



# **REPORT ON CURRENT STATE OF SOLID WASTE MANAGEMENT AND FACILITIES IN NUNAVUT AND COST-BENEFIT ANALYSIS OF SELECTED SOLID WASTE MANAGEMENT APPROACHES**

**GN-CGS PROJECT #2010-27**

March 30, 2011

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IN NUNAVUT AND COST-BENEFIT ANALYSIS OF SELECTED SOLID WASTE  
MANAGEMENT APPROACHES**

GN-CGS Project #2010-27



March 30, 2011

**Government of Nunavut – Community and Government Services**

P.O. Box 1000, Station 700  
Iqaluit, NU, X0A 0H0

**ATTENTION: Bill Westwell**

**RE: REPORT ON CURRENT STATE OF SOLID WASTE MANAGEMENT AND FACILITIES IN  
NUNAVUT AND COST-BENEFIT ANALYSIS OF SELECTED SOLID WASTE MANAGEMENT  
APPROACHES (GN-CGS PROJECT #2010-27)**

ARKTIS Solutions Inc. is pleased to provide the Government of Nunavut, Community and Government Services with a report for the above referenced project. We trust that the information presented in this report satisfies the requirements of the project at this stage. Please do not hesitate to contact the undersigned if there are any questions or comments.

Sincerely,

ARKTIS SOLUTIONS INC.

Jamie VanGulck, Ph.D., P.Eng.  
Chief Technical Officer, ARKTIS Solutions Inc.



## **EXECUTIVE SUMMARY**

A study on solid waste management best practices for the territory of Nunavut was completed. The study focused on the management of municipal solid waste (MSW) which may comprise recyclables and compostable materials, as well as, residential, industrial, commercial and institutional operations within the community, and construction and demolition waste. Waste generated outside of the community, unless deposited within a community waste facility, was not addressed. The overall goal of the study is to understand how to sustainably manage solid waste in the territory of Nunavut. The objectives of the study were fulfilled through the completion of the following components:

- i. Evaluation of the current state of solid waste management and facilities;
- ii. Detailed cost benefit analysis and technical evaluation of three selected waste management approaches;
- iii. Development of a best practice guide on sustainable solid waste management;
- iv. Development of a generic operations and maintenance manual for solid waste facilities; and,
- v. Recommendations for solid waste management training.

Within this document the following project components were completed:

- Evaluation of the current state of solid waste management facilities;
- Detailed cost benefit analysis of three waste management approaches; and,
- Technical evaluation of three waste management approaches to observed current conditions.

Fourteen Nunavut communities were visited to gather data that was used to characterize the current state of solid waste facilities and record community concerns regarding waste management. Activities completed during each community visit consisted of: solid waste facility site inspection, interview with hamlet staff involved in solid waste management, and a public meeting to gather residents' perception on solid waste practices within the community. Provided below is a summary of the information that was gathered during the community site visits.

- All communities expressed concerns about the impact of solid waste facilities on the environment (e.g., windblown litter);
- Communities voiced their concerns related to health and safety hazards including: pollution caused by smoke and odours from open garbage burning, contamination of water, cross-contamination onto recyclables and reusable materials, and uncontrolled access to the site which may result in injury or harm to community members;
- Residents in a majority of the communities commented that solid waste facilities may be located too close to homes;
- Most communities expressed their willingness to participate in several solid waste management programs including: waste separation, waste backhauling, recycling, and hazardous waste management;
- Most communities expressed their interest in obtaining additional information and educational materials on alternative waste management approaches;
- Based on discussions with community staff, average solid waste generation within the community is estimated at about 8.5 m<sup>3</sup>/capita/year;
- Based on discussions with community staff, the operational and maintenance budget was estimated to be on average about \$173/capita/year, and on average about 1.8 full time employees are needed to service a solid waste facility;
- Many communities have an incomplete or non-existent fence/gate. A lack of a fence/gate prohibits communities from achieving control over site accessibility by 3<sup>rd</sup> party users or control over waste types that enter the facility;



- Many communities do not have any signs in their solid waste facility which may create problems with proper waste separation and disposal; and,
- With the exception of two communities, all communities practiced open-burning of municipal solid waste.

A cost benefit analysis for three waste management approaches over a 30 year life cycle was completed. The cost benefit analysis was completed for the following three waste management approaches:

- **Approach #1 Modified Landfill:** Municipal solid waste and bulky waste materials are permanently deposited in dedicated waste cells. Hazardous waste materials are temporarily stored in a dedicated cell and then backhauled, as required, to a licensed disposal facility outside of Nunavut. The municipal, bulky, and hazardous waste cells comprise the solid waste facility within the community.
- **Approach #2 Thermal Destruction:** This approach involves the use of equipment (incineration or gasification technology) that provides thermal destruction of organic material contained within solid waste. Residual waste materials from thermal destruction and bulky waste items are permanently deposited in dedicated waste cells. Suitable hazardous waste liquids (oil and fuel) are destroyed using the selected thermal destruction equipment. Non-suitable hazardous waste materials are managed as described in Approach #1. The thermal destruction equipment, as well as, the municipal, bulky, and hazardous waste cells comprise the solid waste facility within the community.
- **Approach #3 Shift and Separate:** This approach involves segregation, removal from site (e.g., backhauling), composting, and/or recycling of solid waste to divert it from final disposal in the solid waste facility. Non-diverted waste materials are permanently deposited in dedicated waste cells. Waste oil and fuel is destroyed within the community through the use of a waste oil burner. Hazardous waste materials are managed as described in Approach #1. Working areas for recycling and composting are required and may be located at the solid waste facility. The municipal, bulky, and hazardous waste cells comprise the solid waste facility within the community.

The cost benefit analysis was completed for a statistically average Nunavut community calculated from Nunavut Bureau of Statistics population data. Average community population data was used to calculate an estimated volume of uncompacted solid waste over a 30 year period. The volume of uncompacted waste was estimated to consist of 81.9% municipal solid waste, 15% bulky waste materials, and 3.1% hazardous waste materials. The waste composition estimates were based on literature reported data.

The calculation of the life cycle costs for each waste management approach consisted of evaluating the capital expenses, operation and maintenance (O&M) costs, and potential revenue streams. Provided below is a summary of key assumptions that were made for the cost benefit analysis.

- Capital costs for site construction included: site preparation and grubbing, waste cells, burn pit, access roads, drainage ditches, fences/gate, and signage;
- Capital costs included: the purchasing of major site equipment, costs for site closure and site mobilization, and fees for contingency and engineering;
- O&M costs included the purchase and maintenance of three waste collection vehicles over a 30 year life cycle;
- O&M costs included fuel required to operate the mobile equipment and site facility infrastructure;
- O&M costs included costs for the labour required to service and operate the site infrastructure and waste collection vehicle;



- O&M costs for the backhaul and disposal of hazardous waste materials;
- O&M costs associated with general activities such as: equipment rentals, minor repairs, site cleanup and annual soil cover; and,
- Garbage disposal fees were considered as a potential revenue source for all three waste management approaches. Other revenue sources, such as scrap metal, recycling and compost material, were considered for Approach #3.

The cost benefit analysis indicated that the overall life cycle costs for Approach #2 (thermal destruction) were significantly higher than when compared to the life cycle costs for Approach #1 (modified landfill) and Approach #3 (shift and separate). Provided below is a summary of how the three waste management approaches compared with respect to their capital costs, O&M costs, revenue streams, and overall life cycle costs:

| Item             | Approach #1<br>Modified<br>Landfill | Approach #2<br>Thermal<br>Destruction | Approach #3 -<br>Shift and<br>Separate | Ranking                                      |
|------------------|-------------------------------------|---------------------------------------|----------------------------------------|----------------------------------------------|
| Capital Costs    | \$9,559,311                         | \$12,146,407                          | \$9,329,217                            | Approach #2 > Approach #1 and<br>Approach #3 |
| O&M Costs        | \$5,524,232                         | \$10,521,467                          | \$8,211,945                            | Approach #2 > Approach #3 ><br>Approach #1   |
| Revenue          | \$1,725,046                         | \$1,725,046                           | \$4,307,063                            | Approach #3 > Approach #1 and<br>Approach #2 |
| Life Cycle Costs | \$13,358,716                        | \$20,942,829                          | \$13,234,098                           | Approach #2 > Approach #1 and<br>Approach #3 |

- Due to the costs associated with the purchase of a thermal destruction equipment unit the capital costs for Approach #2 (thermal destruction) were significantly higher than for the other two approaches;
- Approach #2 (modified landfill) had the highest O&M costs as a result of the large requirement for fuel and labour that is needed to operate the thermal facility. The high O&M costs for Approach #3 are attributed to the labour required to divert the various waste streams including scrap metal, recycling and compost material.
- Approach #1 (modified landfill) and Approach #2 (shift and separate) are only able to generate potential revenue from the collection of garbage service fees. Approach #3 (shift and separate) has the potential to generate revenue through distinct revenue streams including the sale of scrap metal, compost and recyclable materials.

A comparative summary of the three waste management approaches defined in the cost benefit analysis to the current waste management conditions was completed. Provided below is a summary of the key design features in each evaluated approach.

#### Current Conditions:

- Typically uncontrolled to minimal waste separation and disposal within a disposal area;
- Typically open burning of domestic waste;
- Typically minimal separation of bulky waste from municipal waste, and limited hazardous waste management;
- Facility has no to limited facility operations and maintenance;
- Facility is typically not design or constructed to acceptable engineering standards; and,
- Facility may or may not be fenced.



### **Approach #1 Modified Landfill**

- Facility is fenced and access can be controlled;
- The solid waste facility is separated into separate cells (bulky waste, municipal waste, and hazardous waste);
- Each cell is enclosed in a berm and self-contained;
- Separate controlled burn pit is maintained for suitable waste;
- Solid waste facility has regular operation and maintenance activities completed; and,
- Solid waste facility is designed and constructed to acceptable engineering standards.

### **Approach #2 Thermal Destruction**

- Incinerator or gasification equipment is used to burn waste and thereby reduce the volume of waste for disposal within a solid waste facility;
- Disposal of ash generated from thermal destruction, as well as, bulky waste requires disposal in a modified landfill as described in Approach #1.
- Incineration allows the presence of oxygen during the burning process, gasification does not.
- Gasification generally produces less harmful air emissions.
- A modified landfill, similar to Approach #1, is used to store waste ash and waste that is not suitable for incineration/gasification.

### **Approach #3 Shift and Separate**

- Waste is separated into several streams for diversion. The diversion activities include temporary storage, reuse, and recycling.
- A wide variety of materials can be diverted from disposal in the solid waste facility. These materials can include scrap metal, waste wood and organic waste (compostable materials).
- Materials that are not suitable for diversion are separated and disposed of in a modified landfill as described in Approach # 1.
- A composting area is provided to destroy suitable organic materials.

The technical evaluation of the three waste management approaches compared to the current conditions considered the following:

- Waste management and operations criteria: including the management of solid waste, bulky waste and hazardous waste, odour and litter control, and site security and signage.
- Environmental criteria including: air quality, surface water protection, leachate management, hazardous waste contamination, and Nunavut Water Board licensing; and,
- Financial criteria including: capital costs, operation and maintenance costs, revenue potential, and financial risk.

Each criterion was numerical ranked based on a scale of one to four, with a value of 1 representing a poor evaluation, and a value of 4 representing an excellent evaluation (i.e., excellent = 4, good = 3, average = 2 and poor = 1). Financial risk was included in the analysis to reflect how likely an approach is either going to cost more than estimated, or bring in less revenue than estimated. The numerical ranks were weighted to place emphasis on factors that were considered important to the public, community, and territorial government.



Provided below is a summary of the weighted rankings.

- Weighted rank of **70** for current conditions;
- Weighted rank of **97** for Approach #1 Modified Landfill;
- Weighted rank of **79** for Approach #2 Thermal Destruction; and,
- Weighted rank of **82** for Approach #3 Shift and Separate.

The final ranking results indicate that the current conditions are inferior to the other three waste management approaches considered in the evaluation. Approach #1 - Modified Landfill, was ranked the highest and is considered the most financially feasible approach that provides environmental protection and safe and efficient waste management operations. Waste management Approach #1 - Modified Landfill, was recommended as the preferred strategy to sustainably manage waste materials in the territory of Nunavut.



*Letter of Transmittal*  
*Executive Summary*

## TABLE OF CONTENTS

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| 1.0 INTRODUCTION .....                                                                 | 1  |
| 2.0 COMMUNITY VISITS .....                                                             | 2  |
| 2.1 Objectives.....                                                                    | 2  |
| 2.2 Introduction.....                                                                  | 2  |
| 2.3 Community Meeting .....                                                            | 2  |
| 2.3.1 Discussion of Results .....                                                      | 4  |
| 2.4 Interviews with Community Staff .....                                              | 6  |
| 2.4.1 Discussion of Results .....                                                      | 7  |
| 2.4.2 Estimated Waste Volume .....                                                     | 8  |
| 2.4.3 SWF By-laws and Budget .....                                                     | 8  |
| 2.5 Visual Inspection of the Solid Waste Disposal Facility.....                        | 9  |
| 2.5.1 Discussion of Results .....                                                      | 10 |
| 2.6 Additional Community Specific Comments .....                                       | 12 |
| 2.7 Summary of Findings .....                                                          | 12 |
| 3.0 COST-BENEFIT ANALYSIS OF SOLID WASTE MANAGEMENT APPROACHES .....                   | 21 |
| 3.1 Objective .....                                                                    | 21 |
| 3.2 Introduction.....                                                                  | 21 |
| 3.3 Alternative Waste Management Approaches.....                                       | 21 |
| 3.3.1 Approach #1 – Modified Landfill.....                                             | 21 |
| 3.3.2 Approach #2 – Thermal Destruction .....                                          | 22 |
| 3.3.3 Approach # 3 – Shift and Separate .....                                          | 23 |
| 3.4 Waste Generation Estimates .....                                                   | 24 |
| 3.4.1 Estimate of Population Growth.....                                               | 24 |
| 3.4.2 Waste Volume and Composition.....                                                | 24 |
| 3.5 Cost-Benefit Analysis - Assumptions .....                                          | 25 |
| 3.5.1 Life-cycle Costs .....                                                           | 25 |
| 3.5.2 Net Present Value .....                                                          | 26 |
| 3.5.3 Capital Costs .....                                                              | 26 |
| 3.5.4 O&M Costs .....                                                                  | 27 |
| 3.5.5 Revenue .....                                                                    | 28 |
| 3.6 Cost-Benefit Analysis – Summary of Inputs for Each Waste Management Approach ..... | 28 |
| 3.6.1 Waste Management Approach #1 – Modified Landfill .....                           | 28 |
| 3.6.2 Waste Management Approach #2 – Thermal Destruction .....                         | 28 |
| 3.6.3 Waste Management Approach #3 – Shift and Separate .....                          | 29 |
| 3.7 Cost-Benefit Analysis – Results .....                                              | 30 |
| 3.7.1 Capital Costs .....                                                              | 31 |
| 3.7.2 O&M Costs .....                                                                  | 31 |
| 3.7.3 Revenue .....                                                                    | 32 |
| 3.7.4 Life-Cycle Costs .....                                                           | 33 |
| 4.0 WASTE MANAGEMENT APPROACHES TECHNICAL EVALUATION.....                              | 56 |
| 4.1 Objective .....                                                                    | 56 |
| 4.2 Design Approaches Summary .....                                                    | 56 |
| 4.2.1 Current Conditions .....                                                         | 56 |
| 4.2.2 Approach #1- Modified Landfill.....                                              | 56 |
| 4.2.3 Approach #2- Thermal Destruction .....                                           | 56 |



|                                              |    |
|----------------------------------------------|----|
| 4.2.4 Approach #2- Thermal Destruction ..... | 56 |
| 4.3 Technical Evaluation .....               | 57 |
| 4.4 Conclusions and Recommendations .....    | 58 |
| 5.0 CONCLUSIONS.....                         | 72 |
| 6.0 LIMITATIONS OF LIABILITY.....            | 73 |
| 7.0 CLOSURE.....                             | 73 |

## LIST OF TABLES

|                                                                                                                                                              |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Table 2.1:</b> Summary of communities selected for the waste study, date of community meeting, and number of participants that attended the meeting. .... | 13 |
| <b>Table 2.2:</b> Summary of the responses from the public meetings. ....                                                                                    | 14 |
| <b>Table 3a:</b> Summary of responses from the administrative staff interview regarding site layout and location. ....                                       | 15 |
| <b>Table 2.3b:</b> Summary of selected responses from the administrative staff interview regarding waste collection, volumes, and container type. ....       | 16 |
| <b>Table 2.3c:</b> Summary of the responses from the administrative staff interview regarding by-laws, policies and budgetary information. ....              | 17 |
| <b>Table 2.4:</b> Summary of selected solid waste facility features observed during the community site visit. ..                                             | 18 |
| <b>Table 2.5:</b> Community specific comments gathered during public meetings and interview with administrative staff. ....                                  | 19 |
| <b>Table 3.1:</b> Summary of key features of three approaches to waste management.....                                                                       | 34 |
| <b>Table 3.2:</b> Estimated total community solid waste volume generated. ....                                                                               | 36 |
| <b>Table 3.3:</b> Summary of waste composition estimates. ....                                                                                               | 37 |
| <b>Table 3.4:</b> Summary of waste mass, volume, and composition for waste management Approach #1.....                                                       | 38 |
| <b>Table 3.5:</b> Waste type and mass reduction in thermal destruction process.....                                                                          | 39 |
| <b>Table 3.6:</b> Summary of waste mass, volume, and composition for waste management Approach #2.....                                                       | 40 |
| <b>Table 3.7:</b> Summary of waste mass, volume, and composition for waste management Approach #3.....                                                       | 41 |
| <b>Table 3.8:</b> 2010 Government of Nunavut agreement and private shipping rates. ....                                                                      | 42 |
| <b>Table 3.9:</b> Disposal costs of typical hazardous waste materials .....                                                                                  | 43 |
| <b>Table 3.10:</b> Estimated total annual disposal cost for hazardous waste materials.....                                                                   | 43 |
| <b>Table 3.11:</b> Summary of revenue from garbage disposal fees. ....                                                                                       | 44 |
| <b>Table 3.12:</b> Summary of capital costs for waste management Approach #1.....                                                                            | 45 |
| <b>Table 3.13:</b> Summary of O&M costs for waste management Approach #1. ....                                                                               | 46 |
| <b>Table 3.14:</b> Average costs for acquiring and operating a thermal facility. ....                                                                        | 47 |
| <b>Table 3.15:</b> Summary of capital costs for waste management Approach #2.....                                                                            | 47 |
| <b>Table 3.16:</b> Summary of O&M costs for waste management Approach #2. ....                                                                               | 48 |
| <b>Table 3.17:</b> Summary of capital costs for waste management Approach #3.....                                                                            | 49 |
| <b>Table 3.18:</b> Summary of O&M costs for waste management Approach #3. ....                                                                               | 50 |
| <b>Table 3.19:</b> Example of ferrous and non-ferrous prices. ....                                                                                           | 51 |
| <b>Table 3.20:</b> Summary of revenue for waste management Approach #3.....                                                                                  | 52 |
| <b>Table 4.1:</b> Evaluation of waste management and operations criteria for each waste management approach .....                                            | 59 |
| <b>Table 4.2:</b> Evaluation of environmental criteria for each waste management approach .....                                                              | 63 |
| <b>Table 4.3:</b> Evaluation of financial criteria for each waste management approach.....                                                                   | 67 |
| <b>Table 4.4:</b> Summary of total rankings for each criterion group .....                                                                                   | 71 |



## LIST OF FIGURES

|                                                                                                          |    |
|----------------------------------------------------------------------------------------------------------|----|
| <b>Figure 3.1:</b> Schematic layout of a SWF for waste management Approach #1 (modified landfill).....   | 53 |
| <b>Figure 3.2:</b> Schematic layout of a SWF for waste management Approach #2 (thermal destruction)..... | 54 |
| <b>Figure 3.3:</b> Schematic layout of a SWF for waste management Approach #3 (shift and separate).....  | 55 |

## LIST OF APPENDICES

|                                                              |
|--------------------------------------------------------------|
| <b>APPENDIX A – COMMUNITY POSTER AND PRESENTATION SLIDES</b> |
| <b>APPENDIX B – COMMUNITY FEEDBACK</b>                       |
| <b>APPENDIX C – INTERVIEW WITH COMMUNITY STAFF</b>           |
| <b>APPENDIX D – VISUAL SWF INSPECTION</b>                    |
| <b>APPENDIX E – THERMAL TECHNOLOGIES INFORMATION</b>         |



## 1.0 INTRODUCTION

The Government of Nunavut, Community and Government Services (GN-CGS) contracted ARKTIS Solutions Inc. (ARKTIS) to complete a study, and associated analysis and reporting, on solid waste management best practices in Nunavut communities (GN-CGS Project #2010-27; Solid Waste Management in Nunavut: Best Practices and Cost Estimates for Various Strategies and Options). The focus of the study will be the management of municipal solid waste (MSW), which refers to recyclables and compostable materials, as well as, garbage from residences, industry, commercial and institutional operations within the community, and construction and demolition waste. This study will not focus on waste generated outside of a community, unless such waste is reported by local staff to be managed within a community facility. One of the overall objectives of the study is to understand how to sustainably manage solid waste in Nunavut.

