FINAL REPORT

WASTE CHARACTERIZATION STUDY FOR BARBADOS 2015

PROJECT MANAGEMENT COORDINATION UNIT

Ministry of Environment and Drainage

Warrens Towers II, Warrens, St. Michael

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Waste Characterisation Study for Barbados 2015 - 2016

1.0 Background

In 2005, the Government of Barbados (GOB) as part of a wider initiative to improve the solid waste management practices on the island commissioned a Waste Characterisation Study to determine the composition and quantities of the solid waste stream generated in Barbados including residential waste and industrial, commercial and institutional (ICI) waste. The results of that study provided invaluable information at that time which was used to successfully plan for solid waste diversion, treatment, and disposal in Barbados.

Since then, the GOB has undertaken a number of initiatives to improve solid waste management which included the upgrading of the main physical facility, the Mangrove Pond Sanitary Landfill as well as the construction and establishment of the Solid Waste Management Centre called Sustainable Barbados Recycling Centre (SBRC). The SBRC, a privately owned entity, undertook the initiative to design and build a facility, under a public-private partnership (PPP) arrangement with GOB which saw them entering into a Build, Own, Operate and Transfer contract. Under the contract SBRC will receive and process waste for a fee for a minimum period of ten years, after which the government has the option to purchase the facility.

The principal objective of the facility is to divert waste from the sanitary landfill. The immediate benefit to the Government and to Barbados is less waste going to the landfill and an extended landfill life. Long term benefits include the reuse of materials which ultimately would be replaced with imports if no recycling is implemented. In addition, it has also provided considerable incentives and encouragement to persons in the private sector to build and sustain recycling operations in Barbados, the aim of which is to divert waste from the landfill and thereby expand the life of the facility.

As part of the policy development component of the Integrated Solid Waste Management Programme (ISWMP), a comprehensive waste characterisation study (WCS) is required within ten (10) year increments to provide relevant and reliable data on the status of the dynamic solid waste stream that is constantly being influenced by prevailing economic, social and environmental factors.

In April 2015, in keeping with the above mentioned requirement, the Project Management Coordinating Unit (PMCU) engaged the services of Simmons & Associates, to undertake the preparation of the comprehensive waste characterization exercise. This waste characterisation exercise was undertaken over three rounds (April 2015, July 2015 and February 2016) to assess the

composition and quantity of the municipal solid waste (MSW[1]) generated in Barbados and any changes which might have occurred in the respective periods. Those dates were selected to coincide with the dry season (April 2015), the Crop-over Festival and the middle of the wet season (July 2015) and the height of the tourist season (February 2016).

This final report, which was prepared following the completion of Round Three of the characterisation exercise, is an analysis of all the three rounds, any observations and challenges associated with the exercises and recommendations for going forward with the ISWMP being implemented under the guidance of the PMCU.

1.1 Situational Analysis

The responsibility for the management of waste is shared by a number of different agencies including the Ministry of Health, the Sanitation Services Authority (SSA) the PMCU formerly the Solid Waste Project Unit (SWPU) and the Environmental Protection Department (EPD). Overall responsibility as specified in the Health Services Act (1963) lies with the Ministry of Health. The SSA, which was established as a statutory body under the Sanitation Services Authority Act and Regulations (1996) has responsibility for the provision of municipal solid waste collection and disposal services as well as the operation of four solid waste disposal sites. The SWPU, established in 1993 was set up within the Ministry of Health with specific responsibility for the establishment of the framework for the implementation of the ISWMP, and specifically with the development of legislation, public outreach, awareness and education with respect to solid waste management. The EPD, through the Solid Waste and Hazardous Substances Section (established in 2005), is responsible for monitoring and regulation of solid waste management.

The SSA provides a state funded national collection service to all households in Barbados at least once a week. In densely populated areas on the island, this service is offered two (2) days a week. In Bridgetown, the capital, there are daily collections due to the commercial activity there. Generators of commercial and bulky waste can also call the SSA to remove their waste at a cost. Alternatively, they also have the option of utilising private commercial services to remove their waste.

A vital component in the development of the solid waste sector has been the construction and commissioning of the Sustainable Barbados Recycling Centre (SBRC) in 2009 at Vaucluse, St. Thomas which is adjacent to the Mangrove Pond Landfill site. The facility was developed at a cost of US$30 million and is operated as a joint public private partnership. With the establishment of SBRC, all of the MSW generated in Barbados, with the exception of recyclable

[1] The World Bank defines municipal solid waste as including 'non-hazardous waste generated in households, commercial and business establishments, institutions, and non-hazardous industrial process wastes, agricultural wastes and sewage sludge

materials collected by private recyclers, passes through the SBRC. Each vehicle entering the facility is required to be weighed at the Scale House as well as disclosing the contents of their load which is then entered into the respective categories established by the PPP agreement.

The household and commercial waste is then delivered to the Transfer Station Building where it is pre-sorted to remove bulky items and green waste. Items with little or no recyclable value or special waste are transported directly to special disposal sites. The different types of waste accepted/handled at SBRC are as follows:

- Municipal Solid Waste (MSW)
- Construction and Demolition (C&D) waste (includes pallets, lumber, metal, utility wire)
- Organic/Green waste (GW) which includes coconuts, grass, tree trimmings, logs
- Rocks and Soil (R&S)

There are a number of items such as vehicle tyres and metals which are not among the items accepted but which still arrive (weighed and sorted before being sent to other areas for storage or recycling) at the facility.

Recovered recyclable materials include:

- Cardboard
- Scrap Metal
- Organic/Green waste: including tree clipping, coconut shells from vendors, used pallets, etc.
- Construction & Demolition (C&D)

The remaining waste is then transported to the Mangrove Pond landfill where it is spread, compacted and daily cover applied.

