on the rate of material being delivered from projects as well as the rate of material being sent out to construction projects; both of which can be sporadic and differ from the intended schedule. It is well known that construction season peaks during the summer months and slows considerably during the winter. It's expected that material production would follow a similar trend. This is not always the case. Looking at the monthly volumes of crushed material for 2015, shown in Figure 3, it is clear to see the irregularity of the material flow. January shows no production at all while there are two main spikes outside of what is considered peak construction season; one in April and the other in October.

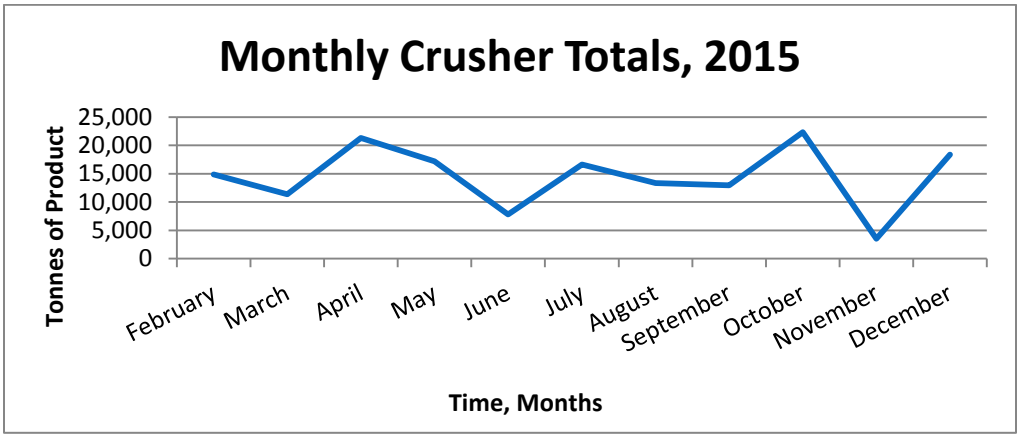


Figure 3: Monthy production of recycled aggregate, 2015

The majority of the irregularity can be explained by the gaps in communication and coordination between Kent Yard and the City branches. City Engineering currently does not follow an established communications or planning protocol with Streets, Water or Sewers, therefore, there is no short-term predictive capacity for inbound and outbound material streams. This makes it especially difficult to plan the reuse of these materials, including creating the crushed products.

There are also times when Kent Yard reaches maximum stockpile capacity and is unable to accept any more material. This results in a direct loss of material that Kent Yard could process and put to beneficial reuse. Instead, this material is sent directly to the VLF to be disposed of. Developing suitable communication system and construction project coordination would help Kent Yard to create a steady production stream and prevent material from being sent elsewhere.

Over time Kent Yard has circumvented these challenges and has steadily increased the use of recycled material in their products.

Figure 4 show the trends for recycled material, mineral (virgin) aggregates and total of all material since 2000. We can see the trend line for recycled material has steadily increased at the same rate that the virgin material has decreased. On average, the rate of incline and decline is approximately 13,000 tonnes per year. Kent Yard has been able to improve operations to the point that the volume of recycled material is almost equal to the volume of virgin aggregate. Overall, the trend for total material demand has been relatively steady at roughly 410,000 tonnes since 2000. The City experienced worker strikes in 2000 and 2007 which caused drastic drops in production and material consumption for those years.

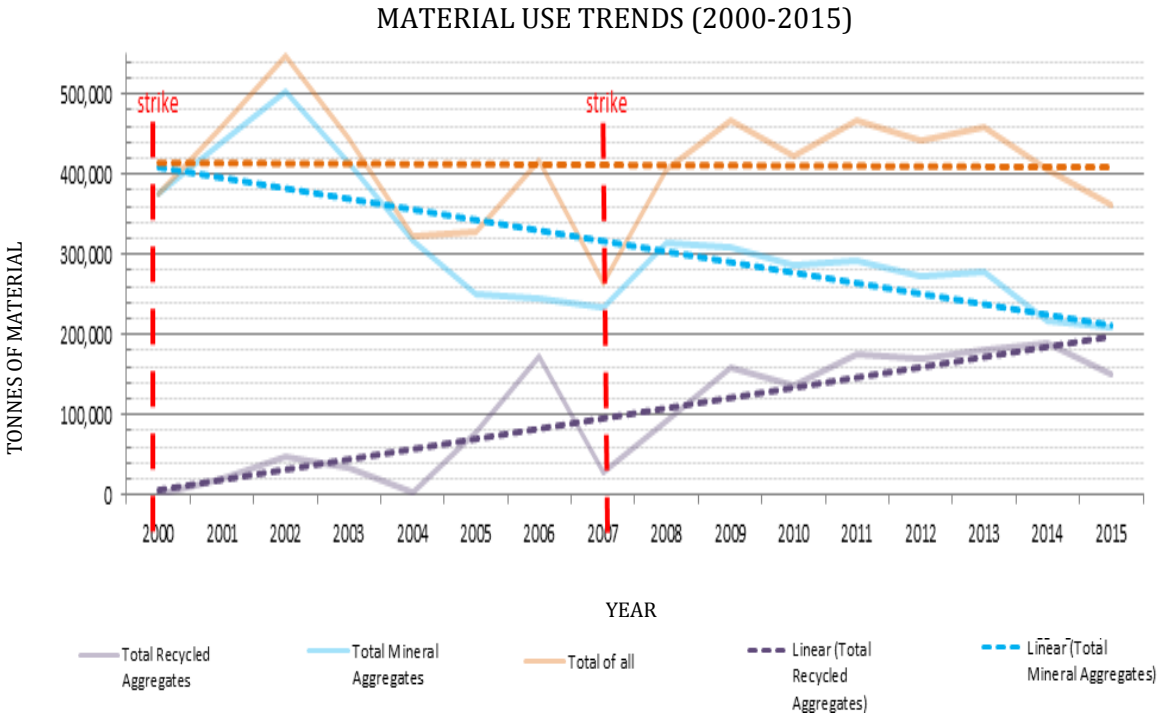


Figure 4: Material use trends (2000-2015)

In consideration of these obstacles and accomplishments, City Engineering continues to facilitate the City's corporate goals and to meet Engineering's service objectives. Quality control and assurance needs to be a core consideration in all their processes and products to ensure that City operations continue to function smoothly. While exploring opportunities to incorporate increased recycled material into production, understanding the most efficient use of products without sacrificing quality should be a priority.

4 OBJECTIVE 2: INVESTIGATE OTHER POTENTIAL RECYCLING USES

As stated previously, Objective 2 is a direct follow through of Objective 1: Investigate current operations. Having established baseline production statistics for Kent Yard and getting a general understanding of material flow and processes, it is clear to see where the majority of surplus waste material will come from. In future years, when the VLF has fewer garbage cells to cap and is receiving less waste as per the Green Operations and Zero Waste plan established in the GCAP and Corporate Plan, rubble will constitute the main portion of Engineering's surplus material. Given that excavated rubble was found to be the most wasteful material by weight, determining ways to repurpose it was a primary task for the project with asphalt and concrete slab being of lesser focus.

After discussion with Kent Yard branch manager and local Subject Matter Expert (SME), Jeff Markovic, it was determined that the most beneficial course of action would be to provide Kent Yard with some lateral diversification. For this report, lateral diversification will refer to the expansion of finished product types. Kent Yard already has several products that it produces but to create long-term stability, new opportunities should be explored. The justification behind this reasoning is simple. A business that only relies upon a select few products has less financial stability than a business with a diverse range of products when a demand for a particular item drops.