The study involves the following main components:

- i. Report on current state of solid waste management and facilities in Nunavut, as best characterized by knowledge gained during visits to various communities<sup>1</sup>;
- ii. Cost-benefit analysis on selected approaches to waste management in Nunavut;
- iii. Best practice guide on the sustainable management of solid waste in Nunavut<sup>2</sup> (herein referred to as the “SWF Best Practice Guide”);
- iv. Generic operations and maintenance manual for solid waste disposal facilities<sup>3</sup>; and,
- v. Report on recommendations for solid waste management training<sup>4</sup>.

This document was developed to report on: the current state of solid waste management and facilities in Nunavut, and a cost-benefit analysis on three waste management approaches.

Fourteen Nunavut communities were visited to gather information to characterize the current state of the solid waste facilities (SWF). Activities completed during each community visit consisted of: solid waste facility site inspection, interview with hamlet staff involved in solid waste management, and a public meeting to gather residents’ perception on solid waste practices within the community. Information gathered from the community visits on current state of solid waste facilities and solid waste management is provided in **Section 2.0** of this report.

Three solid waste management approaches were reviewed and analyzed with the objective to assess the cost-benefit, and also, to identify non-monetary advantages and disadvantages of each approach. The three solid waste management approaches considered are:

- Approach #1 - modified landfill;
- Approach #2 - thermal destruction; and,
- Approach #3 - shift and separate.

The analysis and recommendations of the cost-benefit analysis may provide the GN-CGS with technical

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<sup>1</sup> Arktis Solutions inc., October 18, 2010, Report On Current State of Solid Waste Management and Facilities in Nunavut, GN-CGS Project #2010-27.

<sup>2</sup> Arktis Solutions inc., December 23, 2010, Solid Waste Best Management Guide Nunavut, GN-CGS Project #2010-27.

<sup>3</sup> Arktis Solutions inc., December 16, 2010, Generic Solid Waste Facility Operation and Maintenance Manual, GN-CGS Project #2010-27.

<sup>4</sup> Arktis Solutions inc., December 23, 2010, Assessment of Training Needs for Solid Waste Facilities in Nunavut, GN-CGS Project #2010-27.



and financial facts that can be used to select a sustainable solid waste management strategy for Nunavut communities. Information on solid waste management approaches is provided in **Section 3.0** of this report.

The presentation of this report is as follows:

- Section 1.0: Introduction;
- Section 2.0: Community Visits;
- Section 3.0: Cost-Benefit Analysis of Solid Waste Management Alternatives;
- Section 4.0: Waste Management Approaches Technical Evaluation;
- Section 5.0: Conclusions;
- Section 6.0: Limitations of Liability; and,
- Section 7.0: Closure.

## 2.0 COMMUNITY VISITS

### 2.1 Objectives

There are two objectives of this component of the study:

- To better understand current waste management practices and constraints on their improvement; and,
- To record community concerns regarding waste management.

### 2.2 Introduction

In order to develop a better understanding of the current state of the solid waste facilities (SWF) and solid waste management practices in Nunavut, fourteen Nunavut communities as selected by the GN-CGS were visited between August and October 2010 (see **Table 2.1**). For each community, a community meeting, interviews with community staff, and a visual inspection of the solid waste disposal facility were completed. All activities completed during the community visits were planned to be accomplished within a single working day.

All statements and results presented in this section should be considered as obtained from public meetings or interviews with community staff. Information and data collected during community visits was not verified for accuracy. This limitation should be considered for all findings, interpretation, and recommendations of this section of the report.

### 2.3 Community Meeting

A public meeting was administered by ARKTIS in each community. The community meeting involved a presentation by ARKTIS that detailed the goals and objectives of the solid waste management study and for the meeting. The focus of the community presentation was to gather information pertaining to:

- Characterization of current waste management practices and constraints on improvement; and,
- Record community concerns/comments regarding waste management.

Public meetings took place in the community hall, gymnasium, or conference room. The public was informed about the study prior to the ARKTIS personnel arrival to the community through radio announcements and posters placed in frequently visited areas, such as the hamlet office or the store entrance. An example of the poster is provided in the **Appendix A**.

Communities were contacted in advance (usually a couple of weeks) of the visit. Many senior administrative officers (SAOs) and assistant senior administrative officers (ASAOs) were not aware of the



waste study. As such, ARKTIS informed the SAO or ASAO during this initial call about the nature of the study and the purpose of the community visit. All of the planned activities were discussed, such as: visual inspection of the SWF (usually in the morning), interview with SAO or ASAO (often accompanied by a person whose role is to operate and/or manage the solid waste facility), and a public meeting in the evening (usually at 7 pm). Assistance from the hamlet staff was requested to advertise the public meeting through poster placement and radio announcements.

In the case of two communities: Pangnirtung and Resolute Bay, the initial schedule to visit the community had to be changed. The visit to Pangnirtung was originally scheduled for August 25<sup>th</sup>; however, due to weather, no flights were available. The community of Resolute Bay was not available in late August due to military training in the area and an associated increase in the amount of work experienced by the Hamlet staff. As such, both of these communities were visited on the second week of October.

Due to a lack of attendance, in Qikitarjuag, a recreation coordinator in charge of the gymnasium where the meeting was held was interviewed, and in Kugaaruk, no feedback was gathered. For two communities, Baker Lake and Resolute Bay, due to a lack of attendance a radio interview was held instead of a formal community meeting. A local radio station is a common feature in the northern communities and it is frequently listened to. Many calls were received during a night radio show.

Representatives of the Pangnirtung community requested that no GN-CGS directed public consultation program be performed due to a previous council meeting and community consultation completed in 2007 (see **Appendix B** for more details).

Community feedback was grouped into the following five categories:

1. Solid waste type, sources and generators – feedback was gathered to gain an understanding of key solid waste generators within the community including businesses and institutions, as well as, any unusual solid waste generators (e.g., fish plant or resource exploration/mining)
2. Garbage pick-up, fees and by-laws – this category aimed to understand how the community perceive garbage disposal services (e.g., frequency of garbage pick-up or type of garbage containers used) and any associated by-laws and fees.
3. Landfill operation – this category aimed to understand the perceived environmental, economic, and social impacts to the community as a result of the operation of the solid waste facility. The community information was arranged into the following subcategories:
  - a. Smoke and odour –input gathered into whether the community is affected by smoke (in case of garbage open burning) and/or odour generated at the solid waste facility.
  - b. Landfill location – input gathered into whether there are any issues with the current landfill location. For example, many communities noted that their solid waste facility location was selected several decades ago and due, in part, from community growth, the community is approaching the solid waste facility site (e.g., Pond Inlet, Pangnirtung, and Clyde River).
  - c. Health and safety –feedback related to health and safety issues/concerns were gathered, such as: possible hazards related to lack of fencing and gates (uncontrolled access); potential to contaminate water source or vital resources (such as hunting grounds or fishing areas); potential to contaminate recyclables (such as wooden materials, mechanical parts); and, lack of stability (potential to be trapped/buried under solid waste slide).
  - d. Fencing and litter – gathered into whether fencing/gate is present at the solid waste facility and whether it adequately captures windblown garbage.
  - e. Environment – aimed to understand the perceived impacts the current solid waste facility has on the surrounding environment (e.g., water bodies and wildlife).



- f. Site capacity – aimed to understand whether there are any limitations of the landfill storage capacity (e.g., lack of volume) or the ability to operate the landfill (e.g., lack of proper equipment).
4. Community participation in solid waste management programs – this category aimed to understand whether the community currently, or would be willing to, participate/support the following programs:
  - a. Waste separation – program/practices aimed at improving waste separation by type such as: separation of waste types at the solid waste facility (i.e., mechanical parts, useable wood), and hazardous waste collection days..
  - b. Backhauling of bulky or metal materials – program aimed to ship their metal or bulky waste out of the community.
  - c. Recycling – program aimed to recycle materials..
  - d. Hazardous waste – program aimed to improve hazardous waste (e.g., car batteries, used oil, medical waste) management.
  - e. Composting – program aimed to create a composting facility that would allow the decomposition of organics.
  - f. Community outreach – program aimed to provide informational / educational materials to the community.
5. Community comments / input – community specific feedback related to the solid waste management that was not covered in the previous categories.

A copy of the community presentation is provided in **Appendix A**. A summary of responses in each of the above listed categories is provided in **Table 2.2**. Feedback that was recorded during the public meeting is provided in **Appendix B**.

### 2.3.1 Discussion of Results

#### UNUSUAL SOURCE OF SOLID WASTE

Only one community, Pangnirtung, identified waste generated from the fish processing plant as an unusual source of waste that is accepted in the community solid waste facility. All other communities did not indicate any unusual source of waste beyond what is generated within the community such as: household garbage, wood, construction material, old vehicles, car batteries, etc. It should be noted that it is probable that communities in proximity of resource development activities and/or contaminated site reclamation activities (e.g., Distant Early Warning sites) received solid waste from these generators. However, none of the communities stated that waste disposal from these industrial activities occurs.

#### SMOKE AND ODOURS

Smoke and odours associated with landfill operation and open burning of garbage is perceived as a concern in over half of the communities visited (62%). Typical concerns include: potential impacts that chemicals in the smoke may have on human health, in particular pregnant women, and, the potential for odours to penetrate into, and affect the quality of, meat that is cured outside and exposed to smoke and odour.

The residents of Qikiqtarjuag, Kimmirut, Gjoa Haven and Ranking Inlet do not perceive smoke or odours as an issue. It should be noted that Rankin Inlet currently does not burn garbage. For a list of communities that practice garbage burning see **Table 2.4**.

#### CURRENT SWF LOCATION

The public in 75% of the communities identified some issues with the current SWF location. The most common issues were related to facility being perceived to be too close to the community, due to the community expansion over the past years (Clyde River, Igloolik, Pond Inlet, Baker Lake, Kimmirut), or too



close to a surface water body (Resolute Bay). Additionally, in the case of Resolute Bay, the SWF is located at a historical site and near the cemetery. Further, Coral Harbour identified that the location of the SWF is in a high elevation which allows for potential odours to migrate towards the community.

Lastly, Coral Harbour has a historical, decommissioned solid waste disposal site located near the community. It is unknown if the decommissioning was completed by a qualified engineer. According to the General Sanitation Regulations<sup>5</sup>, a 450 m setback from a solid waste site to the community is required. This setback distance considerably restricts community development in this area, and the public inquired if this setback is still required. No further details on the decommissioning plan were obtained during community visit.

### **HEALTH AND SAFETY**

Health and safety related concerns were voiced in all communities except Kugluktuk. Some of the concerns were related to: pollution caused by smoke produced from open-burning of garbage (Qikiqtarjuag, Resolute Bay); contamination of the water source by windblown litter (Coral Harbour); medical waste (Kimmirut, Igloolik); cross contamination onto recyclables/reusable materials such as wood or construction materials (Gjoa Haven); and, uncontrolled access to the solid waste facility, especially by children (Rankin Inlet, Clyde River, Cambridge Bay). Details on the management of medical waste were not obtained during the community site visits.

### **FENCING AND LITTER**

Fencing and litter is perceived to be an issue in all the communities visited and is largely caused by windblown plastic bags in the area of the solid waste facility and nearby surface water bodies. Interestingly, it was noted in Gjoa Haven that after garbage bag fees were introduced, this problem seemed to be less severe.

### **ENVIRONMENT**

Concerns related to the impact of SWF on the environment were voiced in all the communities visited. Some of the responses included: drinking water source may be impacted by the SWF (Rankin Inlet, Coral Harbour), as well as, potential impacts onto surface water bodies, aquatic life, and/or hunting grounds (Igloolik, Kugluktuk, Clyde River, Rankin Inlet, Resolute Bay).

### **SITE CAPACITY**

Concerns were raised by the community regarding the future capacity of the SWF in the following communities: Kimmirut, Pangnirtung, Gjoa Haven, Rankin Inlet, and Pond Inlet.

### **GARBAGE PICKUP/COLLECTION ISSUES**

The public indicated the following issues related to garbage pickup services: campsites and cabins are not serviced (Igloolik); garbage is picked up only when the bin is completely full, which results in times when the container is full and garbage cannot be discarded (Pond Inlet); the same garbage truck and personnel resources are perceived to be servicing the community despite community growth over the years (Clyde River); and, drums fill up too quickly, more frequent pickup would be required (Cambridge Bay).

### **REGULATORY AND BUDGETARY CONCERNS**

The communities of Igloolik and Pond Inlet expressed concerns related to a perceived lack of enforcement on the 3<sup>rd</sup> party users from within the community (for more information on 3<sup>rd</sup> party users identified to be local contractors and businesses see **Appendix B**) of the solid waste facility. It should be

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<sup>5</sup> Public Health Act. 1990. Consolidation of General Sanitation Regulations. R.R.N.W.T. 1990, C.P-16.



noted that the public was not aware how these items were addressed in by-laws. Overall, the majority of the participants in the public meeting were not aware of regulatory policies and budgetary commitments.

## **COMMUNITY WILLINGNESS TO PARTICIPATE IN WASTE MANAGEMENT PROGRAMS**

Several communities indicated support for the following waste management programs: waste separation program, recycling program, hazardous waste management and waste backhauling. Coral Harbour stated that waste backhauling is not needed at the moment due to a lack of a sufficient quantity of bulky waste. A program for composting did not receive any interest. Of the communities that responded, 9 out of 11 were interested in receiving additional information regarding waste management (refer to **Section 2.4** for additional information).

### **2.4 Interviews with Community Staff**

During the community visit, interviews were completed with relevant community staff (SAO, ASAO, solid waste facility operator and/or manager – refer to **Appendix C** and **D** for information obtained for each community) to gather specific information pertaining to:

1. Site layout and location – information was gathered to establish how long the current solid waste facility location has been in use and the reason(s) the location was selected. In addition, data was recorded on any recent upgrades to the solid waste facility/management infrastructure, and an estimate of the remaining lifespan of the facility.
2. Waste volume and composition – information was gathered to understand solid waste generation/volume and composition. Also, the frequency of garbage pickup, type of garbage truck (including volume), and estimates on average household garbage generation rate (if possible) were recorded. Lastly, information regarding registered users and 3<sup>rd</sup> party users of the solid waste facility was collected.
3. Solid waste collection, management, and operations – information gathered under this category included the following:
  - a. Type of waste containers employed at individual houses – information was gathered on the method used to temporarily contain waste at residential houses prior to pick up.
  - b. Solid waste facility access in the winter – information was gathered on whether the SWF can be easily accessed in the winter and associated access maintenance.
  - c. Waste segregation – information was gathered regarding waste segregation and the types of waste targeted.
  - d. Hazardous waste management – information was gathered on whether the community employs any kind of hazardous waste management program or segregation.
4. Community and policies – information gathered under this category included the following:
  - a. Challenges and opportunities related to solid waste management.
  - b. Nunavut Water Board (NWB) water license – information pertaining to the status and compliance with the water license was gathered.
  - c. Current solid waste facility by-laws – information was gathered on whether the community has established solid waste collection and disposal by-laws, and associated waste tipping fees.
  - d. Solid waste management budget – several types of data was gathered, including: annual budget for solids waste management, staffing levels, any changes made to the effort to dispose of garbage in recent years, whether there is a possibility to opt out of community garbage pickup, and estimated cost of garbage disposal per person.
  - e. Historical solid waste disposal programs – information was gathered on any historical programs such as recycling, backhauling or composting.
  - f. Staff training – information was gathered on the training landfill operators receive to perform their job.



A series of questions/inquiries were developed prior to the site visits in an attempt to gather the same information from each community. Responses from the questions/inquiries are provided in **Appendix C**. A summary of selected responses are presented in **Tables 3a, 3b, and 3c**. For additional details refer to **Table 2.4**.

#### **2.4.1 Discussion of Results**

##### **START OF OPERATION OF THE SWF**

Most current facilities started operation several decades ago and are likely approaching or exceeded their initial planned design life of about 20 to 40 years. The newest facilities, started in the 1990s, are located in Qikiqtarjuag, Pond Inlet, Clyde River, Baker Lake, Kugluktuk and Gjoa Haven.

##### **REASONS FOR SELECTING THE CURRENT LOCATION OF THE SWF**

Limited information was recorded regarding the reasons for the location of the current SWF facility. Pangnirtung and Kugaaruk facilities are located where natural conditions were favorable (open area and behind a hill to reduce visual impacts, respectively). Clyde River, Baker Lake, and Kugluktuk indicated that the site was most probably chosen to be in proximity to other potentially impacted areas (contaminated soil location in Clyde River and sewage lagoon in Baker Lake and Kugluktuk).

##### **RECENT UPGRADES**

Four communities (Pangnirtung, Igloolik, Resolute Bay, Gjoa Haven) indicated that no recent upgrades had been performed, while other communities implemented some recent upgrades, as shown in **Table 2.3a**. The most significant upgrade is the construction of a new facility in Cambridge Bay.

##### **REMAINING LIFESPAN**

Only one community, Cambridge Bay, has a 20-year design life span on their newly constructed SWF. The remaining communities were not aware of the remaining life span of their SWF.

##### **DISTANCE FROM DRINKING WATER SOURCE**

Solid waste facilities may pose the risk of contaminating community drinking water sources. Pertinent regulations (Public Health Act and General Sanitation Regulations – for more detail see Section 2 and Section 4 of the SWF Best Practice Guide) do not specify an acceptable distance from a water source or reservoir to the SWF. Instead, it is required that the SWF be situated “at such a distance from a source of water or ice for human consumption or ablution that no pollution shall take place”. It should also be noted that in the case of drinking water from groundwater wells, a minimum setback is established at 30 meters. None of the communities considered in this study utilize groundwater as a drinking water source. The locations of key interest points (e.g. landfill location, water source location, airport location) are provided on a map of each community in **Appendix C**.

##### **DISTANCE FROM HABITATION**

The minimum distance between habitation and the SWF is regulated under the Public Health Act and General Sanitation Regulations. The minimum setback is established at 450 meters for any building used for human occupancy or for storage of food. Also, a 90 m setback is required between any public road allowance, railway, right-of-way, cemetery, highway or thoroughfare. Kimmirut has an estimated<sup>10</sup> distance of 0.4 km from the SWF to the nearest habitation site. It should be noted that the topography in Kimmirut is very hilly, which means that straight distance obtained from the map may not hold true when measured onsite. All other communities are located beyond a minimum distance of 450 m. It should be noted that these distances may change in the near future since several communities (e.g. Igloolik) have been growing and approaching the SWF location.