In addition to SBRC there are a number of private operators who are also involved in the collection and exportation of recyclable materials. These operators are as follows:

- B's Recycling
- ACE Recycling
- Recycling Preparation Inc.
- Scrap Man

Materials Recycled

Materials collected are primarily plastics, ferrous and non-ferrous metals, lead acid batteries, glass bottles, paper and cardboard. These are broken down as follows:

- Plastics

- A range of plastics are accepted including Polyethylene Terephthalate (PET), Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE). Plastics are sorted according to size, colour and product manufacturer.

- Food cans
  - Including milk, sardines, tuna
- Used automotive batteries
- Glass bottles
  - Including beer, rum, wine, other liquor bottles and all non-alcoholic beverage bottles
- Scrap metals
  - Including stainless steel, brass, copper, iron, aluminium, lead, galvanise sheets and permaclad sheets
- Cardboard
- Paper
- E-waste
  - Computers, television sets, etc.

2.0 Aim and Objectives of the Waste Characterisation Study 2015

2.1 Aim of the Waste Characterisation Study 2015

The aim of the WCS 2015 is to provide relevant, reliable, impartial and valuable data along with its analyses and recommendations with respect to the composition and quantities of solid waste being generated in Barbados.

2.2 Objectives

The overall objectives of the WCS 2015 are as follows:

a) Estimate the composition and quantities of waste generated from the following sources:
   - Residential
   - Industrial
   - Commercial
   - Institutional
   - Construction and demolition

b) Utilize recognized and technically sound protocols with respect to the characterisation of all of the waste streams listed above.

c) Utilize the results from the study to assess the impact of the recycling industry and SBRC on the composition and quantities of solid waste disposed at Mangrove Pond Landfill.

d) Utilize the results of the study to assess the effectiveness of the public outreach, awareness and educational component of the ISWMP.

e) Utilize the results from the study and its analyses to make relevant recommendations with

respect to future policy development and legislation associated with the solid waste management in Barbados.

2.3 Design of the Study

In designing the overall study, a number of factors were taken into account which was intended to inform the study and ensure that the representative samples provided a reliable and accurate account of the type of waste being generated, the quantities generated and other information. This will help in making decisions with respect to recycling and sustainable management of the MSW being generated and disposed of in Barbados. In that regard, the following information was utilized and formed an important part of this exercise. This was as follows:

- Population data
- Tourism related data including high and low season
- Cultural related information e.g. Crop Over Festival
- Location of institutional and commercial generators of waste
- Available landfill delivery records
- Waste diversion records and data
- Waste collection route plans

3.0 Approach and Methodology

The methodology for the study followed that of the previous study undertaken in 2005. In the regard it consisted of field sampling of waste arriving at the SBRC facility and analysis of data collected over the time-period established. A total of thirty (30) samples (MSW and ICI waste) were collected over seven (7) days. In respect of the waste recycling and educational awareness exercises, field visits to assess recycling activities were undertaken and a number of round table discussions with various stakeholders were convened to assess the effectiveness of the public outreach, awareness and educational component of the ISWMP.

3.1 Field Sampling

With respect to the waste characterisation exercise, the Terms of Reference (ToR) recommended that a minimum of three (3) characterization studies or sessions should be implemented over a ten (10) month period, so that the disposal practices in both the wet and dry seasons as well as the busy tourist seasons and cultural events which impact waste generation patterns will be captured. In that regard, the choice of April for the conducting of the first sorting exercise was intended to capture not only waste generated during the dry season, but also, the tail-end of the tourist season (December to April). It is generally believed that less green waste is generated during the dry season which would have implications for the percentage of organics in the waste stream.

A landfill-based sorting program, to estimate the composition of waste was utilized. Initially, it was thought that the MSW could have been divided into three sub-sectors (i.e., urban, suburban and rural) to ensure good representation of communities across the entire island. However, it was discovered from the SBRC scale-house operators that trucks containing residential waste are not identified in this manner but instead are identified as coming from North, South, City East and City West of the island. As well, the recording of data at the scale house does not take that differentiation into account neither does it make any distinction between residential and institutional, commercial and industrial (ICI) waste. It was therefore decided to use the original classification for MSW, and combine the institutional, commercial and industrial into a single ICI category. In addition, the high number of vehicles containing Green Waste (GW) meant that another category could be singled out for analysis, though its contents clearly allows for classification as MSW. This type of sampling allows for a better capture of the different waste streams and will provide better insights into the total waste stream arriving at the disposal site, including yard, bulky and special waste items.

Since the required number of MSW samples to be taken in each sampling event has not been specified in the ToR it was determined that the current exercise should be based on a typical statistical confidence level often desired in MSW management. That number is also dependent on the degree of categorization to be observed in the sorting exercise, as well as the expected variability in the categorization.

Typically, the result of a waste composition survey will express the percentage (%) composition of a certain material in this way: *"…the occurrence of textile [for example] in the stream is 10%, plus or minus 2%, said with a confidence of 95%..."* The true average is very likely (said with 95% confidence) between 8% and 12%."

Taking fewer samples simply spreads out the confidence interval, such that the true mean (arithmetic average) of a set of values lies within a broader range, at a given confidence expressed as a percentage. For example, having three data points for the occurrence of a material may mean that the confidence interval at 95% confidence is a range of plus or minus 2% around an average of 5%, whereas having three hundred data points means that the confidence interval at the same percentage confidence is plus or minus 0.51% around an average of 5%. The more samples, the tighter the confidence interval within which the true average is found, at a given confidence level.

In the case of this WCS, we have established the number of samples in the usual way, as described in a commonly used reference document (the 1999 SENES manual referenced in the 2005 study). The fundamental mathematical procedure requires some prior knowledge about the materials of interest. This was derived from data from the 2005 WCS in Barbados which

provided an idea of the variability amongst samples. The difference in the data from the three (3) survey events in 2005 suggests a considerable variability in the residential waste stream.