4.1 LITERATURE REVIEW

The literature review performed served as a brainstorming activity to explore how other cities and contractors deal with their construction waste. The City is fairly unique in that it has its own internal construction crews which are responsible for road and utility construction. Most other municipalities hire private contractors to repair and maintain city systems. Therefore, it was difficult to find reports on other cities who successfully manage internally produced construction waste.

The first topic review performed targeted concrete recycling. Concrete being the more versatile of the two slab materials, asphalt and concrete, it was logical to see what unique uses concrete could fulfill. The most common suggestions made were to crush the concrete slabs into gravel and use it as a base or backfill material or as aggregate for new concrete. Smaller slabs of concrete can also be used as retaining walls, erosion control, to create raised garden beds or as walkway stepping

stones. These concepts, however, do not easily scale to the level necessary for Kent Yard's operations. Demand for this type of product would be difficult to determine within the timeframe of this project. At this time, these were not viable options for Kent Yard to pursue.

The second area explored through the literature review process investigated different ways that excavated soil could be repurposed. Crossrail, the company responsible for the construction of a new railway in London, England has successfully repurposed 98% of the seven million tonnes of excavated material generated from their project. This was done by diverting the material across several other regional projects. It was used to create wildlife habitat and reserves, wetland nature reserve, agriculture, grazing pastures, a golf course and to assist landfill restoration. The new purpose for the excavated soils in these projects is roughly summarized as soil repurposed as a growing medium for other local projects. Since Crossrail was able to successfully repurpose nearly all of its excavated soil on such a large scale it was worth further investigation to see if Kent Yard would be able to adopt similar tactics to tackle its rubble surplus.

4.2 ASPHALT

Since Kent Yard already produces warm mix asphalt with recycled content in bulk, a brief exploration into their processes was performed to see if any easy opportunities could be found. The investigation discovered that Kent Yard can and does incorporate up to 25% Recycled Asphalt Pavement (RAP) into their warm-mix asphalt. This is approaching the upper limit of adding RAP in terms of the facility equipment, quality control and quality assurance objectives.

4.2.1 CONSTRAINTS

Kent Yard is limited from incorporating more due to two reasons. First, permitting for the asphalt plant restricts the amount of greenhouse gas emissions during asphalt production. The asphalt plant runs on a batch process and not on a continual basis. This allows the plant to create different mix designs from truck to truck to better service multiple job sites at once. The piece of equipment that controls the RAP feed into the mix, the surge hopper, is only able to hold around 650 kilograms for every 2.5 tonnes of asphalt produced. The RAP is added after the virgin material has been heated so that it is heated by induction, sandwiched between layers of hot mineral aggregate. For each batch, this works out to roughly 25% recycled content. If additional RAP were to be added to a mix design, with the current operating equipment, if would need to go through the heating drum with the mineral aggregate. This would cause the old asphalt cement to burn off creating huge quantities of greenhouse gas emissions.

Quality control is the second limiting factor for RAP content in asphalt. Using RAP reduces the quality of the finished product but not beyond acceptable standards. Quality becomes a problem only when the asphalt plant is not able to run continuously or on a consistent basis. This happens as a direct effect of small jobs that are scheduled sporadically. The plant is unable to reach a steady rhythm of production and it is therefore much more difficult to achieve quality standards. Kent Yard has had success incorporating high levels of RAP for surface coarse asphalt in arterial roadways which require a more robust asphalt mix. Figure 5 shows a high performing arterial road

that was paved with warm-mix asphalt containing 20% RAP content. Large jobs are much easier to increase the RAP content as the plant operates most efficiently for large scale production.

Figure 5: High-performance arterial road paved with warm-mix asphalt containing 20% RAP (Photo courtesy of Kent Yard)

4.2.2 Potential Solutions

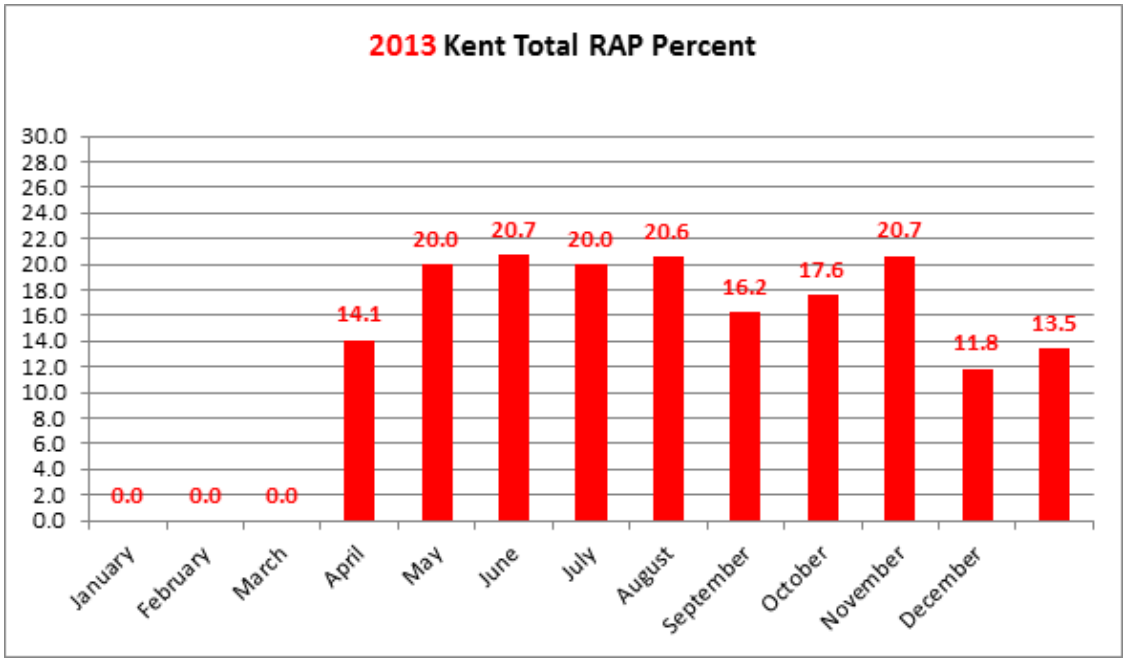
The first obstacle, emissions permit limits, can be overcome with newer technology that will reduce greenhouse gas produced by the asphalt plant. Examples of improvements to the asphalt plant equipment could include a double burning system or emissions scrubber. The double burner would feed the emissions produced from heating the mineral aggregate back into the drum to be burned a second time using the greenhouse gases as additional fuel. Kent Yard could alternatively incorporate an emissions scrubber to remove greenhouse gases and any other contaminants before the plant exhaust is released back into the atmosphere.

Kent Yard could increase RAP content without substantially altering plant emissions by installing a larger surge hopper for their system. This would be the most direct way to boost recycled content. Increasing the size of the surge hopper however, would not be enough on its own. The plant creates a batch of asphalt every 45-60 seconds. At this rate the current material bin that would feed the larger surge hopper would only stay full for 6-7 minutes. This is too short of a time for the heavy equipment operators to maintain adequate supply of RAP for the asphalt plant. Therefore, Kent Yard would also need to install a second material bin that feeds into the improved surge hopper simultaneously. The financial implications for these options could be quite significant. Feasibility studies will need to be performed in order to quantify the exact costs associated with these upgrades and their respective benefits.