##### **DISTANCE FROM THE AIRPORT/ISSUES WITH AIRPORT AUTHORITIES**



Solid waste facilities in close proximity to airports may increase the risk to airport public safety. For example, the presence of birds at a SWF located in close proximity to SWFs can pose a potential hazard to aircraft traffic as a result of aircraft collisions. SWFs have the potential to attract birds (e.g., seagulls and ravens). Transport Canada<sup>6</sup> has established a guideline for airport bird control which recommends an 8 kilometer buffer distance between garbage dumps and food waste landfills and an airport location. The GNWT MSW Guidelines<sup>8</sup> indicate that the Transport Canada separation distance is often not practical for Northern Communities.

The GNWT MSW Guidelines recommend a 3 kilometer buffer distance, based on guidelines<sup>7</sup> developed for the GNWT Community Works and Capital Planning Department of Municipal and Community Affairs. Transport Canada recommends that any prohibitions for bird hazard considerations should be only included upon the expert advice of a bird hazard specialist. During the SWF site selection process, ARKTIS notes that a bird hazard study may be required to assess the effect the SWF will have on attracting and/or migration of birds and the birds' impact on aviation safety at the airport.

Only one community (Coral Harbour) currently meets Transport Canada requirements, while five others (Qikiqtarjuag, Clyde River, Resolute Bay, Baker Lake, Cambridge Bay) meet GNWT MSW guidelines. Only one community (Pangnirtung) reported some issues with airport authorities. It should be noted that these issues are related to smoke and visibility problems during garbage burning.

#### 2.4.2 Estimated Waste Volume

Waste volume was estimated based on the reported number of garbage truck trips per day and garbage truck volume. It was assumed that the garbage truck is filled to capacity and the average number of trips per day were used in the calculation. The estimated average annual garbage volume per capita was calculated at 8.5 m<sup>3</sup>/person/year (with standard deviation of 4.8 m<sup>3</sup>/person/year). This value is about 55% higher than the value reported in relevant literature<sup>8</sup> of 5.5 m<sup>3</sup>/person/year (or 0.015 m<sup>3</sup>/person/year). The assumptions and approximations in the calculation of waste volume in this study are likely contributing to the difference in the estimated value compared to guideline value. ARKTIS considers a waste generation rate of 8.5 m<sup>3</sup>/person/year as a conservative estimate rather than an accurate number.

#### 2.4.3 SWF By-laws and Budget

##### SWF BY-LAWS

All communities have developed garbage disposal by-laws. Schedule fees for garbage collection and disposal from residential and commercial users are part of these by-laws. With the exception of Gjoa Haven and Resolute Bay, all communities have also established tipping fees for self-serviced users. Communities that apply a flat rate tipping fee typically allow each registered generator unlimited use of the SWF for a specified timeframe (usually one month). Communities that use tipping fees are highlighted in **Table 2.3c**. Some communities do not allow users (private or commercial/businesses) to opt out of the garbage collection program (Pangnirtung, Clyde River, Rankin Inlet, Kugaaruk and Cambridge Bay). The community of Gjoa Haven does not have a tipping fee schedule. None of the communities visited are able to monitor 3<sup>rd</sup> party users due to unrestricted access to the SWF site (unlocked or open gate).

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<sup>6</sup> Transport Canada. 2005. Aviation Land Use in the Vicinity of Airports. Air Navigation Planning and Operational Requirements. TP 1247E.

<sup>7</sup> Soberman R.M., Lovicsek M. and Heinke G.W. *Guidelines for the Separation of Solid Waste Disposal Sites in the Northwest Territories*. Prepared for the Community and Capital Planning Department of Municipal and Community Affairs, Government of Northwest Territories. s.l. : Transmode Consultants Inc, 1990.

<sup>8</sup> Kent, R., Marshall, P., and Hawke, L. (2003). *Guidelines for the Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the Northwest Territories*. Prepared by Ferguson Sime Clark Engineers and Architects. Prepared for Government of Northwest Territories, Department of Municipal and Community Affairs.



## SWF BUDGET

The annual budget is presented in **Table 2.3c**. Data was collected from site visits to fourteen communities and from the Government of Nunavut<sup>9</sup>. This SWF budget encompasses operational and maintenance costs. It is noted that operational and maintenance costs specifically include employee salaries and benefits and mobile equipment costs; however, equipment maintenance and facility upgrade costs are not included in this budget.

The Government of Nunavut owns the SWF sites; therefore, municipal governments would not record capital items as assets on their accounting books. It was indicated by the GN-CGS<sup>9</sup> that any capital expenditures related to the solid waste sites would be recorded through infrastructure budgets.

Based on information collected during the site visits, the average cost per person per year for garbage disposal was estimated at \$173.2. Using the GN costing data, the cost per person per year for garbage disposal is \$145.9. The following communities had a difference between the community and GN garbage disposal costs: Kimmirut, Resolute Bay, Baker Lake, Rankin Inlet, Kugaaruk, Gjoa Haven, and Cambridge Bay. The reason for these discrepancies is unknown.

## GARBAGE DISPOSAL FEE GENERATED REVENUE

Based on the garbage disposal fees set in the by-laws for residential households and the number of people per household it was estimated that on average a community should generate \$99.9 CAN/person/year in revenue. It should be noted that this value was estimated based only on residential households and any businesses, institutions and government offices were excluded from these estimates. This means, that each community should generate additional revenue per year, if non-residential garbage generators were included. At the time of writing of this report, it is not known if communities collect data on total amount of revenue generated from garbage collection services.

## 2.5 Visual Inspection of the Solid Waste Disposal Facility

For each community, a visual inspection of the SWF was conducted. The purpose of the visual inspection was to gather information on the current state of the SWF with respect to the following parameters/features:

1. Site conditions and layout – to establish general topography of the site, SWF features such as fencing, gate and signage, distance from the drinking water source and from the airport.
2. Site access road – to establish whether the road is graded and if any type of water management such as culverts or drainage ditches is employed.
3. Water management at the SWF – to establish whether any type of water management features such as ditches, berms or culverts are present to deal with surface runoff and/or leachate.
4. Solid waste facility operations and maintenance – several features were noted:
  - a. Garbage open burning – to establish whether the community open burns its garbage and what, if any, control measures are employed.
  - b. Solid waste segregation – to establish whether any form of solid waste segregation exists.
  - c. Waste placement procedure – whether there exists any formal or informal way of solid waste placement at the SWF.
  - d. Waste height and stability – to establish whether waste height and stability is an issue.
  - e. Remaining space – to establish whether the SWF is limited in its capacity (volume) in the foreseeable future (next 5 to 10 year horizon).
  - f. Cover material – to establish whether a cover layer is applied and what material is used.

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<sup>9</sup> Email received on November 10, 2010 from Margaret Taylor, Manager Community Operations, Government of Nunavut, Community and Government Services



- g. Windblown litter – to establish whether windblown litter is visible around the SWF area.
  - h. Hazardous waste management – to establish whether any form of hazardous waste management is employed at the SWF or in the community (hazardous waste may include car batteries, used oil, chemicals and liquids, and contaminated soil).
  - i. Solid waste gas management – to establish whether any form of solid waste gas management is in use.
  - j. Wildlife – to establish whether wildlife interacts with the SWF.
5. Other observations – additional solid waste management features that are routinely applied by the community.

A template site inspection form was developed prior to the site visits in an attempt to gather the same information from each community. The complete form for each community is provided in **Appendix D**. A summary of select responses in each category is provided in **Table 2.4**. Photographs of each solid waste facility were taken during the site visit and included in a separate compact disk that accompanies this report.

### 2.5.1 Discussion of Results

#### SECURITY FENCING AND GATE

50% of the SWF sites visited had an incomplete or non-functioning gate, of which, about 30% of the SWF sites had no fence or gate and about 20% had a complete gate and fence. None of the SWFs lock their gates and therefore uncontrolled access can occur.

#### WARNING AND INSTRUCTION SIGNS

70% of the SWF sites visited had some form of warning and/or instruction signs. Based on visual inspection, 20% of the communities had signs in good condition, while the remaining 50% had some damaged or missing components of proper signage. 30% of SWF sites visited had no signs at all.

#### TOPOGRAPHY

50% of the facilities visited are located in predominantly flat areas, while the other 50% are located in mixed topography. Generally, mixed topography is referred herein as a site condition where part of the solid waste facility is located on a gently sloped area and some on a flat area.

#### SITE ACCESS ROAD

Each community had an access road to the facility that was graded and therefore maintained. 50% of the access roads had culverts installed, while 36% had ditches; implying that some form of water/drainage control occurs. All of the access roads were reported to stay dry all year so they can provide access to the SWF.

#### SWF WATER MANAGEMENT ONSITE

Three facilities, located in Clyde River, Resolute Bay, and Rankin Inlet, did not have any type of water management infrastructure installed. The remaining facilities had either ditches, berms or culverts onsite.

#### LEACHATE MANAGEMENT

None of the facilities visited collect or treat leachate. Three facilities, located in Qikiqtarjuag, Pangnirtung and Igloolik, have either a ditch or berm around the SWF facility which would also provide leachate containment. The facility in Rankin Inlet had monitoring points for leachate quality sampling. No further details regarding leachate management were available.

#### SOLID WASTE OPEN BURNING



Out of all facilities visited, only two communities (Rankin Inlet and Kugaaruk) did not practice open-burning of garbage. In communities that practice open-burning of waste, the decision to ignite garbage by the SWF operator is wind dependent; open-burning would not occur when wind is blowing toward the community. Only two communities (Qikiqtarjuag and Resolute Bay) did not indicate that smoke is an issue when garbage is burning. Most probable reasons why these two communities are perceived to be unaffected by the smoke include the distance between the SWF and the community (Qikiqtarjuag), and the predominant winds in Resolute Bay are not directed towards the community.

### **WASTE SEPARATION BY TYPE**

All of the facilities, with the exception of Gjoa Haven and Cambridge Bay, employ some type of waste separation. It should be noted that the facility in Cambridge Bay is currently being upgraded and the upgraded facility will also have waste separation. The most common waste types that are separated included:

- Household garbage;
- Bulky/oversized waste and/or metal waste;
- Large appliances;
- Wood and paper;
- Contaminated soil;
- Batteries and other small hazardous waste items; and,
- Barrels.

### **WASTE PLACEMENT PROCEDURE**

Only one facility (Rankin Inlet) employs waste placement procedures. It involves garbage pushing 3 times per week, and garbage compaction on a monthly basis.

### **WASTE HEIGHT AND STABILITY**

Waste height and stability is only an issue in Cambridge Bay where considerable amounts of bulky waste were piled haphazardly (after school fire).

### **REMAINING SPACE**

Two facilities (Pangnirtung and in Rankin Inlet) have limited space for waste disposal/operation, while facilities in Gjoa Haven, Baker Lake and Igloolik may have space limitations in the near future (5 to 10 year horizon).

### **COVER MATERIAL**

Over 70% of the facilities apply a cover over their waste. The facilities that did not employ a cover layer were located in Qikiqtarjuag, Pangnirtung, Coral Harbour, and Gjoa Haven. The reason for not employing a cover material is unknown.

### **WINDBLOWN LITTER**

Windblown litter is an issue in all the communities visited and was voiced as a concern during the public meetings. Qikiqtarjuag appears less affected likely since the SWF is located relatively far away from the community.

### **HAZARDOUS WASTE MANAGEMENT**

All communities with the exception of Gjoa Haven employ limited hazardous waste management. The management typically included: a container for old batteries, lined and bermed area for contaminated soil, and barrels for used oil and old liquids. In Pond Inlet, the SWF also had a bermed and lined area for used oil.



## SOLID WASTE GAS MANAGEMENT

No community has infrastructure for monitoring or management of solid waste gas.

## WILDLIFE ISSUES

50% of the visited communities reported some issues with wildlife (mostly birds). The community of Pangnirtung experienced additional problems with insects (flies and beetles) in the summer months. These insects were perceived to be related to the solid waste facility.

## 2.6 Additional Community Specific Comments

**Table 2.5** summarizes additional community specific comments gathered during the public meetings and interviews with administrative staff.

## 2.7 Summary of Findings

Although each community should be treated individually there are some common concerns and observations that can be summarized as follows:

- Community feedback:
  - o All communities expressed their concern about the impact of the SWF site on the environment; especially windblown litter;
  - o An overwhelming majority of the communities voiced their concerns related to health and safety hazards including: pollution caused by smoke and odours from open garbage burning, contamination of water, cross-contamination onto recyclables and reusable materials, and uncontrolled access to the SWF site which may results in injury or harm (especially to children);
  - o Residents in a majority of the communities perceive that the SWF site may be located too close to the habitation area especially considering community expansions that have occurred in recent years;
  - o Another important observation is that most communities expressed their willingness to participate in several solid waste management programs including waste separation, waste backhauling, recycling, and hazardous waste management; and,
  - o Most communities expressed their interest in obtaining additional information and educational materials on alternative waste management approaches.
- Discussions with community staff provided the following observations/findings:
  - o Solid waste generation within the community is estimated at 8.5 m<sup>3</sup>/capita/year;
  - o The operational and maintenance budget was estimated to be on average \$173/capita/year based on data collected during site visits; and based on data obtained from the GN this value was calculated at \$145/capita/year;
  - o Estimated that on average 1.8 full time employees service the SWF.
- Site visits provided the following observations:
  - o Many communities either have an incomplete fence/gate or no fence. This prohibits communities from achieving control over site accessibility by 3<sup>rd</sup> party users or control over waste types that enter the facility;
  - o Many communities do not have any signs which has potential to create problems with proper waste separation and disposal;
  - o With the exception of two communities (Rankin Inlet and Kugaaruk) all communities practice open-burning of municipal solid waste. Many communities also experience smoke and odour problems caused by the open burn; and,
  - o All communities practice some solid waste segregation.

**Table 2.1:** Summary of communities selected for the waste study, date of community meeting, and number of participants that attended the meeting.

| Community                 | Meeting Date                       | Number of Participants |
|---------------------------|------------------------------------|------------------------|
| <b>Qikiqtalluk Region</b> |                                    |                        |
| Qikitarjuaq               | August 23, 2010                    | 1                      |
| Pangnirtung               | No community meeting was requested |                        |
| Igloolik                  | August 28, 2010                    | 12                     |
| Pond Inlet                | August 30, 2010                    | 9                      |
| Clyde River               | August 31, 2010                    | 8                      |
| Kimmirut                  | September 2, 2010                  | 6                      |
| Resolute                  | October 7, 2010                    | 10                     |
| <b>Kivalliq Region</b>    |                                    |                        |
| Baker Lake                | September 16, 2010                 | 18                     |
| Coral Harbour             | September 15, 2010                 | 3                      |
| Rankin Inlet              | September 13, 2010                 | 6                      |
| <b>Kitikmeot Region</b>   |                                    |                        |
| Kugluktuk                 | September 7, 2010                  | 4                      |
| Kugaaruk                  | September 11, 2010                 | 0                      |
| Gjoa Haven                | September 9, 2010                  | 7                      |
| Cambridge Bay             | September 8, 2010                  | 4                      |



GN-CGS Project #2010-27

**Table 2.2:** Summary of the responses from the public meetings.

| Community                | Unusual source of solid waste | Landfill Operation Concerns |                  |                   |                    |              |               | Concerns related to garbage pick up | Concerns Related to Regulations | Budgetary Concerns | Community Feedback/Willingness to Participate in the Following Programs: |                   |           |                            |            |                                                         |
|--------------------------|-------------------------------|-----------------------------|------------------|-------------------|--------------------|--------------|---------------|-------------------------------------|---------------------------------|--------------------|--------------------------------------------------------------------------|-------------------|-----------|----------------------------|------------|---------------------------------------------------------|
|                          |                               | Smoke and Odours            | Current Location | Health and Safety | Fencing and litter | Environ-ment | Site Capacity |                                     |                                 |                    | Waste Separation                                                         | Waste Backhauling | Recycling | Hazardous Waste Management | Composting | Community Outreach – Educational / Information Sessions |
| Qikitarjuaq              | No                            | No                          | -                | -                 | -                  | -            | -             | No                                  | -                               | -                  | -                                                                        | -                 | -         | -                          | -          | Yes                                                     |
| Pangnirtung*             | Yes                           | Yes                         | Yes              | -                 | Yes                | Yes          | Yes           | -                                   | -                               | -                  | -                                                                        | -                 | -         | -                          | -          | -                                                       |
| Igloolik                 | No                            | Yes                         | Yes              | Yes               | Yes                | Yes          | No            | Yes                                 | Yes                             | No                 | Yes                                                                      | Yes               | Yes       | Yes                        | No         | Yes                                                     |
| Pond Inlet               | No                            | Yes                         | Yes              | Yes               | Yes                | Yes          | Yes           | Yes                                 | Yes                             | No                 | Yes                                                                      | Yes               | Yes       | Yes                        | No         | Yes                                                     |
| Clyde River              | No                            | Yes                         | Yes              | Yes               | Yes                | Yes          | No            | Yes                                 | No                              | No                 | Yes                                                                      | Yes               | Yes       | Yes                        | No         | Yes                                                     |
| Kimmirut                 | No                            | No                          | Yes              | Yes               | Yes                | Yes          | Yes           | No                                  | No                              | -                  | Yes                                                                      | Yes               | Yes       | Yes                        | Maybe      | Yes                                                     |
| Resolute Bay             | No                            | No                          | Yes              | Yes               | Yes                | Yes          | -             | -                                   | -                               | -                  | -                                                                        | Yes               | Yes       | Yes                        | -          | -                                                       |
| Baker Lake               | No                            | Yes                         | Yes              | Yes               | Yes                | Yes          | -             | -                                   | -                               | -                  | -                                                                        | Yes               | -         | -                          | -          | Yes                                                     |
| Coral Harbour            | No                            | Yes                         | Yes              | Yes               | Yes                | -            | -             | No                                  | -                               | -                  | -                                                                        | No                | Yes       | Yes                        | No         | Yes                                                     |
| Rankin Inlet             | No                            | No                          | Yes              | Yes               | Yes                | Yes          | Yes           | No                                  | -                               | -                  | -                                                                        | Yes               | Yes       | Yes                        | No         | No                                                      |
| Kugluktuk                | No                            | Yes                         | No               | No                | Yes                | Yes          | No            | No                                  | No                              | No                 | Yes                                                                      | Yes               | Yes       | Yes                        | No         | No                                                      |
| Kugaaruk*                | No                            | -                           | -                | -                 | Yes                | -            | -             | -                                   | -                               | -                  | -                                                                        | -                 | -         | -                          | -          | -                                                       |
| Gjoa Haven               | No                            | No                          | No               | Yes               | Yes                | -            | Yes           | No                                  | No                              | No                 | Yes                                                                      | Yes               | Yes       | Yes                        | No         | Yes                                                     |
| Cambridge Bay            | No                            | Yes                         | No               | Yes               | Yes                | Yes          | No            | Yes                                 | -                               | -                  | Yes                                                                      | Yes               | Yes       | Yes                        | No         | Yes                                                     |
| Percentage responded Yes | 7.1%                          | 62%                         | 75%              | 91%               | 100%               | 100%         | 50%           | 40%                                 | 33%                             | 0%                 | 100%                                                                     | 91%               | 100%      | 100%                       | 0%         | 82%                                                     |

\*- based on administrative personnel responses  
Responses: Yes – positive response or willingness to participate in management program, No – negative response or no willingness to participate in management program, - – no direct response was obtained from the public meeting, Maybe – member of Kimmirut community indicated that composting is not required at the moment but the community could set an example for others.