The SENES manual suggests that twenty seven (27) samples per strata would be needed to provide a precision level satisfactory for system design purposes of +/-20% corresponding to, up to 50% variability amongst samples, corresponding to a 95% confidence level. That number is intuitively credible in that a "normal distribution" (nicknamed as the ordinary "bell curve" in a diversified data set) is generally equated with around 30 samples.

The suggested number (27) is greater than the number performed in 2005 (i.e. 15 from the residential) stream, but we recommend the effort as the statistics will be considerably more precise. Our reporting therefore will include calculations and display of the averages and confidence intervals associated with each material in the categorization scheme. That will provide very useful statistical data for management purposes as well as a set of displays that can be used to communicate the statistics (confidence levels etc.) to a lay audience.

3.1.1 MSW

A review of the 2005 WCS suggests that the greatest number of categories of waste in loads of the incoming waste materials will be found in the residential (MSW) sector. As a generalization, we propose that a very robust statistical method, such as those recommended by reference manuals noted in the ToR, be applied to characterizing the residential stream, regardless of how it is collected and transported. The categorization (52 categories) is the same as that developed for the reference project (the Waste Characterization Study, 2005, by L.H. Consulting Limited). See Table 2.

3.1.2 ICI, C&D and Other Sourced Materials

The ICI sectors represent significant volumes as well, but loads will tend to be more homogenous in their composition. The variability amongst loads of ICI and C&D sourced from non-residential generators can be very large. Also a load may be entirely cardboard, or scrap lumber, and if it were possible to only pick every second truck load to characterize, the statistical result would not reflect that variability. In that regard, homogenous loads were avoided. Therefore, a more rigorous method for categorizing and recording waste was utilised in that each in-coming load was identified based on questions put to each driver as to the content of the load, and randomly selected because of its perceived variable content. That information was then automatically entered into the database of the facility based on the various established categories.

3.2 Field Sorting Procedures

The field sorting procedures utilized involved the random selection of vehicles identified according to the major categories (MSW, ICI, and C&D). Once a vehicle was identified as carrying any one of these categories it was directed to the sorting site where the entire load was dumped and a 135 kg sample extracted for analysis. The actual sorting procedures typically involved the selection of four (4) vehicles per day for seven (7) days and utilized the waste characterization exercise as follows:

a. All sorting personnel were advised on the importance of being properly attired in safety gear and appropriate clothes. Safety equipment (footwear, disposable Tyvek coveralls, N95 particulate dust masks, glasses, robust impermeable gloves, and reflective vest) was provided.
b. Data sheets with the 52 categories were prepared to enable weights to be entered for each sample.
c. All empty storage containers were weighed using a digital scale (100 kg scale) and the tare weights recorded.
d. Each vehicle operator was directed to discharge the load onto the designated area in one contiguous pile to avoid gaps in the discharge, and facilitate collection of the samples.
e. After the entire load had been dumped, the sorters were instructed to randomly collect different types of material whilst walking around the edge of the pile and to place these collected materials behind them away from the pile. They were advised that it was important to maintain this level of randomness.
f. The storage containers were positioned around the sorting sample, and each waste item segregated according to the classifications in Table 1. All containers found within the sorting sample, such as capped jars, paper bags, and plastic bags were emptied of their contents and placed in the appropriate container.
g. In the case of composite items found in the waste, the individual materials were separated whenever practical and placed into the appropriate containers. Where this was not practical, the items were classified according to its predominant constituent.
h. The collected materials were gathered up in plastic tubs and brought into the tent for detailed sorting into the different categories. The tubs were weighed empty at 0.95kg and weighed full of materials. The beam balance allowed the weight of the tub to be automatically subtracted using a tare weight button.
i. Sorting continued until the maximum particle size of the remaining waste particles was approximately 1.5 inches. At this point, the remaining particles were classified according to the major constituent of the waste.
j. The weights were taken using the natural moisture content of the disposed materials.
k. Using the data sheet provided, the gross weights of the storage containers were recorded.
l. At the end of each sorting sessions, the sorting site and the load discharge area were

cleared of all waste materials.

m. A designated person was appointed to supervise sorting activities, including recording and entering of computerized data.

4.0 Waste Characterisation and Quantification

In all three (3) rounds of the WCS, a total of thirty (30) loads of waste consisting of MSW, ICI and C&D materials were sorted and weighed into categories in-line with the statistical requirements of the project. The waste categories studied consisted of nine (9) major categories, namely:

1. Paper and Paperboard
2. Glass
3. Metal
4. Plastic
5. Textiles
6. Organics
7. Construction and Demolition (C&D) Materials
8. Special Care Wastes
9. Other Wastes

Table 1 shows the number of samples that were targeted for collection for each of the sectors.

Table 1: Numbers of Waste Samples Characterized, by Sector

Sector	No. of Samples
MSW	20
ICI & C&D	10
Total	**30**

For the overall disposed waste stream, and for each waste sector (Residential and ICI), data is presented in three ways. First, a detailed table lists the full composition and quantity results for the 52 standard materials (Table 2.) Next, a summary (main categories) of waste composition by broad material class is presented in tabular and pie chart formats. Finally, a summary table lists the mean, margin of error and confidence level of the major categories of waste.