Overcoming the problem of managing quality control, the second constraint, would require more organizational management. Kent Yard SME Jeff Markovic verifies that asphalt with 25% RAP content has no quality problems when the plant is producing large batch orders. Consistency is the key for creating a quality product. The only time where the RAP asphalt mix is at risk for quality problems is when the batches are small or the plant is run irregularly. Current practice

investigations show that Kent Yard reduces the RAP content for small batches in order to still meet quality standards. If several small projects were set up to be paved on the same day Kent Yard operations could produce asphalt as a bulk order and keep the RAP content high for all of the projects. This would require coordination and regular communication between Kent Yard and the various branches of the City who require asphalt for their construction projects.

From 2013 to 2015 annual average RAP content over all mix types supplied ranged from 13.5% to 16.2% as shown in Figure 6. The last value on each graph is the annual average RAP content for its respective year. 2014 shows the ideal trend for RAP content in asphalt. During peak construction season, the asphalt plant is able to produce bulk amounts of asphalt in which higher RAP content is achievable. During the slow construction season, the RAP content is much lower. Years 2013 and 2015 show erratic RAP content each month with no clear trend curve. This is due to scheduling limitations and series of small projects that require only small amounts of asphalt per day. As mentioned previously, the asphalt plant operates at peak efficiency with the highest RAP content for large orders. This establishes consistent operation and produces the best quality product. These figures further support the need to coordinate small projects to pave at the same time. This is not to say that their mix design would necessarily be the same. Kent Yard has the capacity to change the asphalt mix to different specifications from one truck to the next without delay in production. If these smaller jobs were synchronized, and communication lines established between Kent Yard and Streets, Water and Sewers there would easily be an increase in the RAP content for future asphalt production.



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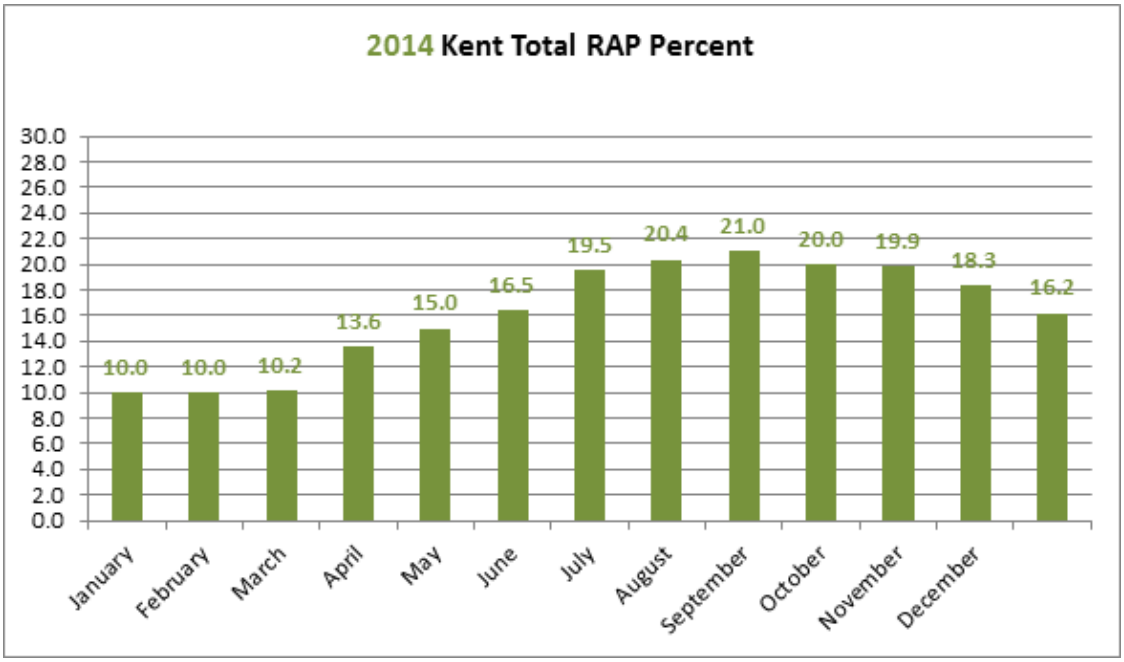

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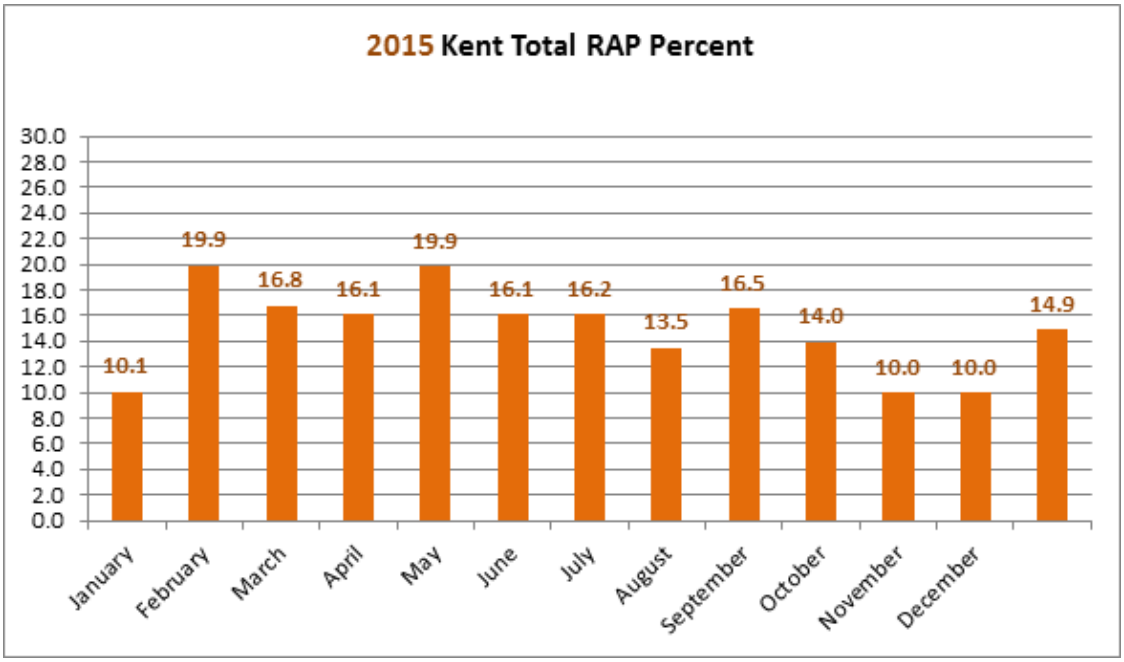


(c)

Figure 6: Average asphalt RAP content per month (2013-2015) and annual; (a) 2013, (b) 2014, (c) 2015

On average, RAP content is around 20-21% for all asphalt production during the second and third quarters and 14.9% for a three year average. SME Jeff Markovic estimates that approximately 75% of asphalt pavement produced at Kent Yard goes to collector and local roads which are more likely to be small projects. If the RAP content for these projects could be increased by grouping asphalt

production we could see up to an additional 10% RAP content from the previous years. This would equal roughly 6000 tonnes of recycled slab annually assuming perfect synchronization of all local and collector road projects.