**Table 3a:** Summary of responses from the administrative staff interview regarding site layout and location.

| Community     | Site layout and location              |                                       |                                                                 |                    |                                                   |                                         |                                                 |                                        |                                 |
|---------------|---------------------------------------|---------------------------------------|-----------------------------------------------------------------|--------------------|---------------------------------------------------|-----------------------------------------|-------------------------------------------------|----------------------------------------|---------------------------------|
|               | Operation started at current location | Reason for selecting current location | Recent upgrades                                                 | Remaining lifespan | Distance from drinking water source <sup>10</sup> | Distance from the airport <sup>10</sup> | Distance from marine environments <sup>10</sup> | Distance from habitation <sup>10</sup> | Issues with airport authorities |
| Qikitarjuaq   | Late 90s'                             | N/A                                   | New road; new fence; new berm; new sea can for hazardous waste  | not available      | 1.6 km                                            | 3.2 km                                  | 0.9 km                                          | 2.3 km                                 | Not reported to Hamlet          |
| Pangnirtung   | Mid 80s'                              | Open area                             | No                                                              | not available      | 0.9 km                                            | 1.9 km                                  | 0.1 km                                          | 1.3 km                                 | Smoke and visibility            |
| Igloolik      | not available                         | N/A                                   | No                                                              | not available      | 3.3 km                                            | 2.6 km                                  | 0.4 km                                          | 0.8 km                                 | Not reported to Hamlet          |
| Pond Inlet    | 1996                                  | N/A                                   | New contaminated soil cell; new cover                           | not available      | 2.8 km                                            | 2.0 km                                  | 0.5 km                                          | 1.4 km                                 | Not reported to Hamlet          |
| Clyde River   | Mid 90s'                              | Within contaminated soil area         | New signs                                                       | not available      | 1.4 km                                            | 4.1 km                                  | 0.7 km                                          | 1.0 km                                 | Not reported to Hamlet          |
| Kimmirut      | not available                         | N/A                                   | Soil cover                                                      | not available      | 0.6 km                                            | 0.6 km                                  | 0.4 km                                          | 0.4 km                                 | Not reported to Hamlet          |
| Resolute Bay  | Mid 70s'                              | N/A                                   | No                                                              | not available      | 3.4 km                                            | 4.0 km                                  | 0.2 km                                          | 3.8 km                                 | Not reported to Hamlet          |
| Baker Lake    | Early 90s'                            | Proximity to sewage lagoon            | New fence; new access road                                      | not available      | 2.0 km                                            | 4.9 km                                  | 0.1 km                                          | 1.2 km                                 | Not reported to Hamlet          |
| Coral Harbour | Early 80s'                            | N/A                                   | New sea can; new container for batteries                        | not available      | 2.1 km                                            | 8.2 km                                  | 2.1 km                                          | 2.5 km                                 | Not reported to Hamlet          |
| Rankin Inlet  | Mid 80s'                              | N/A                                   | New signs                                                       | not available      | 3.0 km                                            | 1.3 km                                  | 0.5 km                                          | 0.7 km                                 | Not reported to Hamlet          |
| Kugluktuk     | Early 90s'                            | Proximity to sewage lagoon            | New fence; bulky metal waste buried; hazardous waste backhauled | not available      | 4.5 km                                            | 1.4 km                                  | 1.6 km                                          | 2.8 km                                 | Not reported to Hamlet          |
| Kugaaruk      | Late 60s'                             | Topography                            | Gravel cover                                                    | not available      | 3.7 km                                            | 1.2 km                                  | 0.5 km                                          | 1.2 km                                 | Not reported to Hamlet          |
| Gjoa Haven    | Early 90s' or earlier                 | N/A                                   | No                                                              | not available      | 5.3 km                                            | 1.4 km                                  | 0.6 km                                          | 1.0 km                                 | Not reported to Hamlet          |
| Cambridge Bay | Early 60s'                            | N/A                                   | New landfill under construction                                 | 20 years           | 1.9 km                                            | 4.3 km                                  | 0.3 km                                          | 0.8 km                                 | Not reported to Hamlet          |

<sup>10</sup> Distance is approximate and inferred based on Google Earth maps.



**Table 2.3b:** Summary of selected responses from the administrative staff interview regarding waste collection, volumes, and container type.

| Community     | Waste collection and volume                            |                       |                               |                                    |                                   |                           |                                                                                        |                                                        |                               | Type of individual garbage container |
|---------------|--------------------------------------------------------|-----------------------|-------------------------------|------------------------------------|-----------------------------------|---------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------|--------------------------------------|
|               | Frequency of garbage pick-up – number of days per week | Type of garbage truck | Garbage truck volume          | Number of trips to the SWF per day | Estimated annual deposited volume | Estimated 2010 population | Estimated annual per capita deposited volume of solid waste (m <sup>3</sup> /cap/year) | Estimated number of garbage bags per household per day | Animal waste deposited in SWF |                                      |
| Qikitarjuaq   | 4 days                                                 | F 450                 | 4.5 m <sup>3</sup>            | 6 to 7                             | 6084 m <sup>3</sup>               | 527                       | 11.5                                                                                   | N/A                                                    | Yes                           | Wooden box + lid                     |
| Pangnirtung   | 5 days                                                 | F 450                 | 12.3 m <sup>3</sup>           | 4 to 5                             | 7020 m <sup>3</sup>               | 1,459                     | 4.8                                                                                    | N/A                                                    | Yes                           | Wooden box + lid                     |
| Igloolik      | 5 days                                                 | F 450                 | 4.6 m <sup>3</sup>            | 7 to 8                             | 8775 m <sup>3</sup>               | 1,662                     | 5.3                                                                                    | N/A                                                    | Yes                           | Wooden box + lid / drums             |
| Pond Inlet    | 5 days                                                 | F 800                 | 15.3 m <sup>3</sup>           | 2 to 3                             | 9945 m <sup>3</sup>               | 1,440                     | 6.9                                                                                    | N/A                                                    | Yes                           | Wooden box + lid                     |
| Clyde River   | 5 days                                                 | F 350                 | 4.5 m <sup>3</sup>            | 7 to 11                            | 10530 m <sup>3</sup>              | 908                       | 11.6                                                                                   | 4 to 5                                                 | Yes                           | Wooden box + lid                     |
| Kimmirut      | 3 days                                                 | F 550                 | 6 m <sup>3</sup>              | 8                                  | 7488 m <sup>3</sup>               | 449                       | 16.7                                                                                   | N/A                                                    | Yes                           | Wooden box + lid                     |
| Resolute Bay  | 3 days                                                 | F 350                 | Minimum of 1.6 m <sup>3</sup> | 2                                  | 499 m <sup>3</sup>                | 252                       | 2.0                                                                                    | 2                                                      | N/A                           | Wooden box + lid / drums             |
| Baker Lake    | 5 days                                                 | Sterling              | 13.8 m <sup>3</sup>           | 4                                  | 14352 m <sup>3</sup>              | 1,906                     | 7.5                                                                                    | N/A                                                    | Yes                           | Drums                                |
| Coral Harbour | 5 days                                                 | F 450                 | 4.5 m <sup>3</sup>            | 5 to 6                             | 6435 m <sup>3</sup>               | 854                       | 7.5                                                                                    | 4 to 5                                                 | Yes                           | Drums + lid                          |
| Rankin Inlet  | 5 days                                                 | Heil 4000             | 15.3 m <sup>3</sup>           | 3                                  | 11934 m <sup>3</sup>              | 2,692                     | 4.4                                                                                    | N/A                                                    | Yes                           | Drum                                 |
| Kugluktuk     | 5 days                                                 | N/A                   | N/A                           | N/A                                | N/A                               | 1,412                     | N/A                                                                                    | N/A                                                    | Yes                           | Wooden box + lid / drums             |
| Kugaaruk      | 5 days                                                 | F 350                 | 4.6 m <sup>3</sup>            | 4 to 5                             | 5382 m <sup>3</sup>               | 732                       | 7.4                                                                                    | N/A                                                    | Yes                           | Drums / Steel containers             |
| Gjoa Haven    | 5 days                                                 | F 550                 | 6 m <sup>3</sup>              | N/A                                | 7020 m <sup>3</sup>               | 1,131                     | 6.2                                                                                    | N/A                                                    | Yes                           | Drums                                |
| Cambridge Bay | 5 days                                                 | Sternum               | 16 m <sup>3</sup>             | 6 to 8                             | 29120 m <sup>3</sup>              | 1,613                     | 18.1                                                                                   | N/A                                                    | Yes                           | Drums                                |
| Average       |                                                        |                       |                               |                                    |                                   |                           | 8.5 m <sup>3</sup> /cap/year                                                           |                                                        |                               |                                      |



**Table 2.3c:** Summary of the responses from the administrative staff interview regarding by-laws, policies and budgetary information.

| Community     | SWF by-laws          |                 |                                                        | Estimated residential garbage fee revenue                       |                                              |                                     | SWF budget                                 |                       |                           |                                              |         |                 |                               |                                       |
|---------------|----------------------|-----------------|--------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------|-------------------------------------|--------------------------------------------|-----------------------|---------------------------|----------------------------------------------|---------|-----------------|-------------------------------|---------------------------------------|
|               | SWF bylaws developed | Tipping fees    | Monthly garbage pickup fee <sup>11</sup> per household | Average number of people per households/dwellings <sup>12</sup> | Estimated annual total revenue <sup>13</sup> | Estimated annual per capita revenue | Annual O&M budget for solid waste facility |                       | Estimated 2010 population | Estimated SWF O&M budget per capita per year |         | SWF staff level | Effort change in recent years | Possibility to opt out of SWF program |
|               |                      |                 |                                                        |                                                                 |                                              |                                     | Data obtained from site visit              | GN data <sup>14</sup> |                           | Data obtained from site visit                | GN Data |                 |                               |                                       |
| Qikitarjuaq   | Yes                  | Yes (flat rate) | \$30.0                                                 | 3.0                                                             | \$63,240                                     | \$120.0                             | \$ 74,137                                  | \$74,137              | 527                       | \$140.7                                      | \$140.7 | 1 FT 2 PT       | N/A                           | Yes                                   |
| Pangnirtung   | Yes                  | Yes (flat rate) | \$30.0                                                 | 3.1                                                             | \$169,432                                    | \$116.1                             | \$ 166,960                                 | \$162,125             | 1,459                     | \$114.7                                      | \$111.1 | 2 FT            | Increase                      | No                                    |
| Igloolik      | Yes                  | Yes             | \$20.0                                                 | 4.2                                                             | \$94,971                                     | \$57.1                              | \$185,000                                  | \$186,683             | 1,662                     | \$111.3                                      | \$112.3 | 2 FT            | Increase                      | Yes                                   |
| Pond Inlet    | Yes                  | Yes             | \$25.0                                                 | 3.9                                                             | \$110,769                                    | \$76.9                              | \$149,300                                  | \$149,131             | 1,440                     | \$103.7                                      | \$103.6 | 2 FT            | Steady                        | Yes                                   |
| Clyde River   | Yes                  | Yes (flat rate) | \$25.0                                                 | 4.5                                                             | \$60,533                                     | \$66.7                              | \$66,200                                   | \$66,200              | 908                       | \$72.9                                       | \$72.9  | 1 FT            | Increase                      | No                                    |
| Kimmirut      | Yes                  | Yes             | \$38.5                                                 | 3.5                                                             | \$59,268                                     | \$132.0                             | \$ 196,000                                 | \$59,400              | 449                       | \$436.5                                      | \$132.3 | 3 PT            | No change                     | Yes                                   |
| Resolute Bay  | Yes                  | No              | \$25.0                                                 | 2.8                                                             | \$27,000                                     | \$107.1                             | \$58,000                                   | \$116,078             | 252                       | \$230.2                                      | \$460.6 | 1 FT            | Increase                      | Yes                                   |
| Baker Lake    | Yes                  | Yes (flat rate) | \$30.0                                                 | 3.6                                                             | \$190,600                                    | \$100.0                             | \$307,500                                  | \$216,300             | 1,906                     | \$161.3                                      | \$113.5 | 2 FT 1 PT       | N/A                           | Yes                                   |
| Coral Harbour | Yes                  | Yes             | \$50.0 <sup>15</sup>                                   | 3.2                                                             | \$160,125                                    | \$187.5                             | \$78,574                                   | \$78,574              | 854                       | \$92.0                                       | \$92.0  | 1 FT 1 PT       | N/A                           | Yes                                   |
| Rankin Inlet  | Yes                  | Yes             | \$30.0                                                 | 3.0                                                             | \$323,040                                    | \$120.0                             | \$636,000                                  | \$273,961             | 2,692                     | \$236.3                                      | \$101.8 | 3 FT            | Increase                      | No                                    |
| Kugluktuk     | Yes                  | Yes (flat rate) | \$30.0                                                 | 3.2                                                             | \$158,850                                    | \$112.5                             | N/A                                        | \$167,260             | 1,412                     | N/A                                          | \$118.5 | N/A             | N/A                           | Yes                                   |
| Kugaaruk      | Yes                  | Yes             | \$25.0                                                 | 5.0                                                             | \$43,920                                     | \$60.0                              | \$ 110,031                                 | \$110,032             | 732                       | \$150.3                                      | \$150.3 | 1 FT            | N/A                           | No                                    |
| Gjoa Haven    | Yes                  | No              | \$15.0                                                 | 5.0                                                             | \$40,716                                     | \$36.0                              | \$ 320,000                                 | \$190,668             | 1,131                     | \$282.9                                      | \$168.6 | 2 FT            | N/A                           | Yes                                   |
| Cambridge Bay | Yes                  | Yes             | \$25.0                                                 | 2.8                                                             | \$172,821                                    | \$107.1                             | \$193,000                                  | \$266,200             | 1,613                     | \$119.7                                      | \$165.0 | 2 full time     | Increase                      | No                                    |
| Average       |                      |                 |                                                        |                                                                 |                                              | \$99.9                              | Average                                    |                       |                           | \$173.2                                      | \$145.9 |                 |                               |                                       |

11 Where by-laws provide distinct fee for private homeowners or Housing Association units, the latter fee was used  
12 For more details see Appendix C.  
13 Estimated based on: Monthly garbage pickup fee per household x Estimated 2010 population / Average number of people per household x 12 months  
14 Based on information provided on November 19, 2010 by Margaret Taylor, the Manager of Community Operations, email: mtaylor@gov.nu.ca.  
15 Actual rate not included in by-law; value assumed as per tipping permit



**Table 2.4:** Summary of selected solid waste facility features observed during the community site visit.

| Community                 | Site conditions and layout: |                               |            | Site access road |                  | Water management on site |                      |       |          |                     |                    |       |         |                   | Operations and maintenance |                                        |                                 |                         |                            |                                   |                 |                |                  |                            |                            |                 |    |
|---------------------------|-----------------------------|-------------------------------|------------|------------------|------------------|--------------------------|----------------------|-------|----------|---------------------|--------------------|-------|---------|-------------------|----------------------------|----------------------------------------|---------------------------------|-------------------------|----------------------------|-----------------------------------|-----------------|----------------|------------------|----------------------------|----------------------------|-----------------|----|
|                           | Security fence and gate     | Warning and instruction signs | Topography | Grading          | Water management |                          | Diversion from waste |       |          | Leachate management |                    |       |         |                   | Garbage open burning       | If open burning of garbage is employed |                                 | Waste organized by type | Waste placement procedures | Waste height and stability issues | Remaining space | Cover material | Windblown litter | Hazardous waste management | Solid waste gas management | Wildlife issues |    |
|                           |                             |                               |            |                  | Culverts         | Ditches                  | Ditches              | Berms | Culverts | Collection sump     | Leachate treatment | Berms | Ditches | Monitoring points |                            | Is it wind dependent                   | Smoke blowing towards community |                         |                            |                                   |                 |                |                  |                            |                            |                 |    |
| Qikitarjuaq               | Yes                         | Yes                           | Mixed      | Yes              | Yes              | Yes                      | No                   | Yes   | No       | No                  | No                 | Yes   | No      | No                | Yes                        | Yes                                    | No                              | Yes                     | No                         | No                                | Yes             | No             | Some             | Yes                        | No                         | Some            |    |
| Pangnirtung               | Some                        | No                            | Mixed      | Yes              | Yes              | Yes                      | Yes                  | No    | No       | No                  | No                 | No    | Yes     | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | No              | No             | Yes              | Yes                        | No                         | Yes             |    |
| Igloolik                  | No                          | Some                          | Mixed      | Yes              | Yes              | Yes                      | No                   | Yes   | No       | No                  | No                 | No    | No      | Yes               | No                         | Yes                                    | Yes                             | Yes                     | Yes                        | No                                | No              | Some           | Yes              | Yes                        | Yes                        | No              | No |
| Pond Inlet                | Yes                         | Yes                           | Mixed      | Yes              | Yes              | No                       | No                   | Yes   | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | No              |    |
| Clyde River               | No                          | No                            | Flat       | Yes              | No               | No                       | No                   | No    | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | No              |    |
| Kimmirut                  | Some                        | Some                          | Mixed      | Yes              | Yes              | Yes                      | Yes                  | No    | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | Some            |    |
| Resolute                  | No                          | No                            | Flat       | Yes              | No               | No                       | No                   | No    | No       | No                  | No                 | No    | No      | No                | Yes                        | Some                                   | No                              | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | Some            |    |
| Baker Lake                | Yes                         | No                            | Flat       | Yes              | Yes              | No                       | No                   | No    | Yes      | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Some            | Yes            | Yes              | Some                       | No                         | No              |    |
| Coral Harbour             | Some                        | Yes                           | Flat       | Yes              | No               | No                       | No                   | No    | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Yes             | No             | Yes              | Yes                        | No                         | Some            |    |
| Rankin Inlet              | Some                        | Some                          | Flat       | Yes              | No               | No                       | No                   | No    | No       | No                  | No                 | No    | No      | Yes               | No                         | N/A                                    | N/A                             | Yes                     | Yes                        | No                                | No              | Yes            | Yes              | Yes                        | No                         | No              |    |
| Kugluktuk                 | Some                        | Some                          | Mixed      | Yes              | Yes              | No                       | No                   | Yes   | Yes      | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | No              |    |
| Kugaaruk                  | Some                        | Some                          | Mixed      | Yes              | Yes              | Yes                      | Yes                  | Yes   | Yes      | No                  | No                 | No    | No      | No                | No                         | N/A                                    | N/A                             | Yes                     | No                         | No                                | Yes             | Yes            | Yes              | Yes                        | No                         | Some            |    |
| Gjoa Haven                | Some                        | Some                          | Flat       | Yes              | No               | No                       | No                   | Yes   | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Some                    | No                         | Some                              | Some            | No             | Yes              | Yes                        | No                         | Some            |    |
| Cambridge Bay             | No                          | Some                          | Flat       | Yes              | No               | No                       | Yes                  | Yes   | No       | No                  | No                 | No    | No      | No                | Yes                        | Yes                                    | Yes                             | Some                    | No                         | Yes                               | Yes             | Yes            | Yes              | No                         | No                         | Some            |    |
| Percentage responded No   | 29%                         | 29%                           | N/A        | 0%               | 43%              | 64%                      | 64%                  | 50%   | 79%      | 100%                | 100%               | 93%   | 86%     | 93%               | 14%                        | 0%                                     | 17%                             | 0%                      | 93%                        | 86%                               | 14%             | 29%            | 0%               | 7%                         | 100%                       | 43%             |    |
| Percentage responded Yes  | 21%                         | 21%                           | N/A        | 100%             | 57%              | 36%                      | 36%                  | 50%   | 21%      | 0%                  | 0%                 | 7%    | 14%     | 7%                | 86%                        | 92%                                    | 83%                             | 86%                     | 7%                         | 7%                                | 65%             | 71%            | 93%              | 86%                        | 0%                         | 7%              |    |
| Percentage responded Some | 50%                         | 50%                           | N/A        | 0%               | N/A              | N/A                      | N/A                  | N/A   | N/A      | N/A                 | N/A                | N/A   | N/A     | N/A               | N/A                        | 8%                                     | N/A                             | 14%                     | N/A                        | 7%                                | 21%             | N/A            | 7%               | 7%                         | N/A                        | 50%             |    |