Table 2: Waste Characterisation Table

	Paper and Paperboard
1	Newspaper
2	Uncoated Corrugated Cardboard
3	Magazines and Catalogues
4	Boxboard
5	Fine (Office) Paper
6	Telephone Books and Directories
7	Other Miscellaneous Paper
8	Remainder/Composite Paper
	Glass
9	Clear Beverage Containers
10	Clear Food Containers
11	Coloured Beverage Containers
12	Coloured Food Containers
13	Remainder/Composite Glass
	Metal
14	Tin/Steel Beverage Containers
15	Tin/Steel Food Containers
16	Major Appliances
17	Other Ferrous Metal
18	Aluminum Beverage Containers
19	Aluminum Food Containers
20	Other Non-Ferrous Metal (Aerosol)
21	Remainder/Composite Metal
	Plastic
22	PET Beverage Containers
23	Other PET Containers
24	HDPE Containers
25	Styrotex
26	Film Plastic
27	Durable Plastic Items
28	Remainder/Composite Plastic

	Textiles
29	Nappies
30	Clothes/Rags
	Organics
31	Food Waste
32	Yard Waste
33	Agricultural Crop Residues
34	Branches and Stumps
35	Grass Cuttings
36	Remainder/Composite Organic
	Construction and Demolition (C&D)
37	Concrete and Masonry
38	Lumber
39	Asphalt Shingles
40	Drywall
41	Rock, Soil and Fines
42	Remainder/Composite C&D
	Special Care Wastes
43	Paint
44	Hazardous Materials
45	Used Vehicle Oil and Filters
46	Batteries
47	Biomedical
48	Remainder/Composite Special Care
	Other Wastes
49	Tires
50	Furniture
51	E-waste
52	Other Unspecified

Whilst all three rounds of the WCS followed the same pattern, it should be noted that following the completion of the first round (April 2015) the Government of Barbados introduced a BDS $25.00 VAT inclusive per tonne tipping fee on all waste delivered to the SBRC facility to assist in defraying the cost of collection and disposal. This tipping fee was widely criticised by the private sector haulers, when it was first announced and implemented, and several of these haulers refrained from going to that facility, choosing instead to take their loads to other sites around Barbados for disposal. This reduction in the number of vehicles and amount of waste was

evident at the time the Round Two of the waste characterisation was being carried out. However, whilst the lower number of vehicles resulted in a reduction in the quantity of waste arriving at the SBRC, it did not adversely interfere with the characterisation exercise.

5.0 Comparison of Waste Data for Rounds One, Two and Three

The waste characterisation exercise was undertaken over three distinct periods in order to obtain an understanding of waste generation patterns over different time periods. Round 1 was undertaken in April 2015, at the tail end of the tourist season and the middle of the dry season. Round 2 was undertaken in July/August 2015, at the height of the Crop Over Festival, and Round 3 in February 2016, in the middle of the tourist season. As can be seen in Table 3 below, whilst there are some differences in the composition of waste along the different material types over the three rounds, these differences were significant in only in a couple of the categories.

Table 3: Composition of Combined (Residential and ICI) Waste: Rounds 1, 2 and 3

Material Type	Round 1: Mean	Round 2: Mean	Round 3
Paper and Paperboard	10.28%	23.30%	22.4%
Glass	2.40%	4.30&	8.1%
Metal	3.07%	3.90%	6.4%
Plastic	7.70%	13.90%	16.7%
Textiles	7.16%	8.70%	10.1%
Organics	41.00%	30.10%	24.5%
C&D Materials	20.09%	3.30%	6.0%
Special Care Wastes	0.20%	0.02%	2.1%
Other Wastes	8.10%	7.30%	3.7%

In respect of Paper & Paperboard, the percentage in Round 2 and Round 3 are more than double the amount in Round 1. The only factor which could account for that significant change is that both Round 2 and Round 3 were conducted at times usually associated with the festive periods (Crop Over and Christmas) in Barbados. Likewise, in respect of Plastics, the mean for Round 1 is 7.7%, but almost double in Round 2 (13.9%) and in more than double (16.7%) in Round 3. Like Paper and Paperboard, the only factor accounting for this significant increase is that Rounds 1 and 2 of the studies were conducted around the Crop Over and Christmas period when larger quantities of soft drinks and water are consumed. Also factors associated with the tipping fee and the fluctuating international recycling market contributed to the increase in the plastics percentage.

The other data of any noticeable significance is in respect of C&D Materials where the quantities making up the waste stream was significantly higher in Round 1 than in Round 2 and Round 3. The reason, as noted in the report of Round 1 was that there was significant construction going on in Barbados which tend to get started in the early part of the year to take advantage of the dry period as well as the tipping fee. This can be confirmed by looking at the results in Figure 1.

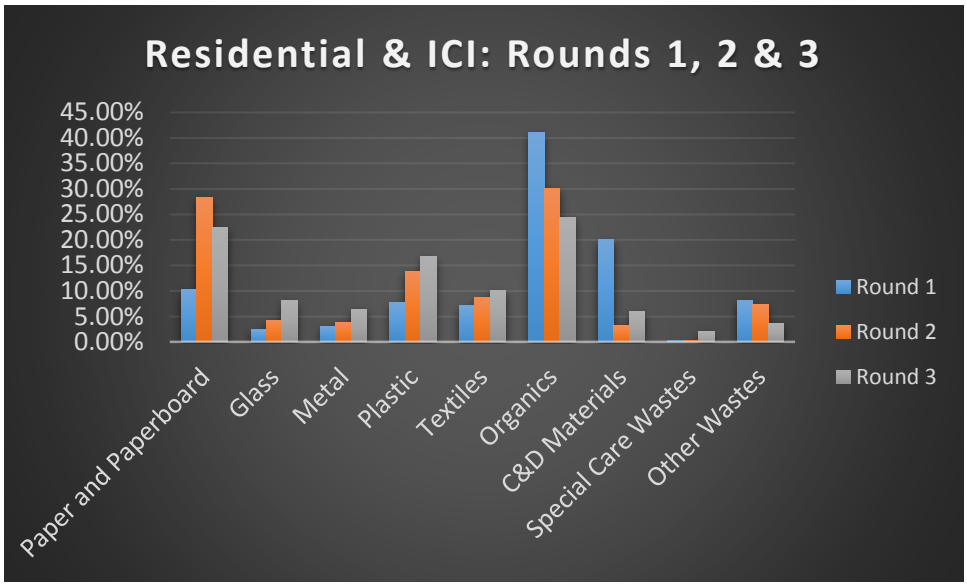

Figure 1: Residential & ICI Combined Rounds 1- 3

In respect of organics, the higher percentage in Round 1 can be attributed to a fairly dry period in the weeks leading up to the characterisation exercise.