4.3 Excavated Soil and Rubble

4.3.1 Growing Medium

During the investigation it was important to keep the big picture in mind. While there were many solutions presented in the Crossrail's project, none of them could be identically replicated for Kent Yard since they only provide a short term waste diversion plan. Kent Yard needs a long-term, steady solution for their surplus material. A once-off project or short-term demand for the rubble would not solve Kent Yard's material surplus for long. However, using Crossrail's success as guidance, a feasible use for excess excavated soil would be to create a growing medium for various other projects that provide long term demand.

4.3.1.1 Desired Specifications

There are a wide variety of growing medium types, each with its own set of desired specifications. Two sources were used to investigate the best soil specifications for Vancouver. The first document reviewed was the Master Municipal Construction Documents (MMCD). These are a set of documents that were developed through a collaborative process between government, consultants, contractors and owners. They are widely accepted throughout British Columbia and provide a solid foundation for municipal infrastructure projects. Section 32 91 21 of the MMCD documents outlines the requirements for various types of topsoil based on its traffic loading. These specifications are briefly summarized in Table 3.

Table 3: Topsoil specifications as per MMCD

Properties of Growing Medium for Different Applications			
Application	Low Traffic	High Traffic	Planting Areas
Texture	**Percent of Dry Weight Mineral Fraction (%)**		
Gravel	0-10	0	0
Sand	50-70	80-90	50-70
Silt	10-30	5-20	10-30
Clay	7-20	2-5	7-20
Acidity (pH)	6.0-6.5	6.0-6.5	5.0-6.0
Minimum Hydraulic Conductivity (cm/hr)	2.0	7.0	2.0
Organic Content (% Dry Weight)	5-10	3-5	25-30

Another source for growing medium specifications was found in the City's Request for Proposals (RFP) reference number PS20150950. This outlines the contract requirements for fulfillment of Streets and Parks soil needs. The soil specifications from this document are outlined in Table 4. In total, the document states a need of over 7,500 cubic yards of material soil.

Table 4: Topsoil specifications as per RFP PS20150950

Product Specifications						
	Park Shrub Mix	**Park Turf Blend**	**Special Turf Blend**	**Soil Amendment**	**Street Turf Mix**	**Street Shrub Mix**
Carbon:Nitrogen	<30:1	20:1-10:1	20:1-10:1	25:1-10:1	20:1-10:1	20:1-10:1
% Organic Matter	20-30%	10-20%	5-15%	40-65%	3-10%	10-20%
% Sand	50-70%	70-85%	75-90%	15-35%	30-60%	30-60%
% Silt	10-25%	5-15%	5-15%	5-15%	10-35%	10-35%
% Clay	0-15%	0-15%	0-15%	7-17%	5-15%	5-15%
Total Silt & Clay	25% max	20% max	20% max	15-30% max	40% max	40% max
Acidity (pH)	4.5-8.0	4.5-8.0	4.5-8.0	4.5-8.0	6.0-7.0	4.5-6.5
Max Particle Size	100% passing the 0.5" sieve	100% passing the 0.5" sieve	100% passing the 0.375" sieve	100% passing the 0.5" sieve	100% passing the 0.5" sieve	100% passing the 0.5" sieve
Demand (yd^3)	654	1259	56	919	4524	139

Both of these specifications have several common themes. The most important is to note that nearly all of the designs require a large portion of sand with little to no gravel and clay. The level of acidity for all of the different soil types are quiet close as well and fall near 6.0 pH, but the organic content varies significantly depending upon the intended use for the product. This can range anywhere from 3% to 90%.

4.3.1.2 Engineering's Excavated Soil and Rubble Data

Kent Yard has been collecting data on the inbound excavated rubble for several years. One particular data set that was useful for this project compiled the gradation results of nearly 250 samples collected from 2006 to 2013. The summary of this data is shown in Table 5. Based on the averages for the samples it is safe to conclude that excavated rubble is composed of approximately 55% sand and 20% gravel. While there are some samples that contain gravel larger than 12.5 mm, it is fairly rare which is the typical maximum grain size allowed in the RFP PS20150950 standards. Of the remaining 25%, SME Jeff Markovic estimates that a very small portion is clay. Conservative estimates place the clay content as 5% or less. The remaining 20% is silt. With these values (75% sand and gravel, 20% silt, 5% clay) it is clear to see a strong likeness to the two sets of specifications for growing mediums.

Table 5: Gradation summary for rubble (2006-2013)

Percent Passing													
Sieve Size (mm)	50	37.5	25	19	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Ave	99.3	98.5	96.3	94.5	91.4	89.5	83.9	79.6	74.5	66.6	50.6	36.1	26.7
Min	71.2	68.4	65.1	62.8	59.0	55.4	40.7	33.3	25.5	16.8	9.5	1.9	0.1
Max	100	100	100	100	100	100	100	99.9	99.8	99.4	95.4	93.2	87.9

Often, the concern of contamination in excavated soils is a large deterrent to its use. Kent Yard takes steps in its quality control and assurance measures to avoid contaminated soils. Its facilities will refuse to accept any rubble that shows signs of potential contamination. The on-site laboratory is fully equipped to test for a variety of potential contaminant including hydrocarbons and heavy metals, the two most common concerns. Previous test results show that the sampled excavated rubble contains negligible amounts of hydrocarbons or heavy metals.

As for the other details in the specifications, more testing and investigation is needed. Currently, no tests on the carbon to nitrogen ratio or hydraulic conductivity of Kent Yard's rubble have been performed. Additionally, the rubble can be assumed to have little or no organic content as it is typically excavated from a depth greater than the topsoil or root bearing soil. In order to increase the organic content and provide nutrients for future plant growth, the rubble would need to be blended with a soil amender. This could vary from yard trimmings, to food scraps or even fertilizer.

4.3.1.3 Collaboration Potential

There are several large manufacturers of soil amender that should be investigated should this route be pursued. The most local and also internal source that was explored was the compost produced at the VLF. Currently, the VLF collects yard trimmings as part of their regular garbage and recycling collection. These trimmings are then mulched and placed in windrows for approximately six months, getting turned every month to help facilitate decomposition of the organic matter. At the end of the windrow period, the compost-mulch mixture is sent through a screen that separates the oversized pieces from the fine, ready to use soil-like compost. The oversized material is sent back into the windrows for another six months while the fine grained compost is sold. Approximately 8,000 cubic meters of compost are produced annually this way. However, the VLF is currently in the process to identify the best market for their product and collaboration between VLF compost and Kent Yard rubble is unlikely at this time.

Other operations that could offer some synergies are Harvest Power and Metro Vancouver. Harvest Power is responsible for composting Vancouver's food scraps and may have extra compost for purchase. They market several ready-made soil-compost blends as part of their product line. Metro Vancouver produces *Nutrifor™* biosolids cake. Both products could be potential soil amenders for Kent Yard's excess rubble. It is known that Metro Vancouver produces approximately 50,000 wet tonnes of Nutrifor biosolids and works with a private contractor to blend this with aged bark and river sand to create a landscaping soil. Biosolids Project Coordinator at Metro Vancouver has confirmed that there is typically an excess of Nutrifor biosolids every year. There are a multitude of

other fertilizer options within the private sector that should be explored in more depth than this project was able to cover.