**Table 2.5:** Community specific comments gathered during public meetings and interview with administrative staff.

| Community     | Administrative staff comments                                                                                                                                                                                            | Public comments                                                                                                                                                                                                                                                                                  |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Qikitarjuaq   | <ul style="list-style-type: none"> <li>Barrel crusher would be needed</li> </ul>                                                                                                                                         | <ul style="list-style-type: none"> <li>What are health related effects due to garbage burning</li> </ul>                                                                                                                                                                                         |
| Pangirtung    | <ul style="list-style-type: none"> <li>Interest in incineration/gasification technology</li> <li>Larger garbage truck to be purchased in 2011</li> </ul>                                                                 | <ul style="list-style-type: none"> <li>N/A</li> </ul>                                                                                                                                                                                                                                            |
| Igloodik      | <ul style="list-style-type: none"> <li>Medical waste end up at the SWF</li> <li>Building for recycling program is available</li> </ul>                                                                                   | <ul style="list-style-type: none"> <li>Interest in incineration technology was expressed</li> <li>Notice about public meeting to be provided in Inuktitut</li> <li>Is financing available for current upgrades?</li> </ul>                                                                       |
| Pond Inlet    | <ul style="list-style-type: none"> <li>Possible SWF relocation may be required due to community growth</li> <li>Leak from wastewater lagoon collects on SWF site</li> <li>Uncontrolled 3rd party users access</li> </ul> | <ul style="list-style-type: none"> <li>Requested copy of the final report</li> </ul>                                                                                                                                                                                                             |
| Clyde River   | <ul style="list-style-type: none"> <li>New SWF to be placed in location so that it is not visible from the community</li> <li>Children access SWF site</li> </ul>                                                        | <ul style="list-style-type: none"> <li>Interest in incineration technology was expressed</li> <li>Used oil furnace would be beneficial</li> <li>Plans to relocate SWF facility under development</li> </ul>                                                                                      |
| Kimmirut      | <ul style="list-style-type: none"> <li>New SWF has not been officially opened</li> </ul>                                                                                                                                 | <ul style="list-style-type: none"> <li>Better education for youth on waste management would be beneficial</li> <li>Concerns regarding medical waste</li> <li>Ships perceive to dump their waste near shore – what is the legal status?</li> </ul>                                                |
| Resolute Bay  | <ul style="list-style-type: none"> <li>Indication that PCB containing materials may be buried at the old SWF by the airport</li> </ul>                                                                                   | <ul style="list-style-type: none"> <li>Interest in incineration technology was expressed</li> <li>Is Resolute Bay part of cleanup sites? If not, why?</li> <li>New SWF location was approved few years ago but studies not completed yet – can it be fast-tracked?</li> </ul>                    |
| Baker Lake    | <ul style="list-style-type: none"> <li>N/A</li> </ul>                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Better education for youth on waste management would be beneficial</li> </ul>                                                                                                                                                                             |
| Coral Harbour | <ul style="list-style-type: none"> <li>N/A</li> </ul>                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Old garage by the airport is full of asbestos</li> <li>Setback around old SWF within community limits community development</li> <li>Improved garbage containers would be needed</li> </ul>                                                               |
| Rankin Inlet  | <ul style="list-style-type: none"> <li>Paper shredder and additional burner for used oil would be needed</li> </ul>                                                                                                      | <ul style="list-style-type: none"> <li>Recycling program will not work without subsidy</li> <li>Drinking water source close to new SWF – what is legal status?</li> <li>CG&amp;S did studies on gasification – outcome unknown</li> <li>Notice about public meeting to be provided in</li> </ul> |

**REPORT ON CURRENT STATE OF SOLID WASTE MANAGEMENT AND FACILITIES  
IN NUNAVUT AND COST-BENEFIT ANALYSIS OF SELECTED SOLID WASTE  
MANAGEMENT APPROACHES**

GN-CGS Project #2010-27



|               |                                                                                                                                                            |                                                                                                                                                                                                                                                       |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                            | Inuktitut                                                                                                                                                                                                                                             |
| Kugluktuk     | <ul style="list-style-type: none"> <li>• Old batteries shipped few years ago</li> <li>• Old cars buried onsite after crushing about 5 years ago</li> </ul> | <ul style="list-style-type: none"> <li>• Better management of hazardous waste needed</li> </ul>                                                                                                                                                       |
| Kugaaruk      | <ul style="list-style-type: none"> <li>• Litter within the community makes snow removal difficult</li> </ul>                                               | <ul style="list-style-type: none"> <li>• N/A</li> </ul>                                                                                                                                                                                               |
| Gjoa Haven    | <ul style="list-style-type: none"> <li>• N/A</li> </ul>                                                                                                    | <ul style="list-style-type: none"> <li>• Used oil furnace would be beneficial</li> <li>• Reduced number of garbage bags after fees for plastic bags introduced</li> <li>• More space for hazardous waste required</li> </ul>                          |
| Cambridge Bay | <ul style="list-style-type: none"> <li>• More equipment needed: shredder, compactor, etc.</li> <li>• New SWF under construction</li> </ul>                 | <ul style="list-style-type: none"> <li>• Improved garbage containers would be needed</li> <li>• Used oil furnace would be beneficial</li> <li>• More space for hazardous waste needed</li> <li>• Community expects GN to be more proactive</li> </ul> |



## 3.0 COST-BENEFIT ANALYSIS OF SOLID WASTE MANAGEMENT APPROACHES

### 3.1 Objective

The objective of this section is to:

- Develop a cost-benefit analysis for three waste management approaches over a 30-year life cycle.

### 3.2 Introduction

For the purposes of this report the following definitions for each waste management approach will be used:

- **Approach #1 Modified Landfill:** This approach separates municipal, bulky, and hazardous waste at a SWF. Waste management in this manner is called “modified landfilling”. Solid waste and bulky waste materials are permanently deposited in dedicated waste cells. Hazardous waste materials are temporarily stored in a dedicated cell and then backhauled to a disposal facility located in the South for a designated time period or when a designated stockpile volume of hazardous waste materials has been achieved.
- **Approach #2 Thermal Destruction** This approach involves the use of equipment (incineration or gasification facility) that provides thermal destruction of organic material contained within solid waste. Residual waste materials from thermal destruction and bulky waste items are permanently deposited in dedicated waste cells. Suitable hazardous waste liquids (oil and fuel) are destroyed using the selected thermal destruction equipment. Non-suitable hazardous waste materials are temporarily stored in a dedicated cell and backhauled to disposal facilities located in the South in the same manner as Approach #1.
- **Approach #3 Shift and Separate:** This approach involves segregation, removal from site (e.g., backhauling), composting, and/or recycling of solid waste to divert it from final disposal in the SWF. Non-diverted waste materials are permanently deposited in dedicated waste cells. Waste oil and fuel is destroyed within the community through the use of a waste oil burner. Non-suitable hazardous waste materials are temporarily stored in a dedicated cell and backhauled to disposal facilities located in the South in the same manner as Approach #1.

**Table 3.1** provides details of how select waste streams are managed within each waste management approach.

## 3.3 Alternative Waste Management Approaches

### 3.3.1 Approach #1 – Modified Landfill

A schematic layout of a SWF for waste management Approach #1 (modified landfill) is provided in **Figure 3.1**. The SWF is separated into cells where municipal, bulky, and hazardous waste are managed. The cells for municipal and bulky waste are bermed to facilitate the placement and compaction of waste. The cell for hazardous waste is lined to limit the potential for contamination from leaving the cell. A burn pit area is available to open burn acceptable waste types and to separate the burning from the remainder of the solid waste that is not suitable for open burning. An access road provides the main transportation to/from each waste cell. A perimeter maintenance road around each waste cell is provided to facilitate O&M activities. The SWF is contained within a fenced area.



### 3.3.2 Approach #2 – Thermal Destruction

Thermal solid waste destruction has been recognized as an effective and environmentally sound disposal method<sup>16</sup>. There are two main types of thermal facilities: incinerators and gasification plants. The key difference between these two technologies is the amount of air present during thermal conversion of organic matter. While incinerators allow the presence of air, gasification technology has limited, or minimal, exposure of organic matter to air during thermal organic waste decomposition. In the presence of air, organic matter essentially burns, which can result in the production of a number of gases including: carbon dioxide; carbon monoxide; nitrogen oxides; sulfur oxides; acidic emissions; heavy metal containing emissions; ash; mercury; and, organic compounds including dioxides and furans. Gasification facilities produce mainly carbon monoxide, hydrogen, hydrocarbon oils, and char, in addition to, gases produced during the incineration process (including dioxins and furans)<sup>17</sup>.

Air emissions from thermal processes pose major environmental concerns. Dioxins and furans can be generated from incomplete combustion and/or improper equipment operation. In addition, mercury containing waste may be present in the air emissions from incinerator or gasification plants. Therefore, proper equipment operation and attention to proper solid waste segregation is necessary in order to achieve and meet air quality standards.

Canada participates in several initiatives that aim at reduction of dioxins, furans and mercury including:

- Stockholm Convention on Persistent Organic Pollutants;
- Canadian Council of Ministers of the Environment (CCME) Policy for Management of Toxic Substances;
- Federal Toxics Substances Management Policy (TSMP);
- Canada Wide Standards for Dioxins and Furans;
- Canada Wide Standards for Mercury; and,
- Chemicals Management Plan.

These initiatives should be considered when selecting thermal destruction equipment, because air contaminants are a function of:

- Design and operation of the thermal destruction equipment; and,
- Nature of material being processed.

Incineration facilities may be operated under batch or continuous systems. Batch systems are charged with waste prior to the initiation of the burn cycle.

The door remains closed until the organic matter is completely destroyed and ashes are cooled inside. These systems are commonly applied for loads ranging from 50 to 3,000 kg per batch. Facilities treating more than 26 tonnes per year are recommended to have a dual chamber with controlled air. These systems have the potential treat a wide range of wastes while meeting Canada-wide standards without an air pollution control system (APC). In fact, an APC system may not be recommended for batch systems due to the possibility of formation of dioxins and furans when the temperature of the gas is lowered. For the same reason, heat recovery systems may not be recommended for batch systems. Continuous thermal facilities require a regular input of waste into the system during operations. Continuously thermal facilities may be equipped with APC systems and heat recovery systems. For more background information on thermal destruction technologies please refer to **Appendix E**.

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<sup>16</sup> Environment Canada. 2010. Technical Document for Batch Waste Incineration.

<sup>17</sup> The Blue Ridge Environmental Defense League. 2009. Waste Gasification, Impact on the Environment and Public Health.



Four thermal facility suppliers were approached during this study. Their contact information is provided below. Upon review of the initial submitted draft of this report it was requested by the GN-CGS that they wished to obtain further site specific information on two specific thermal facility suppliers. Site visits were conducted by the GN-CGS and ARKTIS to an Eco Waste Solutions waste unit located in Northern, Quebec and a RES/OP demonstration located outside of Winnipeg, Manitoba. For more details on the technical information provided by the four thermal facility supplies and a summary of information gained during the Eco Solutions and RES/OP site visits refer to **Appendix E**.

| Company name           | Company address                                                                         | Technology provided             |
|------------------------|-----------------------------------------------------------------------------------------|---------------------------------|
| Eco Waste Solutions    | Eco Burn Inc.<br>5195 Harvester Road, Unit 14<br>Burlington, ON, L7L 6E9                | Incineration (batch)            |
| Westland Environmental | Westland Environmental Co. Ltd.<br>20204 - 110 Avenue N.W.<br>Edmonton, Alberta T5S 1X8 | Incineration (batch)            |
| SenreQ                 | SenreQ Inc.<br>2021 Midwest Road, Suite 200<br>Oak Brook, Illinois 60523                | Gasification (batch)            |
| RES/OP                 | RES/OP Technologies<br>15-395 Berry St.<br>Winnipeg, MB R3J 1N6                         | Gasification (continuously fed) |

With exception of the RES/OP system (that does not offer a batch system), the other thermal facility suppliers offer batch systems. Each batch system has the potential to achieve acceptable air quality standards without the use of an APC system. For the purpose of this report, it is also assumed that no heat recovery systems are used.

A schematic layout for a SWF that incorporates thermal destruction into the waste management approach is provided in **Figure 3.2**. The SWF layout for Approach #2 is similar to the SWF for Approach #1. The main differences between the SWF layout for Approach #1 compared to Approach #2 include:

- A thermal treatment facility is positioned within the SWF in Approach #2. The thermal treatment facility is housed inside a dedicated building.
- Approach #2 does not have a permanent municipal waste cell. Instead Approach #2 has a residual disposal and temporary municipal solid waste storage cell.
- The footprint of the SWF is smaller for Approach #2 compared to Approach #1 because the volume of municipal solid waste to be deposited within the SWF is less than Approach #2. The volume reduction is a result of solid waste being destroyed in the thermal treatment facility.
- A two year temporary storage area within the municipal solid waste cell is provided. This temporary storage is provided in case the thermal destruction facility becomes inoperable for a short period of time. As such, there is a location to store solid waste during the repair period.

### 3.3.3 Approach # 3 – Shift and Separate

The shift and separate waste management approach aims to divert waste from final disposal within the SWF. For this cost-benefit analysis it was assumed that the waste generator separates the organic fraction that is compostable material at the source and delivers this material for management within the composting pad at the SWF. The separation of inorganic materials and other recyclables is completed through a combination of on-site personnel to separate waste materials by type, and through the use of a recycling depot for bottles. The waste generator is responsible for separation of recyclables and delivery to the recycling depot. Lastly, waste oil and fuel is destroyed within the community through the use of a waste oil burner.



A schematic layout for a SWF that incorporates waste diversion into the waste management approach is provided in **Figure 3.3**. The SWF layout for Approach #3 (shift and separate) is similar to the SWF for Approach #1 (modified landfill). The main differences between the SWF layout for Approach #3 compared to Approach #1 include:

- The footprint of the SWF is smaller for Approach #3 compared to Approach #1 because the volume of municipal solid waste to be deposited within the SWF is less in Approach #1. The volume reduction is a result of waste diversion activities, primarily backhaul of materials off-site.
- Recycling occurs within a dedicated building. Waste oil burner would be housed within an acceptable building within the community.
- A temporary bulky waste laydown area to store materials for removal off-site is included in Approach #3 but not required for Approach #1.

### 3.4 Waste Generation Estimates

#### 3.4.1 Estimate of Population Growth

In order to provide an analysis of the costs and benefits of operating a SWF, an estimate must be made of the size of the population serviced. This estimate can either be based on the population of a specific community, or calculated for a statistically average community. Since the objective of the cost-benefit analysis is to examine how major capital and operational decisions inherent in the alternative waste management approaches impact costs and revenues, a statistically average community population was used to calculate waste generation estimates.

Based on the Nunavut Bureau of Statistics<sup>18</sup>, in 2010 a statistically average community in Nunavut had a population of 1,255 people (32,614 people in 26 communities). Based on the 30-year life-cycle period of a typical solid waste facility, and a Nunavut wide projected population of 46,566, the population of the statistically average community would be 1,791 people in 2040. See **Table 3.2** for population predictions.

The following assumptions are inherent in the population predictions:

- The population predictions include Iqaluit residents. This assumption may inflate the population since 21% of Nunavut's population resides in Iqaluit.
- The population predictions do not account for non-permanent residents (e.g., migratory workers, military, etc.). This assumption may underestimate the community population.

#### 3.4.2 Waste Volume and Composition

The population estimates can be applied to calculate waste volume and composition estimates. The estimates are based on the solid waste volume model (MACA, 1986<sup>8</sup>) represented in **Equation 1**. This model has been commonly used in Northwest Territories to estimate the uncompacted volume of solid waste generated in any given year. The predicted volume of solid waste generated over the 30 years is shown in **Table 3.2**. The cumulative volume of waste generated over a thirty year period was calculated to be 485,396 m<sup>3</sup>.

$$\text{Volume (year)} = 365 V P_1 (1+G) + 0.084 V P_1^2 (1+G)^{2n}$$

where:

V = average residential solid waste volume (m<sup>3</sup>/person/day)

P<sub>1</sub> = population in current year (persons)

G = average community population growth rate (persons/year)

n = year of interest

<sup>18</sup> Nunavut Bureau of Statistics. 2010. Nunavut Regional Population Projections 2009-2036. Url: <http://www.eia.gov.nu.ca/stats/>. Site accessed: October 20, 2010



A community waste audit that is necessary to verify the composition and quantity of waste generated within the community was not completed as part of this study. As a first approximation to estimate waste composition and quantity, applicable studies and literature reported data<sup>19,20,21,22,23</sup> were applied to this analysis. The management of solid waste can be broadly categorized into: municipal solid waste; bulky waste; and, hazardous waste. Each broad waste category is managed separately within a modified landfill and therefore the volumes of each main waste type are of importance. The volume of waste in each category was estimated and is detailed in **Table 3.3**. In summary, 81.9% of the total solid waste generated is estimated to be municipal solid waste, 15% is bulky waste, and 3.1% is hazardous waste.

The following assumptions are inherent in the waste volume and composition predictions:

- The waste generation rate applied in the waste volume calculation is the average value deduced from the community site visits. As such, it is a first approximation that may, or may not, accurately capture all residential and non-residential waste (e.g., institutional, commercial, construction and demolition, etc.).
- The distribution of solid waste into municipal, bulky, and hazardous waste is based on limited data, and therefore there is uncertainty in the predicted volumes of each waste type.

The waste volume and composition estimates vary for each waste management approach due to differences in capital outlays and operational decisions. **Tables 3.4 to 3.7** outline the waste volume and composition estimates for each approach.

The primary difference between Approach #1 and Approach # 2 is that there is an assumed reduction in the mass and volume of waste due to thermal destruction. The primary difference between Approach #3 and Approach #1 is that a portion of the waste collected is diverted from disposal within the SWF through recycling and composting efforts.

### 3.5 Cost-Benefit Analysis - Assumptions

In order to calculate the life-cycle costs for each waste management approach, several assumptions must be made. **Section 3.5** summarizes the capital and O&M costs, and revenue stream assumptions that are common across all waste management approaches. The costs and revenues that are specific to a waste management approach are described in the corresponding subsection **Section 3.6**.

#### 3.5.1 Life-cycle Costs

There are several expenditures and potential revenues related to the operation of a SWF facility that occur over its life-cycle. Initially, there are capital expenses related to the site development and construction and equipment purchases to support a new SWF. Once the infrastructure is in place, O&M expenses occur that last throughout the life of the facility (such as equipment maintenance, or hazardous waste disposal costs). At the same time, some approaches may provide positive cash flow (such as sale of compost material) that would offset some of the O&M costs. At the end of the SWF life-cycle, capital expenses related to the site closure are expected. All of these anticipated costs are included in the

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<sup>19</sup> Heinke, G.W. (1996) Cold Regions – Utilities Monograph. Section 16. 3<sup>rd</sup> ed, ASCE.

<sup>20</sup> Kent R., Marshall P. and Hawke L.(2003) Guidelines for the Planning Design, Operations and Maintenance of Modified Solid Wastes Sites. Municipal and Community Affairs, Government of Northwest Territories

<sup>21</sup> Sperling Hansen Associates (SHA) (2005). Solid Waste Stream Composition Study. Prepared for Capital Regional District, Environmental Services Department. British Columbia.

<sup>22</sup> Canadian Council of Ministers of the Environment, 1996. Waste Audit Users Manual – A Comprehensive Guide to the Waste Audit Process.