Plastics and glass, items which would normally be associated with the festive seasons showed slightly higher percentages being recorded in Round 2 and Round 3, again associated with the Crop Over and Christmas holiday periods.

The statistical differences between Rounds 1 and 2 shows that some categories vary significantly whilst for some others the differences were slight. For example, the mean for Paper and Paperboard in Round 1 was 10.28% while in Round 2 the mean was significantly higher (23.30%). However, in respect of Organics, the mean in Round 1 was 41.0% versus 30.1% in Round 2, and the C&D Materials Group, the mean in Round 1 was 20.09%, but only 3.30% in Round 2. Much of the differences in the mean can be attributed to the significant drop in the number of commercial vehicles delivering organic waste (particularly yard waste) to the SBRC facility. The same is true for C&D materials as most of that material was transported to the facility via commercial vehicles which saw a significant drop in numbers following the introduction of the Tipping fee at the beginning on May 2015.

In respect of Paper and Paperboard the difference is unusual, but can be explained on the basis that uncoated corrugated cardboard, like a number of items in the ICI waste category is often collected in homogenous loads (for example all brick rubble on this load or all scrap appliances on that load). Another probable reason for this higher mean could be due to the fact that the study was being undertaken during the week leading up to the culmination of the Crop Over Festival, a time when there is a large influx of visitors and a large segment of the country's population is engaged in activities which tends to generate a larger number of disposal items such as paper-cups, bottles and other associated items.

The same can also be said for the slight increase in the mean for plastics, and glass, which saw noticeable increases in both the Residential and ICI waste streams (numbers and confidence levels).

5.1 Comparing statistics from all three (3) rounds

The three rounds of sampling events provide some insight on how the composition and volume of the waste stream varies during the year. There are typical annual cycles in construction, festivals, climate, agricultural production, tourism, and secondary industry that relate to waste volumes and composition, and they are to quite a degree predictable. Other influences can arise suddenly, such as changes in regulations, economic drivers such as tipping or bottle deposit fees, disruption of transportation, and catastrophic events like unprecedented hurricanes and flooding. Those major disruptions can permanently or temporarily change waste production.

In an ideal year for the purpose of such an audit, one hopes for stability of the elements in the typical annual cycles, such as festivals, and for no large disruptions. Such a year would provide the best statistical basis for ongoing planning, as audits have not been done very frequently. However, 2015-16 was a year in which two events occurred, which would give cause for large disruptions, i.e. the introduction of tipping fees. During the three survey periods involved in this waste audit, there are significant variations amongst the data on composition, and a discussion along two lines is in order. First, how significant are the variations, and second, judging the effects of unusual factors. In this discussion, it will be important to not assume that correlation has much to do with causation.

On the first point, a review of the composition data shows some differences among the three survey periods. Looking at the mean and the confidence intervals (CI) for major categories shows that for paper and paperboard, round one, the mean is 14.89%, and CI is from 3.7% to 18.6%, meaning that the true average in the whole waste stream could equally likely be just over 3% up to over 18%. Compare that to round three, where the figures are mean of 21.2%, CI

from 18.3% to 24.2%, a much tighter range. The variability among samples in the three rounds is reflective of the nature of the material.

Table 4: Statistical Comparison of Three Rounds – Selected Categories

Category	Round 1		Round 2		Round 3	
	Mean	CI Range	Mean	CI Range	Mean	CI Range
Paper & Paperboard	14.89	3.69 – 18.58	23.9	17.0 – 30.9	21.2	18.3 – 24.2
Plastics	9.54	2.04 – 11.58	10.1	7.2 – 13.1	16.1	13.5 – 18.8
Organics	36.42	8.15 – 44.58	32.1	23.5 – 40.8	25.3	21.2 – 29.4
Glass	3.00	1.31 – 4.30	5.0	1.7 – 8.3	6.9	5.4 – 8.5

Continuing with paper and paperboard, and consider the three CI ranges for the three rounds, it can be seen, in Table 4 above, that a figure of about 18% will fit in each of the three CI ranges. Since 18% could be the true average of the whole stream being sampled in each round, one might say that not too much weight should be put on Round 1, notwithstanding the fact that it seems that 14.9% is much lower than the 23.9% in Round 2. This is simply a consequence of the variability amongst samples, and one must also remember that the 95% confidence limit says that there is a 5% chance that the true average in the whole stream is actually outside the CI for each sample round.

Before assuming that the inherent imprecision of the estimates is the reason for the variations, one should consider the significant disruptions which occurred during the survey period, and the volumetric data, before deciding on a composite set of means and confidence intervals. In doing so, one must remember that correlation is not the same as causality. In other words, the fact that data are mathematically correlated does not reveal anything about the causes that underlie the correlation. This is where the judgement of the analyst, drawing on other information such as the behaviour of haulers during the strike, becomes very important.

6.0 Waste Recycling

MSW contains many useful materials such as organic matter, plastics, paper and cardboard, glass, metal and inert substance which can be recycled into new products. Carbon and nitrogen-based organic waste from kitchen, market and abattoir is a source of rich organic matter or energy. This helps with conserving natural resources and also generates employment.

The conventional approach of solid waste management has been to manage the removal of the solid discards from the immediate vicinity of the human settlements. This resulted in the mechanized systems of collection and transportation of waste to bury at landfills. It has been, realized that societies will not be able to master the waste avalanche, especially in small island states like Barbados. In addition, the promotion of the waste recycling sector using the 4 R's waste management hierarchy and providing that with an institutional support is seen as an important initiative which if successfully instituted will meaningfully contribute the island's goal of sustainable development.