4.3.1.4 Potential Issues

One potential pitfall for this plan is the difference of an ideal blending medium and the rubble that is available. Currently, both the VLF and Metro Vancouver blend their products with river dredged sand. This material has very consistent physical and chemical properties that make it ideal for quality control and assurance. As the Kent Yard's rubble comes from a variety of locations across the Vancouver area, soil properties can vary from truck load to truck load. It is also known that sand created by water erosion is typically preferred to all other sands as it has superior physical properties. However, with over 40 billion tonnes of water produced sand consumed per annum globally, consideration should be given to its most valuable uses. A growing medium might be a product where an excellent blending material is acceptable in lieu of the perfect blending material. The finished product would be more sustainable and environmentally friendly by using excavated rubble.

While the rubble closely resembles the desired gradation for many of the soil specifications it is not a universal fit. To overcome this problem, Kent Yard may need to investigate potential gradation facility options. Currently, Kent Yard separates the boulders and slab larger than one foot in diameter out from the rest of the excavated rubble, but at present does not have the capacity to separate coarse sand, fine sand, silt and clay. Options to explore could include a series of settling ponds, electrocoagulation, wash plant or a water based centrifuge system. As space at Kent Yard is at a premium, the settling ponds would be less desirable as they would occupy the most real estate. It is probably the least costly of the options however as it is a gravity system it is very simple. Electrocoagulation may not be a viable option either unless placed in conjunction with the settling ponds, as it will force all of the suspended material to settle out at the same time. A centrifuge system or wash plant may be the best option but further investigation is needed to determine the benefits and drawbacks of each system.

4.3.1.5 Demand

Part of a good business plan is to create a product with market demand. In order for this idea to gain traction there must be a meaningful purpose for the engineered growing medium. As mentioned previously, the City issued a Request for Proposals for over 7,500 cubic yards of growing soil early in 2016. Evidence from the VLF shows a strong market for the sale of its compost to private industry. Metro Vancouver also supports this claim as they currently create their own landscaping soil in partnership with a private contractor from their 50,000 wet tonnes of Nutrifor biosolids. Further market analysis is needed to determine if Kent Yard can be competitive with the private sector.

Another purpose for an engineered growing medium comes as a direct result of fellow 2016 Greenest City Scholar and Mentor, Water Conservation Planning Analyst. As part of the initiative to support the responsible use and conservation of water, Cook has investigated the ideal depth of topsoil for private land, including single family homes. As the City prefers to be at the forefront of sustainable initiatives, this suggestion will likely be extended to parks and boulevards as well. The

study has discovered that 450 mm of topsoil provides the depth necessary for water retention and nutrients to support vegetation and reduce water consumption. Current MMCD specifications require only 100-150 mm of topsoil for lawn areas. A member from Engineering Services in the Streets and Electrical Design branch has noted that boulevard restoration projects struggle to get any more than 50-100 mm of topsoil cover.

If the topsoil requirement of 450 mm becomes a standard, projects will require an additional 300-400 mm of topsoil cover for targeted projects. In 2015, the City issued over 1500 building permits for new residential properties. Assuming a lot size of 33'x120' and that 70% of each lot is covered by non-permeable material this translates to an 84,000 tonne increase in topsoil demand annually. Kent Yard can be on the forefront to meet this demand if action is taken now to solidify soil amender sourcing and rubble blending ratios.

Kent Yard can also supply additional soil cover for Streets' boulevards. Currently, grass and other vegetation struggle to take hold in the 50-100 mm of topsoil most greenways have at present. However, there is no current estimate for annual restored or developed greenspace on boulevards so the potential demand for soil is unknown. The City will also apply the topsoil requirement for Parks projects but current opinion holds that Parks already meets or is very close to meeting the 450 mm suggested requirement for topsoil cover and would therefore not substantially increase demand for topsoil.

4.3.2 Fill and Backfill Material

Kent Yard has recently begun to explore the option of blending excavated rubble with mineral aggregate for use as a backfill material on City projects. In July 2016 the first production trial was performed. This involved a coarse mineral aggregate that was blended with approximately 20% rubble by weight. Quality testing shows that the blend still met all specifications. Incremental increases in the rubble content should be performed during future blending trials to determine a safe maximum rubble limit.

Another opportunity might be found by coordinating City projects with the private sector. Various private projects are always in progress in the city of Vancouver. These projects, depending on type and progression, might need extra soils for fill or backfill purposes. If it could be coordinated that soils, once excavated from the City's projects, be sent to the private sector projects the City would then save the time and energy that would normally be spent hauling the rubble to Kent Yard or the VLF. While this is a very specific scenario, it has been suggested that a mapping tool could be created to help with the logistics involved, mainly scheduling and proximity. This tool would need to map both City and private projects as well as denote the projects that are creating or willing to receive excavated soils. If a synergy is found, efforts should be taken to either schedule the excavation for when the receiving project needs the soil or to find a temporary holding area that is easily accessible for the private contractor.

Figure 7: Blending rubble with mineral aggregate for backfill (Photo courtesy of Kent Yard)

4.3.3 Material Stream Modification

While rubble has been identified at the most abundant material, concrete slab is conversely in shorter supply. Already, Kent Yard accepts 50,000 tonnes of concrete and asphalt slab from the private sector which helps to keep a sufficient stockpile of the material. Additionally, boulders larger than one foot in diameter are separated from the rubble to be crushed and blended with the recycled concrete slab. Both of these actions help to increase the recycled content from concrete slab.

If Kent Yard decides to pursue topsoil as a future product, the excavated rubble will have to be screened to remove particles that are too large. Previously stated specifications on topsoil require that rocks larger than 0.5 inches (12.5 mm) in diameter be removed from the finished product. Based on the gradation tests from 2006 to 2013, roughly 8% of rubble would be larger than 0.5 inches. If all of the rubble was screened this would equal an additional 16,000 tonnes of clean

aggregate. This material could be sent to the crusher to be broken down further or used as is depending on the final product requirements to extend the concrete slab supply.

Another opportunity to extend the concrete slab stockpile comes from the private sector. The City has instituted the Green Demolition Bylaw which places regulations on the demolition of houses that were built before 1940. Contractors must recycle or reuse at least 75% of the demolished building's materials. Any pre-1940 houses that are scheduled for demolition and are deemed a 'character house' must meet a 90% recycling rate. Bricks are a commonly accepted material for recycling back into new concrete by private recycling facilities. However, these facilities will only accept grey or brown brick as red brick will create a noticeable discoloration of the final product. As such, the City has allowed red brick to be sent to the landfill without further beneficial use. Kent Yard creates several precast items that are buried such as manholes and catch basins. For these products discoloring of the finished items would not be an issue. It is not known how much red brick is sent to the landfill at this time and so further investigation should be done to explore this option.

5 Objective 3: Survey Similar Operations and Supporting Documents

It was important for this project to obtain a wide lens perspective of all possibilities for improvement at Kent Yard. In order to do so, a survey of other City operations, documents and even other municipality's operations were investigated. This was done in order to find information that could be extrapolated to suit Kent Yard's operations.

5.1 Master Municipal Construction Documents

The Master Municipal Construction Documents (MMCD) is a set of contract documents that are widely accepted in the construction industry throughout British Columbia. They are a critical component of any municipal infrastructure project as they were developed with input from the government, consultants, contractors and owners. Most city infrastructure projects that are fulfilled by private contractors will rely upon the MMCD. They provide a set of specifications and standard drawings for multiple types of projects and can be supplemented for unique or specialized work. Although not required, they are often referred to when City road and utility construction is performed by internal crews.

A brief investigation determined the Kent Yard's asphalt plant is able to control the mix design with high levels of accuracy through their batching process and is able to meet all Superpave asphalt designs as specified by the MMCD. This makes their product highly desirable to private contractors who are working on an MMCD specification project. Kent Yard has even been able to have a Supplementary to the MMCD documents approved by the MMCD organization that allows the use of recycled concrete and asphalt slab to be used in new asphalt.