<sup>23</sup> ARKTIS Solutions Inc. (2008). Resolute, Nunavut Dump Site Investigation. Hamlet of Resolute, Nunavut. Prepared for The Department of Community and Government Services, Government of Nunavut.



financial calculations to provide true representation of actual life-cycle costs. In general, the life cycle cost is represented as:

**Life-cycle costs = Capital costs + O&M Costs - Revenue**

Since the expenditures and revenues occur over time, the net present value for each can be calculated.

### 3.5.2 Net Present Value

In order to compare the net cost and benefits associated with different solid waste management approaches over time, a discounted cash flow valuation needs to be used. This strategy considers the impact of time on capital investment and operation decisions. The present value (PV) of a future investment is dependent upon the value of the future payment, the discount rate, and the time when investment is made. The net present worth (NPV) is the overall sum of the individual present values and is calculated as follows.

$$= \sum_{i=1}^n \frac{C_i}{(1+r)^i}$$

Where:

C – value of payment;

i – time of payment

r – effective annual discount rate; and,

n – number of years.

In order to calculate the NPV of the costs and revenues, a discount rate must be selected. A specific discount rate was not available from GN-CGS<sup>24</sup>; therefore, the recently issued bond rates for the Yukon (4.7%) will be used as a benchmark rate that is representative of the risk inherent in the finances of Territorial Governments. Since the bond is compounded semi-annually, the effective annual discount rate will be calculated as follows:

$$r = (1 + r^{(2)}/m)^m - 1$$

Where:

$r^{(2)}$  – semi-annual rate; and,

m – number of times interest is compounded per year.

The effective annual discount rate was calculated at 4.8% and is used in the NPV calculations.

### 3.5.3 Capital Costs

Capital costs include all costs related to the SWF construction and development, major equipment purchases (e.g., thermal facility), and SWF site closure. The following capital costs are common across all three waste management approaches:

- Site construction<sup>25</sup>:
  - o Site preparation including clearing and grubbing at \$2.50/m<sup>2</sup>;
  - o Domestic solid waste disposal cell construction at \$6,900 plus \$44.00/m<sup>3</sup>;
  - o Bulky waste disposal cell construction at \$3,500 plus \$44.00/m<sup>3</sup>;
  - o Hazardous material cell construction at \$100.00/m<sup>2</sup>;

<sup>24</sup> Westwell, B. 2010. Personal Communication with Bartek Puchajda. December 7, 2010

<sup>25</sup> Unit rates based on Hanscomb Limited. 2010. Pretender Estimate. Solid Waste Disposal Facility New Disposal Cells Resolute Bay, Nunavut. Prepared for Arktis Solutions Inc.



- o Burn pit construction at \$10.00/m<sup>2</sup>;
- o Access road construction within SWF at \$20.00/m;
- o Drainage ditch around SWF site at \$50.00/m;
- o Perimeter chain link fence at \$175.00/m;
- o Double gate for vehicles at \$25,000.00/each;
- o Entrance gate at \$2,000.00/each; and,
- o Signage at \$40,000/lump sum.
- Site closure:
  - o Site preparation that includes waste grading and consolidation of waste at \$2.50/m<sup>2</sup>;
  - o 0.5 m soil cover over waste cells at \$45/m<sup>3</sup>; and,
  - o Signage at \$2,000/lump sum.
- Mobilization of materials/equipment to site assumed to be 10% of the sum of the site construction, major equipment, and closure costs;
- Contingency at 20% of the sum of the site construction, major equipment, and closure costs; and,
- Engineering at 10% of the sum of the site construction, major equipment, and closure costs.

Total capital cost is calculated as follows:

**Total capital cost = Site construction costs + Major equipment costs + Site closure costs + Mobilization costs + Contingency fees + Engineering fees**

### 3.5.4 O&M Costs

The O&M costs include all costs necessary to operate and maintain the SWF over its life-span. The following O&M costs are common across all waste management approaches:

- Mobile equipment:
  - o Garbage collection vehicle – one garbage collection vehicle to service the SWF. Recently purchased Ford F550 truck in Kimmirut was purchased at \$83,000 CAD + shipping costs from Montreal. The lifespan of this vehicle is expected at around 10 years<sup>26</sup> which means that over the 30-year life cycle, three vehicles will be required.
- Fuel:
  - o Fuel to operate mobile equipment - It is assumed that waste collection occurs daily from Monday to Friday. Assuming total average municipal solid waste generation of 49.7 m<sup>3</sup>/day (387,831m<sup>3</sup> / 30 years / 52 weeks / 5 days), it is projected that the garbage truck will make approximately 8 to 9 return trips per day. The garbage truck annual fuel consumption is estimated at 4.8 L/hr x 8 hrs x 5 days x 52 weeks ~10,000 L/year.
- Labour costs:
  - o The community site visits revealed that on average 1.8 full time employees service the SWF (see **Table 2.3c**). It is assumed that on average, 2 full time employees would be required to service the SWF. Each employee would receive a salary and benefits in the amount of \$66,000/yr. It is also assumed that additional expenses related to administrative work would correspond to 10% additional expenses for the community. Therefore, the equivalent labour cost is equal to \$66,000/person/year (or \$132,000/yr for 2 full time employees).
- Backhaul mobilization rate:
  - o It is assumed that hazardous waste would be shipped to the south in a 20' seacan container at average cost of \$4,000/seacan plus the additional surcharge for transportation of dangerous goods (e.g. hazardous waste) that is estimated at 21% or \$5,000/seacan container (see **Table 3.8** for a summary of 2010 shipping rates).

<sup>26</sup> United Nations Environment Programme. 2005. Solid Waste Management.



- o Ground transportation costs from port of destination to disposal facility estimated at \$2,500/sea container (see SWF Best Practice Guide for more information).
- Hazardous waste disposal fee:
  - o Typical average disposal costs for hazardous waste summarized in **Table 3.9** are estimated as follows:
    - Liquids at \$160/drum;
    - Solids at \$243/drum;
    - Paints at \$243/drum; and,
    - Batteries at \$5/kg.
  - o Estimated total annual disposal cost for hazardous waste is provided in **Table 3.10**. Based on visual observations from site visits it was assumed that approximately 80% of hazardous waste by weight would be composed of liquids.
- SWF maintenance and mobile equipment O&M costs:
  - o It is assumed that for the duration of mobile equipment life (such as garbage truck) a minimum of 5% of total capital costs is utilized annually on maintenance. In addition, miscellaneous costs such as equipment rental (i.e., for periodic bulldozing of waste and application of soil cover), minor repairs, additional work related to preparation for shipping, site cleanup, and annual soil cover are estimated at 0.5% of total capital costs of site development for each option.

### 3.5.5 Revenue

Garbage disposal fees are a potential revenue source for all three waste management approaches. These fees include residential, as well as, commercial and institutional rates. Additional revenue can be generated from individual tipping permits. It is assumed that the revenue from garbage disposal is equal to \$200/dwelling/year. It is assumed that the average people/dwelling is 3.6. The revenue from garbage disposal fees is summarized in **Table 3.11**.

## 3.6 Cost-Benefit Analysis – Summary of Inputs for Each Waste Management Approach

This section summarizes the capital and O&M costs incurred, as well as, the revenue that can be generated through application of each of the three waste management approaches. These costs and revenue figures are used to evaluate the overall life cycle costs for each waste management approach. Further, this section highlights the non-monetary cost and benefits associated with each option.

### 3.6.1 Waste Management Approach #1 – Modified Landfill

The costs and revenues associated with implementing waste management Approach #1 are summarized in this section. This approach will be used as the base-case for the cost-benefit analysis and the other two waste management approaches will be compared to this base-case.

The total capital costs associated with waste management Approach #1 are highlighted in **Table 3.12**. The total O&M costs associated with waste management Approach #1 are highlighted in **Table 3.13**.

The only potential revenue stream is through the collection of community waste disposal fees. **Table 3.11** summarizes the assumed total revenue.

### 3.6.2 Waste Management Approach #2 – Thermal Destruction

The costs and revenues associated with implementing waste management Approach # 2 are summarized in this section. Only those assumptions that differ from those described for Approach #1 are described.

The capital costs associated with Approach #2 include the need to purchase a thermal facility and to construct a building to house the equipment to protect it from climactic conditions. It is assumed in this



report that thermal facility building would be erected onsite at a capital cost of \$3,000/m<sup>2</sup>. A summary of the capital costs, fuel and labour requirements and maintenance costs for the four thermal suppliers that were approached is shown in **Table 3.14**. Based on the results obtained during the site visits of thermal facility suppliers (**Appendix E**) the Ecco Waste Solutions unit thermal destruction unit was selected to be evaluated for costing purposes. It was conservatively assumed the minimal preventative maintenance would occur and three incineration units would be required over the 30 year life cycle. The NPV capital cost of purchasing three Ecco Waste Solutions pres over a 30 year life cycle period was calculated to be approximately \$2,000,000.

The total capital costs for construction and closing are presented in **Table 3.15**.

The waste collection and hauling expenses are the same as those described for Approach #1; however, due to the implementation of the thermal treatment process, additional waste processing costs are expected. In addition to the processing costs listed in Approach #1, annually it is assumed that 210,600 L of fuel will be required to operate the Eco Waste Solutions incinerator and, and \$41,750 will be required for facility maintenance (**Table 3.14**). Further, 10 labour hours per week will be required to operate the thermal facility.

It is assumed that approximately 50% of the hazardous waste by weight is composed of liquids (e.g., waste oil, aviation fuel, anti-freeze liquids etc.) that can be destroyed within the thermal treatment facility. Therefore compared to Approach #1, Approach #2 has less hazardous waste that is required to be removed from site.

The total O&M costs for a thermal destruction option are presented in **Table 3.16**.

The only potential revenue stream is through the collection of community waste disposal fees. **Table 3.11** summarizes the total revenue for this waste management approach.

### 3.6.3 Waste Management Approach #3 – Shift and Separate

The costs and revenues associated with implementing waste management Approach # 3 are summarized in this section. Only those assumptions that differ from those described for Approach #1 are described.

The capital costs of Approach #3 include construction of a recycling depot for collection of beverage containers. A recently completed report<sup>27</sup> provided an evaluation of pilot programs operated in three Nunavut communities. It is assumed that the costs and conditions of a recycling program for this study are similar to the pilot programs. Based on the findings from the pilot program, a new recycling depot facility would be constructed at an estimated cost of \$1,300,000. It is recognized that some communities may have appropriate space available to house the recycling operations and therefore a new building would not be required; however, this cost analysis assumes that a building would be constructed. A capital cost associated with the construction of a composting pad and purchase of a waste oil burner is also applied to this waste management approach. The total capital costs for Approach #3 are outlined in **Table 3.17**.

It is assumed that the O&M costs associated with waste collection and hauling would result in an additional 5 km travel distance to account for material drop off at the recycling depot, as well as, the SWF. Waste processing would require an additional \$36,800/year (including all shipping costs) for operating the recycling dept. Additional labour costs would include 1 day per week for management of the recycling depot, and over the summer months for cutting bulky items to a size that would make them acceptable for transport.

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<sup>27</sup> Dillon Consulting. 2010. Evaluation of Recycling Pilot Projects. Department of Environment, Government of Nunavut.



Composting would require a crusher equipped with screen<sup>28</sup> that can be attached to any loader or excavator for mixing. Equipment rental fee was added to the O&M costing in the amount of \$21,600 in year 2010 (5hr/wk \* \$90/hr \* 4 months). Composting activities would require an additional part time laborer during the summer months to operate the composting facility, while during winter months a dedicated person would only mix fresh organic waste with paper products and place them in a new windrow pile twice a month (2 day labour per month). The total O&M costs for Approach #3 are outlined in **Table 3.18**.

Large appliances, scrap metal, and end-of-life vehicles are collected and prepared for transport off site as per study on scrap metal recycling in Nunavut and Northern Manitoba<sup>29</sup>.

It is assumed that approximately 50% of the hazardous waste by weight is composed of liquids (e.g., waste oil, aviation fuel, anti-freeze liquids etc.) that can be destroyed within a waste oil burner. Therefore compared to Approach #1, Approach #3 has less hazardous waste that is required to be removed from site.

In addition to garbage collection fees (summarized in **Table 3.11**), additional revenue from waste management Approach #3 can be generated from compost derived topsoil, recycling, and from the sale of scrap metal. Details of each potential revenue stream specific to waste management Approach #3 are presented below:

- Revenue from compost derived topsoil
  - o It is assumed that 80% of food waste by weight will be lost due to the composting process which results in average of 66.7 tonnes/year compost generated at an assumed density of 0.8 kg/L. (average annual mass of organic material + 10% of Paper and Paperboard) x 0.2 = (314 tonnes + 19.5 tonnes) x 0.2 = 66.7 tonnes).
  - o Compost derived topsoil priced at \$92<sup>30</sup>/m<sup>3</sup>. Using a density of 1.2 tonnes/m<sup>3</sup>, compost price is calculated to be \$76/tonne.
- Revenue from a recycling program:
  - o Annual recycled cans produced calculated to be 616,000 cans/year in 2010. (76.9 tonnes x 80% recovery rate / 0.0001 tonnes/can ~ 616,000 cans/year).
  - o Recycling revenue comes from two sources. The first is a non-refundable handling fee that consumers pay during purpose of a container. The non-refundable fee is set at \$0.10/can (in 2010) and is provided to the recycling depot. The second revenue source comes from the sale of the recyclable to market set at \$0.01/can<sup>22</sup>.
- Scrap metal revenue:
  - o It is assumed that the average potential revenue from scrap metal sale would be \$173/tonne (90% ferrous metal @ \$141/tonne + 10% non-ferrous @ \$460/tonne). See **Table 3.19** for additional details.

The total revenue that can be generated from implementation of Approach #3 is presented in **Table 3.20**.

### 3.7 Cost-Benefit Analysis – Results

**Section 3.7** discusses how the three waste management approaches compare with respect to their capital costs, O&M costs, and revenue streams. This section will summarize the overall life-cycle cost and

<sup>28</sup> For more information on this product see: <http://www.pavementgroup.com/screening-plants/allu-crusher-and-screener>

<sup>29</sup> North Central Development. 2007. Scrap Metal Recycling in Nunavut and Northern Manitoba. Collection and Recovery Action Plan. Prepared for Government of Canada.

<sup>30</sup> Based on literature value reported for Whitehorse, Yukon of bulk compost prices of \$54.50 and \$38.15. Reported in Ecology North (2008). Study of Options for a Centralized Composting Pilot Project in the City of Yellowknife.



will provide overall advantages and disadvantages that should be taken into consideration when selecting an appropriate waste management approach.

### 3.7.1 Capital Costs

A summary of the capital costs for each waste management approach is provided below. Due to its high capital costs for purchasing the thermal destruction unit and the building to house it, Approach #2 had the highest capital costs. Approach #1 and Approach #3 had the lowest capital costs with similar values..

| Approach #1 - Modified Landfill | Approach #2 - Thermal Destruction | Approach #3 - Shift and Separate |
|---------------------------------|-----------------------------------|----------------------------------|
| \$9,559,311                     | \$12,146,407                      | \$9,329,217                      |

Capital costs are somewhat dependent on the footprint of the SWF, the larger the footprint to be constructed the higher the costs. SWF closure costs are also primarily dependent on the footprint. The capital costs associated with developing Approach #3 included costs related to the construction of a new recycling depot (estimated at \$1.3 M), the total capital costs of this approach were similar than those for Approach #1. This suggests that developing a smaller facility may provide considerable savings if site development and closure costs are included. However, it should be noted that there is a point at which the cost savings of constructing a smaller facility cannot balance the significant capital costs associated with purchasing equipment..

### 3.7.2 O&M Costs

Each waste management approach has unique SWF operations which are reflected in the O&M costs associated with mobile equipment, fuel, labour, hazardous waste management, and miscellaneous site costs; a summary discussion for each O&M cost is provided below. Approach #2 had the highest O&M costs, and Approach #1 had significantly the lowest O&M costs.

| O&M Cost                   | Approach #1 - Modified Landfill | Approach #2 - Thermal Destruction | Approach #3 - Shift and Separate                        |
|----------------------------|---------------------------------|-----------------------------------|---------------------------------------------------------|
| Mobile Equipment           | \$238,148                       | \$238,148                         | \$238,148                                               |
| Fuel                       | \$249,711                       | 5,511,076                         | \$299,940                                               |
| Labour                     | \$2,748,050                     | \$3,022,855                       | \$3,984,672                                             |
| Scrap Metal                | -                               | -                                 | \$947,244                                               |
| Recycling                  | -                               | -                                 | \$766,123                                               |
| Compost                    | -                               | -                                 | Included in Mobile Equipment, Labour, and Fuel Expenses |
| Hazardous Waste Disposal   | \$1,488,527                     | \$745,304                         | \$745,304                                               |
| Site O&M and Miscellaneous | \$799,796                       | \$1,004,084                       | \$1,230,513                                             |
| <b>Total O&amp;M</b>       | <b>\$5,524,232</b>              | <b>\$10,521,467</b>               | <b>\$8,211,945</b>                                      |

- Mobile equipment- The mobile equipment costs are all equal between the three options. These costs are lowest compared to the other O&M costs.
- Fuel- Fuel costs present approximately half of the total O&M costs for Approach #2 due to the fuel used to operate the thermal treatment facility. It should be noted that there may be additional costs related to such high fuel consumption that are not accounted for in this cost-benefit analysis. For example, higher fuel usage within the community has potential to result in insufficient fuel storage



capacity within the community. To overcome a challenge of this type, the community may require expansion of the fuel storage facility to accommodate the SWF operations.

- Labour- Approach #3 is the most labour intensive option labour intensive due to the added effort required to divert waste from final disposal in the SWF. The labour costs for Approach #2 are higher when compared to Approach #1 due to the extra effort required to operate the thermal destruction facility.
- Hazardous waste- Based on the assumption that the hazardous waste contains a large portion of waste oil and other liquid waste that is suitable for thermal treatment, Approaches #2 and #3 have lower hazardous waste costs. Thermal treatment of select hazardous waste would occur in the thermal treatment facility and a waste oil/fuel burner in Approach #2 and #3, respectively.
- Miscellaneous site costs- This category is related to other SWF costs such as: SWF maintenance; mobile equipment maintenance; thermal facility operation (Approach #2 only); additional waste segregation or preparation for shipment (e.g. removal of hazardous liquids from end of life vehicles); and, other onsite activities that would be difficult to quantify and account for in this initial costs assessment. These costs were assumed to be a portion of capital costs related to the site development (0.5% annually), and a portion of mobile equipment costs (5% annually). Approach #3 had the highest miscellaneous site costs and Approach #1 had the lowest miscellaneous site costs.

### 3.7.3 Revenue

Waste management Approach #3 considers potential revenue streams that are not accounted for in approaches #1 and #2. Provided below is a summary of the potential revenue for each waste management approach.

| Revenue Stream       | Approach no. 1<br>Modified Landfill | Approach no. 2<br>Thermal Destruction | Approach no. 3<br>Shift and Separate |
|----------------------|-------------------------------------|---------------------------------------|--------------------------------------|
| Garbage service fees | \$1,725,046                         | \$1,725,046                           | \$1,725,046                          |
| Scrap metal          | -                                   | -                                     | \$802,973                            |
| Recycling            | -                                   | -                                     | \$1,655,293                          |
| Compost              | -                                   | -                                     | \$123,751                            |
| <b>Total</b>         | <b>\$1,725,046</b>                  | <b>\$1,725,046</b>                    | <b>\$4,307,063</b>                   |

The distinct revenue streams considered in Approach #3 include the sale of scrap metal, compost and recyclable materials. Revenue for garbage service fees is common for each waste management approach. Provided below is a summary of select key results:

- Garbage service fees- Revenue from garbage service are proportional to the population serviced and the garbage service fee.
- Scrap metal- The scrap metal prices were assumed to be constant over the life cycle analysis. In reality, there are fluctuations in the market for scrap metal. The sensitivity to fluctuating metal prices is not reflected in this costing analysis. The costing analysis also did not consider optimizing the scrap metal backhauling to result in a positive net benefit for the operation. For example, no consideration was given to ensure that the cost to deliver a product to market was higher than the resale value. Excluding capital and labour costs, the O&M costs to deliver scrap metal to market is higher than the revenue, leading to a conclusion that there is a negative benefit for this waste diversion practice. By considering the capital and labour costs, this conclusion may not be valid.
- Recycling program- Recycling has the potential to provide a revenue stream. The revenue could come from a non-refundable fee imposed upon consumers and the sale of product to market. from two sources. Current metal prices do not result in a significant revenue from sale of product to market.