The issue of waste diversion from then island's landfill is also of utmost importance to health and safety as Barbados depends on ground water for its water supply. In addition, the increase pressures posed by climate change on its water resources makes it even more important that activities are undertaken which will reduce the risk posed by disposal of materials in landfills. In light of this, the PMCU has not only emphasised "efficient removal" but also waste avoidance, minimization and recycling/diversion options. The private sector in Barbados has played a key role in supporting the Government's agenda of waste diversion. However, they face a number of challenges which limits their ability to realise their full potential.

6.1 Objectives of Waste Recycling

The focus of this waste recycling component will be to summarize the following:

1. Nature and volumes of material recovered for reuse and recycling,
2. Lessons learnt from the existing program,
3. An overall conclusion of the state of Barbados's recycling and diversion efforts from a solid waste management perspective and
4. Recommendations on measures which could be instituted to enhance the effectiveness of the country's waste diversion program.

6.2 Study Approach

The work was split into three (3) segments:

1. A pre-mission understanding of the existing waste management system in Barbados to ascertain the extent of the waste recovery and reuse programme. This included

collection of all available information on issues especially information associated with the existing legislative framework and the draft 2015 waste characterisation report.

2. This was followed by key stakeholders' interviews and site visits in order to select and assess the success of the initiatives introduced thus far and factors which enhance or impeded progress. These stakeholders included the manager of the PMCU and all major recyclers of waste in Barbados. Prior to meeting with the key stakeholders a set of possible performance indicators for the recycling assessment was selected. However, there was the recognition though that many of these indicators related to business performance and the recyclers would not necessarily be open to disclosing such information. The recycling operations selected for the site visits were chosen using information and feedback from industry leaders who possess much needed information on them including the nature of the material they recycled, the relative volumes and their influence in the industry.
3. Finally, an analysis of the findings was undertaken with the objective of developing recommendations which would serve as a basis for discussions with stakeholders prior to policy development.

6.3 Inventory of Current Diversion Activities and Organizations

Data obtained from SBRC indicates that on average, a total of 1024.24[2] tonnes of waste (See Table 5 below) is received at SBRC facility on a daily basis as compared to an estimated 936 tonnes per day recorded in 2005. This represents the volume of waste generated on island less waste diverted from the landfills primarily through the efforts of the private sector.

Table 5: Quantities of Waste going to SBRC (January – April 2015)

Month	Tonnes/Month	Tonnes/Day
Jan	28,449.95	948.33
Feb	24,858.25	887.79
Mar	30,919.62	997.41
April	37,902.83	1,263.43
Total		**4,096.96**
Average Monthly		**1,024.24**

Unfortunately, the total tonnage of waste diverted from the landfill could not be easily and correctly ascertained as there is not a formal system for recording and reporting this information. Whilst SBRC, the main entity responsible for handling all MSW keeps an accurate

[2] Totals for the first four months 2015 were used given the fact that following the introduction of the Tipping fee in May 2015 there was a significant (60%) decrease in the amount of waste going to SBRC.

record of all waste coming and leaving its facility there is still a huge inventory of recyclable materials (appliances, e-waste and C&D) for which sales are either very slow or not financially viable. The large stockpiling of materials was also evident at other major recycling facilities (B's Recycling, Scrap Man and ACE Recycling). This may have resulted from materials being diverted but may not necessarily be used for the purposes intended because of the following:

- Unsatisfactory quality standards
- Market price on the international market was so low that it is not economically feasible to ship the material as such the material may be stock piled in the hope of a price recovery or eventually dumped if storage becomes too challenging.

On the basis of discussions held with recyclers they indicated that they export a total of 16,380 tonnes of waste annually. This reflects the fact that waste is being diverted and exported to several markets on a monthly basis. As such, the necessary ground work has been laid for what can become a model for other SIDS if the required legislative framework, data collection and incentive systems are appropriately established.

Table 6: Quantities of Recyclable Materials[3]

Materials	Monthly Quantities Collected	Annual Exports Tonnes	% Used locally
Paper	300	3,600	0%
Plastics	60	720	0%
Glass	100	1,200	100%
Cardboard	250	3,000	0%
Metals	620	7,440	0%
E-waste	20	240	0%
Batteries	15	180	0%
TOTAL	**-**	**16,380**	-

An assessment of the waste diversion strategy in the island requires that some analysis be done from three (3) perspectives, the Government of Barbados, the recyclers and the general populace.

[3] These quantities were provided by the recyclers (excluding SBRC). These recyclers keep their own data and in the absence of corroborating data from other independent sources, it is difficult to verify the accuracy of the data, particularly paper, plastics and cardboard, since there were no observable weigh scales at the collection points. Also, attempts to obtain export data from Customs and Excise proved futile.

6.4 Efforts of the Government of Barbados

The increasing rates of waste generation which accompanies developing states, depletion of landfill space, and problems associated with the negative environmental impacts associated with disposal of waste at landfills means that efforts that are aimed at improving solid waste recycling performance must be recognized as requiring more than simply enhancing the efficiency of SWM relating to waste disposal facilities.

A deposit refund scheme has been in operation for over thirty (30) years to encourage reuse of beverage containers: wholesalers and distributer pay a deposit on beverage containers, which is refunded on return and disposal of these containers. Current refund values are US $0.05 for PET bottles and US $0.10 for glass bottles. The Returnable Containers Act (1987) covers glass, metal, aluminium, steel or plastic bottles, cans, or jars of one gallon or less used for carbonated drinks, non-carbonated soft drinks, mineral water, soda water, beer, and other malt beverages. Whilst this has been very effective in taking most of these recyclable items out of the waste stream, there are still number of items that are still not covered by the Act. Amendments to the Act have been proposed, but these have not yet been ratified.