5.2 VANCOUVER LANDFILL

The VLF is a critical component of handling the City's waste. Before Kent Yard was established in 1999, the VLF was responsible for managing all of the City's construction waste. It is also a primary user of recycled construction waste. For a typical year's operations, it requires around 100,000 tonnes of rubble annually to meet its weekly garbage cover requirements. In recent years Kent Yard has seen an increase in recycled crushed slab requirements from the VLF due to several garbage cells being closed and sealed in addition to the weekly garbage cover requirement. This has increased the total annual use of combined rubble to approximately 150,000 tonnes in 2015. In the coming years however, the VLF is expected to need much less rubble as several of the City's waste reduction measures begin to take effect. Engineering estimates that the VLF will require less than 75,000 tonnes of rubble and recycled aggregate once all waste reduction measures are implemented. Original plans stated this would take effect as early as 2020 but due to several delays this date has been extended. There is no new estimate for when the waste reduction measures will take effect.

The VLF underwent an independent review in 2015 that investigated several of their operation parameters including garbage cover metrics. It stated that the "City typically used 0.5 meters or more of cover soil to achieve effective operational cover" but notes that average cover for active areas was 0.3 meters with select areas on the slopes in excess of 1 meter in depth. This indicates that there may be some additional efficiencies that the VLF have not taken full advantage of and could further reduce the soil cover requirements.

As the VLF moves towards garbage reduction, the surplus of excavated rubble will make an increasingly large problem. This would make an additional 25,000-50,000 tonnes of rubble to the current material waste stream. The VLF accepts and stockpiles excess soil from heavy construction months in the summer and fall, to supply material for garbage cover requirements in the winter. Eventually, the soil is used and supply and demand evens out over time. However, the supply will be much larger than the demand when garbage reduction actions come on line and if measures are not taken in the coming years to repurpose the excess rubble, the stockpile will surge to its capacity. It has been suggested that a study be undertaken to evaluate the flow of material in and out of the stockpile in efforts to provide some estimate on when it will reach capacity. This should be performed at regular intervals as both Kent Yard and the VLF take more steps towards greener operations.

Due to the closure of the Cache Creek landfill, the VLF can expect an increase of 50,000 tonnes of waste from the eastern municipalities. Metro Vancouver is currently investigating alternative disposal options but until one is found the VLF will continue to accept the additional garbage. The independent review also determined that from 1998 to 2014 the waste to cover ratio varied from 0.88 to 1.79 measured by weight. The overall average ratio for this period was 1.36. The additional garbage will require an increase of approximately 35,000 tonnes in rubble demand.

5.3 Permitting and Demolition Recycling

A meeting with an Environmental Protection Officer (EPO) was performed to understand how the City works with the private sector in order to promote and enforce recycling of home demolition. As stated previously, the City mandates by the Green Demolition Bylaw a minimum 75% recycling or reuse rate for the demolition of a pre 1940s house. The EPO oversees the recycling plans and perform compliance checks for these demolition projects.

As part of the Green Demolition Bylaw, the City has a set of steps established that must be completed in order for a contractor to receive the demolition permit and afterwards, the building permit for their work. The contractor must first begin with a recycling plan that establishes what materials they are demolishing, how much of each can be expected and where these items will be recycled. This is a nonbinding plan, meaning the contractor is allowed to modify the details as the project progresses but must ultimately meet the 75% or 90% recycling requirement. It helps the contractor and the City understand the plan for recycling the demolished materials going forward. Once the demolition is completed, the EPO will review the actual data from the project to check that the contractor was compliant with the recycling requirement. If the contractor performed its duties to satisfaction, then their building permit will be issued. If the recycling rate was not met then the EPO holds a meeting with the lead personnel for the project to discuss where problems occurred and what improvements could be made for the future. Additionally, a portion of the deposit made for the demolition permit is withheld in direct proportion with the level of non-compliance by the contractor. This method ensures a type of forced compliance and has so far produced fairly good results. Rarely are contractors not meeting the recycling rate requirement.

Extending this procedure to apply to the City's internal operations is more difficult. Firstly, no permits of this type are required for City performed road and utility construction projects and there are no standards for the expected rate of recycling on a project. Nor is there currently a practice of creating a recycling or repurposing plan either. It also is illogical for the City to impose punishments, monetary or otherwise, if a branch is underperforming. Forced compliance tactics will likely be ineffective for internal operations.

The City could instead establish a best practice technique of outlining the expected construction waste materials and quantities and encourage the increased use of recycled content. Perhaps certain quotas or benchmarks could be incentivized per branch. This will facilitate each department consciously thinking about their construction waste and exploring potential ways to recycle or repurpose it.

5.4 West Coast Climate and Materials Management Forum

West Coast Climate (WCC) hosted a webinar in June, 2016 to introduce their Climate Friendly Purchasing Toolkit (CFT) as it applies to concrete and asphalt. The toolkit focuses on three items: reducing the carbon footprint from purchases, identifying the most carbon-intensive products, and to provide purchasing guidance for professionals. Their statistics showed that approximately 55% of carbon emissions for public institutions come from purchasing decisions while only 45% is a

result of operations. They also stated that global resource extraction has doubled since 1980 and nearly tripled in the construction industry. Mineral extraction has seen an over 200% increase as well since 1980.

Typical, hot-mix asphalt (HMA) pavement constitutes around 10% of construction emissions. The CFT aims to provide the tools necessary to help reduce this value. It includes modules on Warm Mix Asphalt (WMA) as well as RAP, both of which help to reduce the carbon footprint of asphalt. By using WMA technology, CO_2 emissions per tonne are reduced by 4%. RAP can also be a large contributor to reducing the carbon footprint of asphalt. Table 6 shows a summary of the estimated reduction in CO2 emissions per tonne of asphalt for different scenarios. Other benefits of WMA and RAP include reduction of cost, energy demand and natural resource use and has limited affects on quality, strength, durability and working conditions.

Table 6: Estimated reduction in CO_2 emissions from RAP and WMA compared to HMA

Example Case	Reduction in CO_2
20% RAP	14%
WMA + 20% RAP	17%
30% RAP	21%
WMA + 30 % RAP	24%

WMA has additional health benefits for the construction crews that work with it. Since WMA is produced at a temperature 10-40° Celsius below that of standard hot mix asphalt (HMA), it lets off reduced volatile organic compounds (VOCs) and fumes that are typical with HMA. Figure 8 shows a side by side comparison between hot and warm mix asphalt. It is clear that the laborers who work with HMA are exposed to more air pollution.

(a) *(b)*

Figure 8: HMA versus WMA visual comparison; (a) HMA, (b) WMA (Photos courtesy of Kent Yard)

WCC provided a summary benefits matrix for comparison between HMA and WMA as shown in Table 7. It should be noted that this table was developed by the City of Eugene in Oregon state and

as such may not match completely with Kent Yard operations but it does highlight general trends for the benefits of WMA compared to HMA. Eugene has been able to successfully use 30% RAP mix designs and have been performing trials with incrementally higher recycled content. Late 2016 they expect to trial run a 40% RAP asphalt mix design. Further investigation is required to determine how the City of Eugene is using their high RAP content asphalt and what design criteria are being used.