- Composting program- A composting program has the potential to generate additional revenue for the community through the sale of compost as usable top soil. This cost analysis assumes there is a market for the compost produced. If the compost cannot achieve acceptable quality for resale, or if there is no market for the product, than this potential revenue stream will not be favourable from a costing perspective.

### 3.7.4 Life-Cycle Costs

A final comparison of life cycle-costs between the approaches is provided below. The costs developed during this study should be considered as Class C estimate or within about 30% accuracy. From a financial standpoint, waste management Approach #2 has the highest life cycle cost, followed by Approach #1 and #3. It should be noted that the overall life cycle costs for Approach #1 and #3 are very similar and differ by only approximately \$125,000. For the purpose of evaluation the overall life costs for Approach #1 and Approach #2 are assumed to be equal.

|                                   | Capital Costs | O&M Costs    | Revenue     | Life Cycle Costs | Accuracy of Class C Estimates +/- 30% |
|-----------------------------------|---------------|--------------|-------------|------------------|---------------------------------------|
| Approach #1 - Modified Landfill   | \$9,559,311   | \$5,524,232  | \$1,725,046 | \$13,358,716     | \$4,267,715                           |
| Approach #2 - Thermal Destruction | \$12,146,407  | \$10,521,467 | \$1,725,046 | \$20,942,829     | \$6,543,014                           |
| Approach #3 - Shift and Separate  | \$9,329,217   | \$8,211,945  | \$4,307,063 | \$13,234,098     | \$4,619,808                           |

**Table 3.1:** Summary of key features of three approaches to waste management.

|              | Approach #1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Approach #2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Approach #3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Thermal Destruction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Shift and Separate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Key features | <ul style="list-style-type: none"> <li>• Solid waste is managed within a modified landfill.</li> <li>• Municipal waste gets periodically compacted and covered within a separate area at the SWF for final disposal.</li> <li>• Bulky waste, scrap metal and wood is stored in separate area for final disposal (i.e., no backhauling or removal of the bulky waste from SWF).</li> <li>• Hazardous waste is separated, temporarily stored, and managed in a separate area within the SWF. When the volume of stored hazardous waste materials reaches a designated level or time period the hazardous waste materials are backhauled to disposal facilities located in the South.</li> </ul> | <ul style="list-style-type: none"> <li>• Incineration and/or gasification of municipal solid waste.</li> <li>• Residual waste after thermal destruction is placed in the a modified landfill for final disposal.</li> <li>• Solid waste that cannot undergo thermal destruction is placed in a modified landfill for final disposal.</li> <li>• Bulky waste, scrap metal, and wood is stored in separate area within the SWF for final disposal (i.e., no backhauling or removal of bulky waste form the SWF).</li> <li>• Hazardous waste oil and fuels are thermally destroyed using incineration and/or gasification. Non suitable hazardous waste materials are managed in the same manner as Approach #1.</li> </ul> | <ul style="list-style-type: none"> <li>• Solid waste is separated into several streams for potential diversion from disposal within the SWF. Diversion activities include temporary storage, reuse, and recycle. Waste types considered include: <ul style="list-style-type: none"> <li>• Scrap metal waste (including construction waste);</li> <li>• Mechanical waste (old vehicles, snow mobiles, etc.);</li> <li>• Large appliances;</li> <li>• Wood and paper;</li> <li>• Recycling program for pop cans;</li> <li>• Repatriation of end of life vehicles; and,</li> <li>• Composting of organic portion of household waste.</li> </ul> </li> <li>• Solid waste that cannot be diverted is placed in a modified landfill for final disposal.</li> <li>• Bulky waste, scrap metal and wood that cannot be diverted is stored in separate area within the SWF for final disposal.</li> <li>• Hazardous waste oil and fuels are thermally destroyed using a waste oil burner incineration and/or gasification. Non suitable hazardous waste materials are managed in the same manner as Approach #1.</li> </ul> |

|                                                  | Approach #1                                                                                                                                                                                                                 | Approach #2                                                                                                                                                                                                                                                 | Approach #3                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Significance to the cost-benefit analysis</b> | In Approach #1, the cost-benefit analysis is based on the use of a modified landfill as the waste management approach. This analysis is a base case scenario that can be compared to the other waste management approaches. | In Approach #2, the cost-benefit analysis is based on a waste management approach that utilizes thermal destruction. This cost-benefit analysis can be compared to Approach #1 for a direct assessment of the economic effect of using thermal destruction. | In Approach #3, the cost-benefit analysis is based on a waste management approach that utilizes separation and diversion of solid waste. The cost-benefit analysis provides an assessment of whether the waste types to be separated and diverted are assets or liabilities. This cost-benefit analysis can be compared to Approach #1 for a direct assessment of the economic effect of separation and diversion practices. |

**Table 3.2:** Estimated total community solid waste volume generated.

| Year                                   | Projected Year | Statistically<br>Average<br>Community<br>Population | Growth Rate                  | Community<br>Projected Annual<br>SWF Volume |
|----------------------------------------|----------------|-----------------------------------------------------|------------------------------|---------------------------------------------|
|                                        | T (year)       | P (persons)                                         | G (persons/year)             | V (m <sup>3</sup> )                         |
| 2011                                   | 1              | 1,271                                               | 0.013                        | 13,044                                      |
| 2012                                   | 2              | 1,288                                               | 0.013                        | 13,245                                      |
| 2013                                   | 3              | 1,305                                               | 0.013                        | 13,450                                      |
| 2014                                   | 4              | 1,322                                               | 0.013                        | 13,660                                      |
| 2015                                   | 5              | 1,340                                               | 0.013                        | 13,873                                      |
| 2016                                   | 6              | 1,358                                               | 0.013                        | 14,087                                      |
| 2017                                   | 7              | 1,376                                               | 0.013                        | 14,304                                      |
| 2018                                   | 8              | 1,394                                               | 0.013                        | 14,520                                      |
| 2019                                   | 9              | 1,412                                               | 0.013                        | 14,736                                      |
| 2020                                   | 10             | 1,430                                               | 0.012                        | 14,952                                      |
| 2021                                   | 11             | 1,448                                               | 0.012                        | 15,166                                      |
| 2022                                   | 12             | 1,465                                               | 0.012                        | 15,381                                      |
| 2023                                   | 13             | 1,483                                               | 0.012                        | 15,594                                      |
| 2024                                   | 14             | 1,500                                               | 0.012                        | 15,808                                      |
| 2025                                   | 15             | 1,518                                               | 0.011                        | 16,021                                      |
| 2026                                   | 16             | 1,535                                               | 0.011                        | 16,237                                      |
| 2027                                   | 17             | 1,552                                               | 0.011                        | 16,454                                      |
| 2028                                   | 18             | 1,570                                               | 0.011                        | 16,673                                      |
| 2029                                   | 19             | 1,587                                               | 0.011                        | 16,893                                      |
| 2030                                   | 20             | 1,605                                               | 0.011                        | 17,116                                      |
| 2031                                   | 21             | 1,623                                               | 0.011                        | 17,342                                      |
| 2032                                   | 22             | 1,640                                               | 0.011                        | 17,573                                      |
| 2033                                   | 23             | 1,659                                               | 0.011                        | 17,808                                      |
| 2034                                   | 24             | 1,677                                               | 0.011                        | 18,045                                      |
| 2035                                   | 25             | 1,696                                               | 0.011                        | 18,289                                      |
| 2036                                   | 26             | 1,715                                               | 0.011                        | 18,533                                      |
| 2037                                   | 27             | 1,734                                               | 0.011                        | 18,778                                      |
| 2038                                   | 28             | 1,753                                               | 0.011                        | 19,024                                      |
| 2039                                   | 29             | 1,772                                               | 0.011                        | 19,271                                      |
| 2040                                   | 30             | 1,791                                               | 0.011                        | 19,521                                      |
| <b>Cumulative SWF Volume Generated</b> |                |                                                     | <b>485,396 m<sup>3</sup></b> |                                             |

Note: Data generated based on constant population growth in period 2037-2040 due to lack of official projections.

**Table 3.3:** Summary of waste composition estimates.

| Waste Category                | % by weight | Source             |
|-------------------------------|-------------|--------------------|
| <b>Municipal Solid Wastes</b> | <b>81.9</b> |                    |
| Organic Waste                 | 19.6        | Heinke (1996)      |
| Paper and Paperboard          | 12.2        | Kent et al. (2003) |
| Plastic, rubber, leather      | 12.2        | Heinke (1996)      |
| Diapers                       | 11.6        | Heinke (1996)      |
| Other paper products          | 10.2        | Heinke (1996)      |
| Cans                          | 4.8         | Heinke (1996)      |
| Glass and ceramic             | 4.1         | Heinke (1996)      |
| Textiles                      | 3.7         | Heinke (1996)      |
| Wood and wood products        | 2.0         | Assumed            |
| Other                         | 1.5         | Assumed            |
|                               |             |                    |
| <b>Bulky Wastes</b>           | <b>15.0</b> |                    |
| Construction & Demolition     | 6.3         | SHA (2005)         |
| Bulky metals                  | 8.7         | Assumed            |
|                               |             |                    |
| <b>Hazardous Wastes</b>       | <b>3.1</b>  |                    |
| Industrial Hazardous Waste    | 2.0         | Assumed            |
| Domestic Hazardous Waste      | 1.1         | SHA (2005)         |

**Table 3.4:** Summary of waste mass, volume, and composition for waste management Approach #1.

| Waste Category                | Waste Distribution | 30-Year Cumulative Mass | 30-Year Cumulative Un-compacted Volume | 30-Year Cumulative Compacted Volume | Average Annual Compacted Volume | Waste Height | Average Annual Area | Storage Time | Minimum Area Required |
|-------------------------------|--------------------|-------------------------|----------------------------------------|-------------------------------------|---------------------------------|--------------|---------------------|--------------|-----------------------|
|                               | % by weight        | tonnes                  | m <sup>3</sup>                         | m <sup>3</sup>                      | m <sup>3</sup>                  | m            | m <sup>2</sup>      | years        | m <sup>2</sup>        |
| <b>Municipal Solid Waste</b>  | 79.9               | 38,395                  | 387,831                                | 129,277                             | 4,309                           | 2            | 2,155               | 30           | 64,639                |
| <b>Wood and wood products</b> | 2                  | 961                     | 9,708                                  | 9,708                               | 324                             | 2            | 162                 | 5            | 809                   |
| <b>Bulky Waste</b>            | 15                 | 7,208                   | 72,809                                 | 72,809                              | 2,427                           | 2            | 1,213               | 30           | 36,405                |
| <b>Hazardous Waste</b>        | 3.1                | 1,490                   | 4,256                                  | 4,256                               | 142                             | 1            | 142                 | 5            | 709                   |

Note: Municipal solid waste, wood and wood products, and bulky waste assumed to have density of 0.099 tonnes/m<sup>3</sup>; hazardous waste assumed to have density of 0.35 tonnes/m<sup>3</sup>.

**Table 3.5:** Waste type and mass reduction in thermal destruction process.

| Waste Category                | Waste distribution | Mass          | Assumed Mass Reduction after Thermal Destruction | Ash/Residue Mass |
|-------------------------------|--------------------|---------------|--------------------------------------------------|------------------|
| Unit                          | % by weight        | tonnes        | %                                                | tonnes           |
| <b>Municipal Solid Wastes</b> | <b>79.9</b>        | <b>38,395</b> | <b>84%</b>                                       | <b>6,307</b>     |
| Organic Waste                 | 19.6               | 9,419         | 95%                                              | 471              |
| Paper and Paperboard          | 12.2               | 5,863         | 95%                                              | 293              |
| Plastic, rubber, leather      | 12.2               | 5,863         | 95%                                              | 293              |
| Diapers                       | 11.6               | 5,574         | 95%                                              | 279              |
| Other paper products          | 10.2               | 4,902         | 95%                                              | 245              |
| Cans                          | 4.8                | 2,307         | 0%                                               | 2,307            |
| Glass and ceramic             | 4.1                | 1,970         | 0%                                               | 1,970            |
| Textiles                      | 3.7                | 1,778         | 95%                                              | 89               |
| Other                         | 1.5                | 721           | 50%                                              | 360              |

**Table 3.6:** Summary of waste mass, volume, and composition for waste management Approach #2

| Waste Category                | Waste Distribution | 30-Year Cumulative mass | 30-Year Cumulative Un-compacted Volume | 30-Year Cumulative Compacted Volume | Average Annual Compacted Volume | Waste Height | Average Annual Area | Storage Time | Minimum Area Required |
|-------------------------------|--------------------|-------------------------|----------------------------------------|-------------------------------------|---------------------------------|--------------|---------------------|--------------|-----------------------|
|                               | % by weight        | tonnes                  | m <sup>3</sup>                         | m <sup>3</sup>                      | m <sup>3</sup>                  | m            | m <sup>2</sup>      | years        | m <sup>2</sup>        |
| <b>Municipal Solid Waste</b>  | 79.9               | 6,307                   | 46,584                                 | 17,784                              | 593                             | 2            | 296                 | 30           | 8,892                 |
| <b>Wood and wood products</b> | 2                  | 961                     | 9,708                                  | 9,708                               | 324                             | 2            | 162                 | 5            | 809                   |
| <b>Bulky Waste</b>            | 15                 | 7,208                   | 72,809                                 | 72,809                              | 2,427                           | 2            | 1,213               | 30           | 36,405                |
| <b>Hazardous Waste</b>        | 3.1                | 1,490                   | 4,256                                  | 4,256                               | 142                             | 1            | 142                 | 5            | 709                   |

Note: Ash/residual density assumed to have density of 0.6 tonnes/m<sup>3</sup>, Municipal solid waste, wood and wood products, and bulky waste assumed to have density of 0.099 tonnes/m<sup>3</sup>; hazardous waste assumed to have density of 0.35 tonnes/m<sup>3</sup>. Compaction ratio of ash/residual to be 1:1, compaction ratio for municipal solid waste to be 3:1.

**Table 3.7:** Summary of waste mass, volume, and composition for waste management Approach #3

| Waste Category                                  | Waste Distribution | 30-year Cumulative mass | 30-year Cumulative Un-compacted Volume | 30-year Cumulative Compacted Volume | Average Annual Compacted Volume | Waste Height | Average Annual Area | Storage Time | Minimum Area Required |
|-------------------------------------------------|--------------------|-------------------------|----------------------------------------|-------------------------------------|---------------------------------|--------------|---------------------|--------------|-----------------------|
|                                                 | % by weight        | tonnes                  | m <sup>3</sup>                         | m <sup>3</sup>                      | m <sup>3</sup>                  | m            | m <sup>2</sup>      | years        | m <sup>2</sup>        |
| <b>Municipal Solid Waste for Disposal</b>       | 43.3               | 20,807                  | 210,176                                | 70,059                              | 2,335                           | 2            | 1,168               | 30           | 35,029                |
| <b>Organic Portion of Municipal Solid Waste</b> | 19.6               | 9,419                   | 95,138                                 | 31,713                              | 1,057                           | 2            | 529                 | 5            | 2,643                 |
| <b>Paper and Paperboard</b>                     | 12.2               | 5,863                   | 59,218                                 | 19,739                              | 658                             | 2            | 329                 | 5            | 1,645                 |
| <b>Cans - recycle depot</b>                     | 4.8                | 2,307                   | 23,299                                 | 4,236                               | 141                             | 2            | 71                  | 1            | 71                    |
| <b>Wood and wood products</b>                   | 2                  | 961                     | 9,708                                  | 9,708                               | 324                             | 2            | 162                 | 5            | 809                   |
| <b>Bulky Waste</b>                              | 15                 | 7,208                   | 72,809                                 | 72,809                              | 2,427                           | 2            | 1,213               | 5            | 6,067                 |
| <b>Hazardous Waste</b>                          | 3.1                | 1,490                   | 4,256                                  | 4,256                               | 142                             | 1            | 142                 | 5            | 709                   |

Note: Municipal solid waste, wood and wood products, and bulky waste assumed to have density of 0.099 tonnes/m<sup>3</sup>; hazardous waste assumed to have density of 0.35 tonnes/m<sup>3</sup>.

**Table 3.8:** 2010 Government of Nunavut agreement and private shipping rates.

| Community Region                       | Carrier | Backhaul Rate (\$) |                      | Dangerous Goods |
|----------------------------------------|---------|--------------------|----------------------|-----------------|
|                                        |         | Revenue Tonne      | 20' Seacan Container | Surcharge       |
| <b>GN Agreement Rate</b>               |         |                    |                      |                 |
| Kitkmeot (Port of Hay River)           | NTCL    | 532                | 7,876                | 25%             |
| High Arctic                            | NEAS    | 266                | 4,098                | 20%             |
| Kivalliq (Port of Saint Catherine, QC) | NSSI    | 250                | 3,855                | 20%             |
| Foxe Basin                             | NSSI    | 250                | 3,855                | 20%             |
| South Baffin                           | NSSI    | 230                | 3,542                | 20%             |
| Iqaluit                                | NSSI    | 250                | 2,963                | 20%             |
| Kivalliq (Port of Churchill, MB)       | NTCL    | 184                | 2,780                | 25%             |
| <b>Private Rate</b>                    |         |                    |                      |                 |
| Kitkmeot (Port of Delta BC)            | NTCL    | 410                | 4,011                | 25%             |
| Kitkmeot (Port of Hay River)           | NTCL    | N/A                | N/A                  | 25%             |
| Kitkmeot (Port of Saint Catherine)     | NSSI    | 297                | 4,581                | 20%             |
| Kitkmeot (Port of Valleyfield)         | NEAS    | 291                | 4,257                | 20%             |
| High Arctic                            | NSSI    | 264                | 4,066                | 20%             |
| High Arctic                            | NEAS    | 258                | 3,967                | 20%             |
| Kivalliq (Port of Saint Catherine, QC) | NEAS    | 244                | 3,756                | 20%             |
| Foxe Basin                             | NEAS    | 244                | 3,756                | 20%             |
| South Baffin                           | NEAS    | 224                | 3,443                | 20%             |
| Iqaluit                                | NEAS    | 186                | 3,443                | 20%             |
| <b>AVERAGE RATE</b>                    |         | <b>274</b>         | <b>4,015</b>         | <b>21%</b>      |

Note: The Government of Nunavut agreed shipping rate are subjected to change upon contract renewal (see SWF Best Practice Guide for more information)

**Table 3.9:** Disposal costs of typical hazardous waste materials

| Hazardous Waste Material          | Unit        | Disposal Company and Region |               |                       |               |                |                            |
|-----------------------------------|-------------|-----------------------------|---------------|-----------------------|---------------|----------------|----------------------------|
|                                   |             | Nunatta Quebec              | Newlta Quebec | Enviro Urgence Quebec | Hazco Alberta | Hazco Winnipeg | Earth Tech / Aecom Alberta |
| <b>Liquids</b>                    |             |                             |               |                       |               |                |                            |
| Waste oil                         | \$ per      | 185-106                     | 73            | 40                    | ---           | ---            | 264                        |
| Solvents                          | \$ per      | 300                         | 95            | 120                   | ---           | ---            | 264                        |
| Antifreeze                        | \$ per      | 225-174                     | 104           | 89                    | ---           | ---            | 264                        |
| Jet Fuel                          | \$ per      | 125                         | 95            | 120                   | ---           | ---            | 264                        |
| Diesel fuel                       | \$ per      | 125                         | 95            | 120                   | ---           | ---            | 264                        |
| <b>AVERAGE</b>                    |             | <b>\$ 160 per drum</b>      |               |                       |               |                |                            |
| <b>Paints</b>                     |             |                             |               |                       |               |                |                            |
| Oil Based Paint                   | \$ per      | ---                         | 149           | 180                   | 102           | 203            | 492                        |
| Latex Paint                       | \$ per      | 494                         | 166           | 159                   | 88            | 165            | 492                        |
| <b>AVERAGE</b>                    |             | <b>\$ 243 per drum</b>      |               |                       |               |                |                            |
| <b>Batteries</b>                  |             |                             |               |                       |               |                |                            |
| Lead Acid/Car                     | \$ per kg   |                             | 0.16          | 0.08                  | 0.20          | 0.45           | ---                        |
| Alkaline Batteries                | \$ per kg   |                             | 2.52          | 2.35                  | 0.82          | 4.40           | ---                        |
| Nickel Metal Hydride              | \$ per kg   | 11.34                       | 0.30          | 2.35                  | 0.82          | 4.40           | ---                        |
| Nickel Cadmium                    | \$ per kg   | 11.34                       | 2.42          | 2.35                  | 0.82          | 4.40           | ---                        |
| Lithium Ion Batteries             | \$ per kg   | 11.34                       | 21.85         | 2.35                  | 2.68          | 26.00          | ---                        |
| <b>AVERAGE</b>                    |             | <b>\$ 5 per kg</b>          |               |                       |               |                |                            |
| <b>Solids</b>                     |             |                             |               |                       |               |                |                            |
| Asbestos                          | \$ per      | ---                         | 100           | 180                   | ---           | ---            | ---                        |
| Potassium Chloride                | \$ per      | ---                         | 688           | 172                   | ---           | ---            | 400                        |
| Potassium Bi Carbonate            | \$ per drum | ---                         | 213           | 172                   | ---           | ---            | 400                        |
| <b>AVERAGE</b>                    |             | <b>\$ 274 per drum</b>      |               |                       |               |                |                            |
| <b>Other</b>                      |             |                             |               |                       |               |                |                            |
| Household Appliances/ Electronics | \$ per unit | ---                         | 13            | 1.81                  | 0.27          | 0.27           | ---                        |

Note: For more information about hazardous waste disposal please refer to SWF Best Practice Guide.