In order to partially meet the cost associated with the infrastructural works associated with improved disposal of MSW, the GoB introduced in May 2015 a tipping fee of BDS $25 VAT inclusive per tonne of waste disposed or part thereof. As mentioned earlier, the private sector haulers complained about the tipping fee for disposal of waste.

There is a need for GoB, however, to do more in terms of creating an enabling environment for waste diversion. Whilst efforts have been made to develop legislation to guide the waste management sector, The Draft Environmental Management Act along with the Draft Integrated Solid Waste Management Legislation, prepared since 1998 and 2004 respectively, have yet to be enacted. The fact that haulers were able to skirt around existing legislation and dump their waste in abandoned quarries without incurring any penalties serve to highlight weakness in the existing legislation and the result of a failure on the part of the authorities to enact the relevant legislation (i.e. Heath Services Act) which not only would have specified the needs for all waste disposal facilities to have met strict environmental guidelines, but also monitoring and regulatory requirements under the supervision of the EPD.

6.5 Efforts of the Private Sector

In surveying and evaluating the private sector waste diversion efforts and organizations active in Barbados we noted that there are a number of operators involved in the recovery and reuse of waste materials. These materials are primarily, plastics, ferrous and nonferrous metals, glass bottles and paper and paperboard. These operators are as follows:

- B's Recycling
- ACE Recycling
- Caribbean E- Waste Management
- Recycling Preparation Inc.
- Scrap Man

The largest players in this sector are as follows:

- B's Recycling
- Scrap Man
- ACE Recycling
- Recycling Preparation Inc.

These recyclers are primarily engaged in the recovery and export of the following items:

- Plastic containers- A range of plastics are accepted including Polyethylene Terephthalate (PET), Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE). Containers are sorted according to size, colour and product manufacturer.
- Used automotive batteries
- Glass bottles - including beer, rum, wine, other liquor bottles and all non-alcoholic beverage bottles
- Scrap metals
- Paper and Paperboard

In general, the recovered materials with the exception glass, are cleaned, baled and exported to recycling establishments or transhipment centres. In the case of glass, the materials are primarily jars and beverage containers which are collected, cleaned and made available to the manufacturers of beverages and condiments for reuse. Once the glass containers reach the end of life with respect to re-use they are disposed at the landfills so that the efforts of these establishments is really to extend the useful life of these glass items in the current form and not recycle them.

The recycling industry is a very competitive and fragmented sector which is very vulnerable to prices of recyclable materials in the international market. As such there exist very little collaboration among players and the level of export is very dependent on the prices offered by importers of these materials. The materials are exported to China, Trinidad and Tobago, India, and Brazil among other countries.

6.6 Efforts of the Public

When evaluating Barbados's diversion rate, it is important to note that numerous additional waste reduction (for example minimizing the use of plastic bags when grocery shopping), material reuse, and recycling activities (for example composting of organic waste) are occurring

throughout the island. These efforts contribute directly to the country's diversion of recyclable and reusable materials, and prevent additional material from being disposed and landfilled. Therefore, community participation which has been fostered continuously by the PMCU is paramount in an innovative and sustainable approach to municipal solid waste management.

6.7 Identifying and Prioritizing Waste Diversion Strategies

Separating the different elements found in waste streams is essential for enabling the recovery of useful materials, minimizing the amount of material sent to landfill and allowing recyclable materials to find a new incarnation. Simmons and Associates have identified the following targeted materials that offered the most fruitful options to increase waste diversion in Barbados:

- Paper and Cardboard
- Organics
- Construction & Demolition
- Plastics
- Scrap Metals
- Electronic waste

Paper and Cardboard

This material represents a waste stream which has significant potential for increased diversion. This is because it does not require expensive equipment to process. Additionally, it is believed that the vast majority of paper and cardboard not currently being diverted is originating in Barbados's commercial sector, which if targeted can enhance the diversion participation rate. However, in the absence of any mandatory or significant voluntary initiatives requiring commercial establishments to separate and recycle their waste, much of it ends up comingled as part of regular waste and of little value either as paper products or potential compost.

Organics

This waste stream represents a significant percentage of the overall waste stream i.e. approximately 51% and little or no effort has been made to institute a waste diversion strategy for this waste stream. Though SBRC does engage in some separation at their facility, the only organic material utilized as compost are clean organics (grass cuttings, coconut husks etc.). Improved separation at source would significantly enhance the prospects of larger amounts of organic waste being converted to compost.

Construction and Demolition

This waste diversion rate can be significantly increased if a system is introduced to control the quality of construction debris and create an effective reuse/recycling programme. Much of the C&D material is used in cover material at the landfill.

Scrap Metals

Scrap metal is the most lucrative of recycled materials, given the fact that it attracts the return best prices. However, like other recyclable materials, the market price greatly fluctuates and is extremely unpredictable. With current prices not the most attractive, and with exports slow, recyclers are left with huge inventories. Also, not all metals are easily recovered. A huge part of their inventory is appliances which require, particularly in the case of fridges, tedious labour to remove the insulation which is fused to the desired metal. This is one of the reasons why recyclers are calling for the introduction of a refundable fee on all appliances, part of which should remain with the recycler as the cost of processing the material.