Table 7: Asphalt benefits matrix for Eugene, Oregon

		HMA	WMA
COST	First Cost – Manufacturer	$	$$
	First Cost – Jurisdiction	$	$
	Ongoing/Maintenance Costs	$	$
INSTALLATION	Ease of Workability	✓	✓
	Worker Safety (from Less Exposure)	✓	✓✓
	Lead Time/Availability	**Immediate**	**Depends**
	Durability	✓	✓✓
CARBON	Virgin Materials Extraction	✓	✓
	Recycled Content Incorporation	**Up to 30%**	**35%+**
	Manufacturing Pase Emissions	✓✓	✓
	Installation Phase Emissions	✓✓	✓
	Recyclability at End of Life	✓✓	✓✓

Note: Check marks and dollar signs are approximated and indicate where differences exist between the basecase and the alternative option. More checkmarks or dollar signs indicate a tendency to have greater impact or cost than a single mark. In cases where the basecase and alternative case are estimated to have the same cost or impact, those are shown based on location, availability of materials, and other factors.

Environmental Product Declarations (EPDs) were another item mentioned through the WCC webinar. These are a standardized way of reporting the environmental impacts of various products. They are verified by a third party and are becoming an increasingly important factor in LEED certification. As such, EPDs are gaining popularity in the states and may gain traction in Canada in the future. To stay on the leading edge of the asphalt industry, developing an EPD or similar environment impact summary of Kent Yard's products would be beneficial.

Kent Yard is well established in the techniques discussed in the webinar presentation. They have been an industry leader in WMA for several years and work with the paving crews to maintain a quality, workable product. As stated previously, Kent Yard currently can only produce a 25% RAP asphalt primarily due to equipment restrictions but also quality, permitting, and workability

restrictions. The most frequent complaint about the WMA is that it is too stiff and requires extra effort when worked by hand. Kent Yard is currently investigating the possibilities of incorporating softer oils and wax polymers to increase the workability of the asphalt.

6 Objective 4: Educate City Staff on Kent Yard's Products and Services

In order to create a culture that encourages the use of recycled content for construction projects, it was determined that information on Kent Yard's operations and product details should be provided to the various branches of the City. This will help to facilitate communication and inform Streets, Water and Sewers on Kent Yard's services.

6.1 Options

Several options were discussed in how to best accomplish this objective. These included the production of a brochure, private meetings with individual departments, group meetings with all concerned City branches, informational email, instituting regulations and performing compliance checks, and generating scorecards to judge branch performance. Table 8 summarizes the pros and cons of each option.

Table 8: Pros and Cons of different communication methods

	Pros	**Cons**
Brochure	• Easy to produce • Easy to update • Provides a long term reference document	• Difficult to distribute • Easy to overlook
Private meetings	• Expected high impact	• Difficult to coordinate • Easy to miss vital members of City branches • Short term reference
Group meetings	• Expected moderate impact • Connects multiple City branches at once	• Difficult to coordinate • Easy to miss vital members of City branches • Short term reference
Email	• Easy to produce • Provides a long term reference document	• Easy to overlook • Easy to miss vital members of City branches
Regulations and compliance	• Clearly defines expectations • Opens up a feedback loop	• Difficult to define expectations • Difficult to institute • May receive pushback
Scorecards	• Clearly defines expectations • Opens up a feedback loop	• Difficult to define scores • May receive pushback

Based on feedback from Jeff Markovic, Kent Yard Branch Manager, it was determined that the best option would include a communication medium that was low effort and would be easy to update and maintain. Therefore, a brochure was selected as the best option for Kent Yard's needs. The brochure is visually appealing and offers a quick summary of Kent Yard's services and business objectives. The finished brochure can be distributed by hard copy at the braches offices or electronically to key City employees. A copy of the brochure is provided in the Appendix.

7 RECOMMENDATIONS

The City of Vancouver aims to be the greenest city in the world by 2020. To make this a reality all the divisions and branches need to work toward the goals set out in the Greenest City 2020 Action Plan and the 2016 Corporate Plan. This means that Engineering needs to continue to increase construction waste recycling. Kent Yard has made large strides towards a Zero Waste target but over 100,000 tonnes of material are not recycled annually.

This project aimed to address some of the issues surrounding this goal. As a result of this investigation, several viable recommendations have been developed. Some of the recommendations should be investigated in more depth than this project was able to cover. These are some of the next steps available to Engineering and its branches. These are summarized briefly below.

Branch communication

Improving communication between Engineering's branches would facilitate increased recycled content in Kent Yard's product and give short and long term predictability to supply and demand of materials. This would increase the efficiency of operations throughout the division.

Branch coordination

Coordinating paving projects to pave on the same day will allow Kent Yard's asphalt plant to produce asphalt in bulk quantities. The plant obtains its best efficiency when processing large orders as it is able to produce material on a consistent basis. This will increase the quality control and assurance measures of the asphalt as well as provide additional opportunities to incorporate recycled asphalt pavement into the new product.

Asphalt plant equipment improvements

Equipment restrictions are one of the main constraints on Kent Yard's asphalt plant. In order to increase the recycled content in the product, the plant needs better emissions control or improved capacity in its equipment. Some suggestions for further exploration include a double burner system, emissions scrubber or an improved surge hopper and material feeder bin. Further study is needed to determine the best option.

Growing medium

Excavated soil and rubble is the main material stream that is wasted within Engineering operations. Recycling it as a growing medium to support vegetation would be one way to channel this excess material into a beneficial use. This would require screening the coarse aggregate out of the material, blending with a soil amender and potentially upgrading Kent Yard's processes to include a gradation facility. Opportunities for sourcing a soil amender include synergies with the Vancouver Landfill, Metro Vancouver, Harvest Power as well other private sector companies. Gradation facilities could include settling ponds, electrocoagulation machine, centrifuge system or wash plant.

Internally source materials where possible

Some branches currently source material from the private sector. Some investigation into potentially sourcing the material internally should be performed. This will increase recycled material use.

Backfill blending

Kent Yard is currently performing trials of blending excavated rubble with mineral aggregate as a backfill material. To date, they have successfully performed an 80% mineral aggregate-20% rubble blend that has performed to specification standards. Further trials should be performed with incrementally higher percentages of rubble to obtain a safe maximum blending ratio.

Synergies with private projects

There may be an opportunity to collaborate with the private sector. A new study should be performed that compares City projects that produce excavated soils to private projects that may require extra fill or backfill material. The study should determine the viability of the City providing its excavated waste to the private project. A mapping tool may be useful in managing the temporal and spatial logistics.

Screen rubble

Should the excavated rubble be engineered into a growing medium, it will need to be screened down to 0.5 inches. All material larger than 0.5 inches will be clean aggregate that can be used to extend the supply of concrete slab crushed aggregate as this material has been identified as being in shortest supply.

Red brick

Red brick is a material that can be recycled back into concrete products. Private industry recycling facilities currently do not accept red brick as it discolors the finished product. As Kent Yard produces precast items that are buried, discoloration of the product would not be a detriment to the finished appearance. This material could also be used to supplement the concrete slab material that has been identified as being in the shortest supply.

VLF material demand study

The Vancouver Landfill is currently and will be undergoing changes to their operations. This will directly affect the amount of rubble needed from Kent Yard and Engineering operations each year. A study should be performed that explores the anticipated future demand of excavated rubble and to determine when the stockpile area at the Vancouver Landfill will reach its capacity.

Establish best practices that set precedents for recycled material in each branch

The City has already initiated green and sustainable practices throughout Engineering. This should continue to be promoted and expounded upon. There are opportunities to incentivize the branches to create recycling plans or to reach a particular recycled material or recycled content benchmark. This will help to further establish the culture of green and sustainable thinking and make a good push toward reaching their greenest city goals.

Environmental Product Declaration

Environmental Product Declarations are a third party certified, standard method of declaring the environmental impacts that a particular construction product has. It is gaining recognition in the LEED program and has gained traction in some of the USA. There is potential to create a sustainability rating and compliance system for all work done for or by the City using Environmental Product Declarations. If Kent Yard developed Environmental Product Declarations for its products it could be an opportunity to stay on the forefront of sustainable engineering. It could also be a pilot project for other City Divisions that source work from the private sector.

Facilitate knowledge and communication

It is important for all of Engineering's branches to be knowledgeable about Kent Yard's services and products. In order to do so Kent Yard should continue to reach out to the key members of each branch to discuss future opportunities and current practices. This could be performed using email, brochure, meetings, etc.

Investigate other branches processes

There are potential benefits to exploring the other branches of Engineering to further understand their processes. There could be potential to reduce the amount of construction waste being produced at the job site or opportunities that haven't been investigated to use increased recycled content or recycled materials in finished constriction products.

Interview construction crews

To further investigate the whole picture of Engineering's material streams a brief investigation should be performed that reaches out to the end users of the products. Kent Yard currently reaches out to the paving crews to receive feedback on the asphalt material. This has benefited Kent Yard's operations and the working environment for the crews. This can be extended to all of the branches and all types of projects that receive products from Kent Yard. This should initiate a feedback loop that improves material installation methods and product quality.

REFERENCES

"About Biosolids (Nutrifor™)." Metro Vancouver, n.d. Web. 14 July 2016.

"Climate Friendly Purchasing Toolkit." Review. Video blog post. Annual Webinar Series. West Coast Climate and Materials Management Forum, n.d. Web. June 2016.

"Closure Date Moved Closer for Cache Creek Landfill." CFJC Today. N.p., Jan. 2016. Web. Aug. 2016.

"Concrete Recycling." Wikipedia. Wikimedia Foundation, n.d. Web. May 2016.

"Landfill May Be Closing This Summer - Ashcroft Cache Creek Journal." Ashcroft Cache Creek Journal, n.d. Web. Aug. 2016.

"Master Municipal Construction Documents Association." The. N.p., n.d. Web. May 2016.

"Materials and Waste." Crossrail. Crossrail, n.d. Web. 14 May 2016.

"Products." Harvest. N.p., n.d. Web. 12 Aug. 2016.

"Vancouver Exceeding Greenest City 2020 Targets Already." Daily Hive. N.p., 14 July 2016. Web. 14 July 2016.

“Different Ways to Use Recycled Concrete." Home Guides. N.p., n.d. Web. May 2016.

Canada, City of Vancouver. (2012). Greenest City Action Plan. BC: Hemlock Printers.

Canada, City of Vancouver. (2015). Greenest City 2020 Action Plan: Part Two 2015-2020. Vancouver, BC: Hemlock Printers.

Canada, City of Vancouver. (2015). Renewable City Strategy 2015-2050. BC: Hemlock Printers.

Canada, City of Vancouver. (2016). 2016 Corporate Plan. Vancouver, BC.

Canada. City of Vancouver. Request for Proposals, Supply and Delivery of Soil, RFP NO. PS20150950. Vancouver: City of Vancouver, 2015. Print.

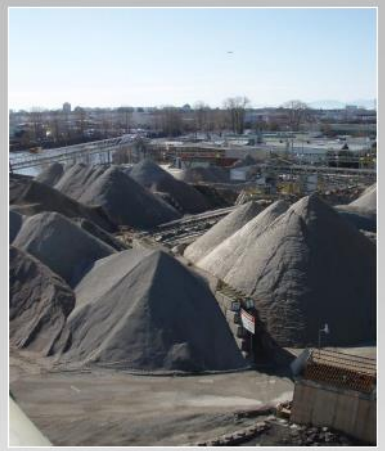
Demolition permit with recycling requirements. (n.d.). Retrieved 14 July, 2016, from http://vancouver.ca/home-property-development/demolition-permit-with-recycling-requirements.aspx

Sonawane, Tushar R., and Sunil S. Pimplikar. "Use of Recycled Aggregate Concrete." Journal of Mechanical and Civil Engineering (n.d.): 52-59.Www.iosrjournals.org. Web. May 2016.

The City of Vancouver. STATEMENT OF BUILDING PERMITS ISSUED. Jan. 2016. Raw data. Http://vancouver.ca/files/cov/building-permit-stats-december-2015.pdf, Vancouver.

Vancouver Landfill 2015 Aerial Mapping. Rep. no. PRJ12030. North Vancouver Office, Sperling Hansen Associates. Vancouver: n.p., 2015. Print.

APPENDIX A



Services

- *Warm and Hot Mix Asphalt*
- *Pre-cast, Dry-mix and Ready-mix Concrete*
- *Aggregate and Soil Fill*
- *Quality Control & Assurance Testing*
- *Soil, Asphalt and Concrete Recycling*

KENT
CONSTRUCTION
SUPPLIES & SERVICES

MISSION: TO FACILITATE THE CITY'S CORPORATE VISION AND TO MEET ENGINEERING'S SERVICE OBJECTIVES.

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Sustainable Engineering

CITY OF VANCOUVER

Kent Services Branch

BRINGING GREEN TO THE TEAM

Warm mix asphalt with 20% recycled content

Sustainability

Kent Services Branch is a green partner within City operations, with many products available. Over 150,000 tonnes of recycled material are used in construction products annually. Since 2000, Kent Yard has recycled roughly 1.6 million tonnes of road and utility construction waste.

By recycling construction waste, Kent has been able to lower their products' carbon footprint, cut demand for new natural resources, and reduce the capital and life-cycle costs. This also diverts large streams of materials from the landfill.

Quality

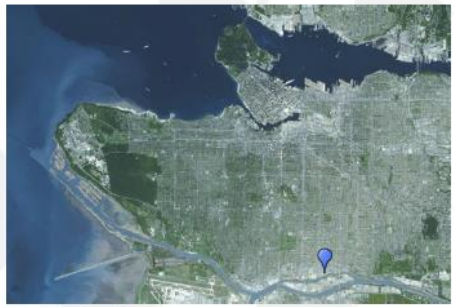
Quality control and quality assurance processes are a critical component for any successful project. By understanding the needs of each project, products can be customized to unique specifications and quality assurance testing can be provided at the Kent facilities.

Diligent work ensures that City operations continue to function smoothly. With years of experience and a long track record of success, Kent produces performance based and durable products that will meet or exceed specifications.

Materials Testing Lab built in 1999 from recycled materials

Proximity

Located on the south side of Vancouver on the north bank of the Fraser River, Kent's proximity to the greater Vancouver area is ideal for Engineering Service's projects.



Kent Yard location

Kent's proximity to City construction sites minimizes trucking distances which lowers transportation costs and reduces greenhouse gases from hauling construction waste materials.

The Fraser River allows Kent Yard to import material by barge. This prevents unnecessary road congestion due to truck traffic and promotes cost reduction from bulk material purchasing.

"The work starts here."

APPENDIX B

Close up of the crushing and sorting machinery and operations

Recycled aggregate product stockpile

Recycled aggregate used as trench fill