Electronic Waste

Throughout the three (3) rounds of the WCS, an unusually high volume of e-waste was noticeable in the waste stream. Though this was a little surprising, subsequent information regarding the absence of any dedicated e-waste recycler in Barbados could be account for this anomaly. Several of the recyclers also pointed to large inventory of computers, (especially monitors) and television sets on their properties, again indicative of the absence of markets for e-waste but also the need for labour intensive effort to dismantle those items to remove valuable items. Notwithstanding those challenges, recent information indicating that Apple Computer, from its recent Environmental Responsibility report had collected over 60 million pounds (27,800 metric tonnes) of e-waste for recycling in 2015, from which it recovered 1 tonne of gold and 3 tonnes of silver as well as over 10,000 tonnes of steel,[4] should provide sufficient indication of the value which exists in recycling e-waste. Apple Computer attributed much of its success to its recycling collection events, take-back initiatives, and efforts like Apple Renew.[5] Unfortunately for Barbados and the Caribbean, there are no similar take-back or Producer Extended Responsibility programmes which would set the foundation to make similar initiatives possible. Whilst a more in-depth study is required to determine the challenges of instituting 'take-back' programmes and options which may be considered for introducing such a programme, Barbados and other countries of the region need to understand the importance of the public and private sectors working closely together in approaching manufactures and/or

[4] https://waste-management-world.com/a/apple-recycling-scheme-recovers-27-800-tonnes-of-materials-from-e-waste-including-1-tonne-of-gold
[5] Ibid.

retailers of e-waste, particularly computers and televisions, to devise protocols by which these items can be returned or recycling programmes established that will achieve similar objectives.

7.0 Total Quantity of Waste (Landfilled and Recyclable)

It has been estimated that the average amount of waste generated (landfilled and recycled) in Barbados during the first period (Round I, April 2015)[6] of the WCS was 26,036.32 tonnes (Table 7 below). This consisted of 24,921.32 tonnes which passed through the SBRC facility and 1,115 tonnes by the different recycling entities.

Table 7: Waste (Quantities) Landfilled & Recycled

Waste Materials	Data Source/Tonnes		Total Tonnes/ Month
	SBRC	Recyclers	
Paper & P/board	323.32	300	623.32
Glass Clear	15.99	100	115.99
Metal	19.93	620	639.93
Plastics	85.57	60	145.57
Organics	15,667.24		15667.24
C&D	8,688.61		8688.61
Tyres	80		80
E-waste	2.33	20	22.33
Batteries		15	15
Other	38.33		38.33
Total	**24,921.32**	**1,115**	**26,036.32**

This amounts to approximately 1,132.014 tonnes per day or 1,132,014 kg per day of waste. This translates to a total of 4.07 kg/person/day of waste. However, given the fact that Barbados attracts a large number of tourists on an annual basis, the overall generation waste amounts to 3.845035 kg/person/day (See Table 8).

[6] April 2015 was the last month before the introduction of the Tipping Fee which was introduced in May 2015. Given the fact that several waste haulers chose to dispose of their waste at other facilities, it was no longer possible to keep an accurate estimate of the amount of waste delivered to those other sites.

Table 8: Waste Characterisation Comparison Data

Source	Year	Waste (kg/person/day)
Simmons & Associates	2016	3.85
LH Consulting	2005	3.43
Caribbean Waste Resources Inc. (CWRI),	2002	3.00

Several studies on the volumes and composition of waste generated in Barbados have been carried out over the last 25 years. L.H. Consulting (2005) reports that the average per capita waste generation was 3.43 kg/person/day. This was up from a figure of 1.7 kg/person/day in 1994 and 3.0 kg/person/day in 2002, indicating a significant increase over that 10 year period and being comparable with waste generation rates of industrialized developed countries.

However, at 3.85 kg/person/day in 2015, this amount is slightly higher than the 2005 study, confirming what is already evident that raising standards of living usually results in an increase in the amount of waste generated.

This also shows that significant efforts with respect to waste recycling and diversion in Barbados have resulted in a small increase when compare to 1995-2005 period which is indeed manageable.

8.0 Conclusion and Recommendations

The results of the WCS 2015 have shown that the recycling rate and diversion rate were at a reasonable level (given the constraints which many of the recyclers were facing) for the waste streams which included metals, plastics, paper and cardboard. However, the waste diversion was limited to those items which have export potential (metals, plastics, paper, e-waste and batteries). Other than the efforts by SBRC to create compost and mulches from green waste, including coconut husks, there is no concerted effort to make great use of organic waste or construction and demolition waste.

Our assessment results also suggest that, in the context of waste diversion programmes implemented in Barbados it could be improved by addressing these influencing factors

including the legislative framework, public participation, increased source separation, and cooperation with NGOs, and civil society. To this end a number of measures have been deemed necessary and complimentary initiatives which if introduced will contribute to building upon the gains made with respect to waste diversion in Barbados. These include fiscal and economic measures (duty and tax incentives), more public awareness and educational campaigns, information dissemination, and training. To be truly successful it is also critical that efforts are made to enhance the legislative and enforcement framework.

In addition, opportunities to increase recycling participation among the island's businesses must be addressed in a comprehensive manner so as to strategically address materials not currently being captured in a systematic way.

Some of the measures which can be introduced to improve recycling systems include:

1. Increased awareness campaigns geared at heightening sensitivity among the entire populace on the importance of waste diversion, the importance of source separation and the role they can play in this regard.
2. Improved information dissemination which seeks to provide critical stakeholders with recommendations on the best practices related to implementing recycling programmes and to show them what influences recycling performance success.
3. Training is necessary for professional and managerial staff in a range of areas such as the use of specialized equipment, operation and maintenance, and monitoring and evaluation. This will require deliberate attempts at enhancing the capacity of the private sector so as to assist them in playing a more active role in transforming this sector by embracing new practices and technology.
4. Subsidies/tax incentives to support the recycling programmes which focus on the waste streams which have been identified as a priority for diversion could encourage recyclers to invest in initiatives for growth and expansion geared at diverting waste from the waste streams which required greatest attention.
5. The Barbados community recognises the importance of a clean and beautiful Barbados to the health and economic prosperity of its people as such efforts should be made to engage communities in a very structured and organised way so as to increase the citizenry's participation in waste diversion efforts. In particular community partners including individual volunteers, local government and non-profit organizations should be involved as part of a comprehensive national effort at increasing the diversion of waste.