**Table 3.10:** Estimated total annual disposal cost for hazardous waste materials.

| Hazardous Waste | Average Disposal Cost | Cost                 |
|-----------------|-----------------------|----------------------|
| Liquids         | \$160 per drum        | \$31,280 (192 drums) |
| Solids          | \$274 per drum        | \$13,360 (49 drums)  |
| Paints          | \$ 243 per drum       | \$2,963 (12 drums)   |
| Batteries       | \$5 per kg            | \$11,849 (2500 kg)   |
| <b>TOTAL</b>    |                       | <b>\$56,500</b>      |

**Table 3.11:** Summary of revenue from garbage disposal fees.

| Year                     | Project Year | Projected Population | Dwellings | Unit Rate \$/dwelling/year | Total              |
|--------------------------|--------------|----------------------|-----------|----------------------------|--------------------|
| 2011                     | 1            | 1271                 | 353       | \$200                      | \$70,615           |
| 2012                     | 2            | 1288                 | 358       | \$204                      | \$72,984           |
| 2013                     | 3            | 1305                 | 363       | \$208                      | \$75,433           |
| 2014                     | 4            | 1322                 | 367       | \$212                      | \$77,965           |
| 2015                     | 5            | 1340                 | 372       | \$216                      | \$80,588           |
| 2016                     | 6            | 1358                 | 377       | \$221                      | \$83,297           |
| 2017                     | 7            | 1376                 | 382       | \$225                      | \$86,086           |
| 2018                     | 8            | 1394                 | 387       | \$230                      | \$88,959           |
| 2019                     | 9            | 1412                 | 392       | \$234                      | \$91,905           |
| 2020                     | 10           | 1430                 | 397       | \$239                      | \$94,931           |
| 2021                     | 11           | 1448                 | 402       | \$244                      | \$98,035           |
| 2022                     | 12           | 1465                 | 407       | \$249                      | \$101,210          |
| 2023                     | 13           | 1483                 | 412       | \$254                      | \$104,478          |
| 2024                     | 14           | 1500                 | 417       | \$259                      | \$107,814          |
| 2025                     | 15           | 1518                 | 422       | \$264                      | \$111,242          |
| 2026                     | 16           | 1535                 | 426       | \$269                      | \$114,761          |
| 2027                     | 17           | 1552                 | 431       | \$275                      | \$118,385          |
| 2028                     | 18           | 1570                 | 436       | \$280                      | \$122,111          |
| 2029                     | 19           | 1587                 | 441       | \$286                      | \$125,942          |
| 2030                     | 20           | 1605                 | 446       | \$291                      | \$129,880          |
| 2031                     | 21           | 1623                 | 451       | \$297                      | \$133,945          |
| 2032                     | 22           | 1640                 | 456       | \$303                      | \$138,133          |
| 2033                     | 23           | 1659                 | 461       | \$309                      | \$142,461          |
| 2034                     | 24           | 1677                 | 466       | \$315                      | \$146,928          |
| 2035                     | 25           | 1696                 | 471       | \$322                      | \$151,533          |
| 2036                     | 26           | 1715                 | 476       | \$328                      | \$156,296          |
| 2037                     | 27           | 1734                 | 482       | \$335                      | \$161,188          |
| 2038                     | 28           | 1753                 | 487       | \$341                      | \$166,214          |
| 2039                     | 29           | 1772                 | 492       | \$348                      | \$171,376          |
| 2040                     | 30           | 1791                 | 497       | \$355                      | \$176,678          |
| <b>Future Value</b>      |              |                      |           |                            | <b>\$3,501,375</b> |
| <b>Net Present Value</b> |              |                      |           |                            | <b>\$1,725,046</b> |

Note: Assumed 3.6 people/dwelling. Inflation rate set at 2% based on Canadian November 2010 value.

**Table 3.12:** Summary of capital costs for waste management Approach #1.

| Description                                    | Unit           | Quantity                            | Unit Rate   | Total              |
|------------------------------------------------|----------------|-------------------------------------|-------------|--------------------|
| <b>General Requirements &amp; Mobilization</b> |                | 10% of Site Works and Closure Costs |             | <b>\$668,483</b>   |
| <b>Site Works</b>                              |                |                                     |             | <b>\$3,328,233</b> |
| Site Preparation                               | m <sup>2</sup> | 207,530                             | \$2.50      | \$518,825          |
| Solid Waste Disposal Cell                      | m <sup>3</sup> | 37,863                              | \$44.00     | \$1,672,872        |
| Bulky Waste Disposal Cell                      | m <sup>2</sup> | 8,053                               | \$15.00     | \$357,836          |
| Hazardous Material Cell                        | m <sup>2</sup> | 2,500                               | \$100.00    | \$250,000          |
| Burning Pit                                    | m <sup>2</sup> | 900                                 | \$10.00     | \$9,000            |
| Access Road within SWF                         | m              | 2,029                               | \$20.00     | \$40,600           |
| Discharge Ditch around SWF                     | m              | 1,831                               | \$50.00     | \$91,600           |
| Perimeter Chain Link Fence                     | m              | 1,831                               | \$175.00    | \$320,500          |
| Vehicle Double Gate                            | Lump sum       | 1                                   | \$25,000.00 | \$25,000           |
| Man Gate                                       | Lump sum       | 1                                   | \$2,000.00  | \$2,000            |
| Signage                                        | Lump sum       | 1                                   | \$40,000.00 | \$40,000           |
| <b>Closure Costs</b>                           |                |                                     |             | <b>\$3,356,600</b> |
| Site Preparation/Grading                       | m <sup>2</sup> | 134,184                             | \$2.50      | \$335,460          |
| Soil cover                                     | m <sup>3</sup> | 67,092                              | \$45.00     | \$3,019,140        |
| Signage                                        | Lump sum       | 1                                   | \$2,000.00  | \$2,000            |
| <b>Contingency</b>                             |                | 20% of Capital Costs                |             | <b>\$1,470,663</b> |
| <b>Engineering</b>                             |                | 10% of Capital Costs                |             | <b>\$735,332</b>   |
| <b>Total Capital Costs</b>                     |                |                                     |             | <b>\$9,559,311</b> |



Table 3.13: Summary of O&M costs for waste management Approach #1.

| Year                    | Project Year | 3.13<br>Garbage truck |           |           | Fuel<br>Gas, liters |           |           | Labour<br>Operator |           |             | Hazardous Waste<br>Sea can |           |           | Hazardous Waste<br>Disposal Fee |           |             | O&M+Misc<br>Vehicle (5%) + SWF site (0.5%) |           |             | Total        |
|-------------------------|--------------|-----------------------|-----------|-----------|---------------------|-----------|-----------|--------------------|-----------|-------------|----------------------------|-----------|-----------|---------------------------------|-----------|-------------|--------------------------------------------|-----------|-------------|--------------|
|                         |              | Unit                  | Unit Rate | Subtotal  | Unit                | Unit Rate | Subtotal  | Unit               | Unit Rate | Subtotal    | Unit                       | Unit Rate | Subtotal  | Unit                            | Unit Rate | Subtotal    | Unit                                       | Unit Rate | Subtotal    |              |
| 2011                    | 1            | 1                     | \$100,000 | \$100,000 | 10,000              | \$1.20    | \$12,000  | 2                  | \$66,000  | \$132,000   | 2                          | \$7,500   | \$15,000  | 1                               | \$56,500  | \$56,500    | 1                                          | \$52,797  | \$52,797    | \$368,297    |
| 2012                    | 2            |                       |           | \$0       | 10,000              | \$1.22    | \$12,200  | 2                  | \$67,320  | \$134,640   | 2                          | \$7,650   | \$15,300  | 1                               | \$57,630  | \$57,630    | 1                                          | \$47,797  | \$47,797    | \$267,567    |
| 2013                    | 3            |                       |           | \$0       | 10,000              | \$1.25    | \$12,500  | 2                  | \$68,666  | \$137,333   | 2                          | \$7,803   | \$15,606  | 1                               | \$58,783  | \$58,783    | 1                                          | \$47,797  | \$47,797    | \$272,018    |
| 2014                    | 4            |                       |           | \$0       | 10,000              | \$1.27    | \$12,700  | 2                  | \$70,040  | \$140,079   | 2                          | \$7,959   | \$15,918  | 1                               | \$59,958  | \$59,958    | 1                                          | \$47,797  | \$47,797    | \$276,452    |
| 2015                    | 5            |                       |           | \$0       | 10,000              | \$1.30    | \$13,000  | 2                  | \$71,441  | \$142,881   | 2                          | \$8,118   | \$16,236  | 1                               | \$61,157  | \$61,157    | 1                                          | \$47,797  | \$47,797    | \$281,072    |
| 2016                    | 6            |                       |           | \$0       | 10,000              | \$1.32    | \$13,200  | 2                  | \$72,869  | \$145,739   | 2                          | \$8,281   | \$16,561  | 1                               | \$62,381  | \$62,381    | 1                                          | \$47,797  | \$47,797    | \$285,677    |
| 2017                    | 7            |                       |           | \$0       | 10,000              | \$1.35    | \$13,500  | 2                  | \$74,327  | \$148,653   | 2                          | \$8,446   | \$16,892  | 1                               | \$63,628  | \$63,628    | 1                                          | \$47,797  | \$47,797    | \$290,471    |
| 2018                    | 8            |                       |           | \$0       | 10,000              | \$1.38    | \$13,800  | 2                  | \$75,813  | \$151,627   | 2                          | \$8,615   | \$17,230  | 1                               | \$64,901  | \$64,901    | 1                                          | \$47,797  | \$47,797    | \$295,354    |
| 2019                    | 9            |                       |           | \$0       | 10,000              | \$1.41    | \$14,100  | 2                  | \$77,330  | \$154,659   | 2                          | \$8,787   | \$17,575  | 1                               | \$66,199  | \$66,199    | 1                                          | \$47,797  | \$47,797    | \$300,329    |
| 2020                    | 10           | 1                     | \$119,509 | \$119,509 | 10,000              | \$1.43    | \$14,300  | 2                  | \$78,876  | \$157,752   | 2                          | \$8,963   | \$17,926  | 1                               | \$67,523  | \$67,523    | 1                                          | \$53,772  | \$53,772    | \$430,783    |
| 2021                    | 11           |                       |           | \$0       | 10,000              | \$1.46    | \$14,600  | 2                  | \$80,454  | \$160,907   | 2                          | \$9,142   | \$18,285  | 1                               | \$68,873  | \$68,873    | 1                                          | \$47,797  | \$47,797    | \$310,462    |
| 2022                    | 12           |                       |           | \$0       | 10,000              | \$1.49    | \$14,900  | 2                  | \$82,063  | \$164,125   | 2                          | \$9,325   | \$18,651  | 1                               | \$70,251  | \$70,251    | 1                                          | \$47,797  | \$47,797    | \$315,723    |
| 2023                    | 13           |                       |           | \$0       | 10,000              | \$1.52    | \$15,200  | 2                  | \$83,704  | \$167,408   | 2                          | \$9,512   | \$19,024  | 1                               | \$71,656  | \$71,656    | 1                                          | \$47,797  | \$47,797    | \$321,084    |
| 2024                    | 14           |                       |           | \$0       | 10,000              | \$1.55    | \$15,500  | 2                  | \$85,378  | \$170,756   | 2                          | \$9,702   | \$19,404  | 1                               | \$73,089  | \$73,089    | 1                                          | \$47,797  | \$47,797    | \$326,546    |
| 2025                    | 15           |                       |           | \$0       | 10,000              | \$1.58    | \$15,800  | 2                  | \$87,086  | \$174,171   | 2                          | \$9,896   | \$19,792  | 1                               | \$74,551  | \$74,551    | 1                                          | \$47,797  | \$47,797    | \$332,110    |
| 2026                    | 16           |                       |           | \$0       | 10,000              | \$1.62    | \$16,200  | 2                  | \$88,827  | \$177,655   | 2                          | \$10,094  | \$20,188  | 1                               | \$76,042  | \$76,042    | 1                                          | \$47,797  | \$47,797    | \$337,881    |
| 2027                    | 17           |                       |           | \$0       | 10,000              | \$1.65    | \$16,500  | 2                  | \$90,604  | \$181,208   | 2                          | \$10,296  | \$20,592  | 1                               | \$77,562  | \$77,562    | 1                                          | \$47,797  | \$47,797    | \$343,658    |
| 2028                    | 18           |                       |           | \$0       | 10,000              | \$1.68    | \$16,800  | 2                  | \$92,416  | \$184,832   | 2                          | \$10,502  | \$21,004  | 1                               | \$79,114  | \$79,114    | 1                                          | \$47,797  | \$47,797    | \$349,546    |
| 2029                    | 19           |                       |           | \$0       | 10,000              | \$1.71    | \$17,100  | 2                  | \$94,264  | \$188,529   | 2                          | \$10,712  | \$21,424  | 1                               | \$80,696  | \$80,696    | 1                                          | \$47,797  | \$47,797    | \$355,545    |
| 2030                    | 20           | 1                     | \$145,681 | \$145,681 | 10,000              | \$1.75    | \$17,500  | 2                  | \$96,150  | \$192,299   | 2                          | \$10,926  | \$21,852  | 1                               | \$82,310  | \$82,310    | 1                                          | \$55,081  | \$55,081    | \$514,723    |
| 2031                    | 21           |                       |           | \$0       | 10,000              | \$1.78    | \$17,800  | 2                  | \$98,073  | \$196,145   | 2                          | \$11,145  | \$22,289  | 1                               | \$83,956  | \$83,956    | 1                                          | \$47,797  | \$47,797    | \$367,987    |
| 2032                    | 22           |                       |           | \$0       | 10,000              | \$1.82    | \$18,200  | 2                  | \$100,034 | \$200,068   | 2                          | \$11,367  | \$22,735  | 1                               | \$85,635  | \$85,635    | 1                                          | \$47,797  | \$47,797    | \$374,435    |
| 2033                    | 23           |                       |           | \$0       | 10,000              | \$1.86    | \$18,600  | 2                  | \$102,035 | \$204,069   | 2                          | \$11,595  | \$23,190  | 1                               | \$87,348  | \$87,348    | 1                                          | \$47,797  | \$47,797    | \$381,003    |
| 2034                    | 24           |                       |           | \$0       | 10,000              | \$1.89    | \$18,900  | 2                  | \$104,075 | \$208,151   | 2                          | \$11,827  | \$23,653  | 1                               | \$89,095  | \$89,095    | 1                                          | \$47,797  | \$47,797    | \$387,596    |
| 2035                    | 25           |                       |           | \$0       | 10,000              | \$1.93    | \$19,300  | 2                  | \$106,157 | \$212,314   | 2                          | \$12,063  | \$24,127  | 1                               | \$90,877  | \$90,877    | 1                                          | \$47,797  | \$47,797    | \$394,414    |
| 2036                    | 26           |                       |           | \$0       | 10,000              | \$1.97    | \$19,700  | 2                  | \$108,280 | \$216,560   | 2                          | \$12,305  | \$24,609  | 1                               | \$92,694  | \$92,694    | 1                                          | \$47,797  | \$47,797    | \$401,360    |
| 2037                    | 27           |                       |           | \$0       | 10,000              | \$2.01    | \$20,100  | 2                  | \$110,446 | \$220,891   | 2                          | \$12,551  | \$25,101  | 1                               | \$94,548  | \$94,548    | 1                                          | \$47,797  | \$47,797    | \$408,437    |
| 2038                    | 28           |                       |           | \$0       | 10,000              | \$2.05    | \$20,500  | 2                  | \$112,655 | \$225,309   | 2                          | \$12,802  | \$25,603  | 1                               | \$96,439  | \$96,439    | 1                                          | \$47,797  | \$47,797    | \$415,648    |
| 2039                    | 29           |                       |           | \$0       | 10,000              | \$2.09    | \$20,900  | 2                  | \$114,908 | \$229,815   | 2                          | \$13,058  | \$26,115  | 1                               | \$98,368  | \$98,368    | 1                                          | \$47,797  | \$47,797    | \$422,995    |
| 2040                    | 30           |                       |           | \$0       | 10,000              | \$2.13    | \$21,300  | 2                  | \$117,206 | \$234,411   | 2                          | \$13,319  | \$26,638  | 1                               | \$100,335 | \$100,335   | 1                                          | \$47,797  | \$47,797    | \$430,481    |
| Future Value            |              |                       |           | \$365,190 |                     |           | \$486,700 |                    |           | \$5,354,986 |                            |           | \$608,521 |                                 |           | \$2,292,096 |                                            |           | \$1,452,156 | \$10,559,651 |
| Net Present Value (NPV) |              |                       |           | \$238,148 |                     |           | \$249,711 |                    |           | \$2,748,050 |                            |           | \$312,278 |                                 |           | \$1,176,249 |                                            |           | \$799,796   | \$5,524,232  |

**Table 3.14:** Average costs for acquiring and operating a thermal facility.

| Supplier            | Capital Cost       | Fuel (liter/year) | Labour           | Maintenance     |
|---------------------|--------------------|-------------------|------------------|-----------------|
| Res/Op              | \$7,490,000        | 12,800            | 2 hrs/day        | \$50,000        |
| Senreq              | \$1,600,000        | 360,800           | 1 hrs/day        | \$25,000        |
| Eco Waste Solutions | \$850,000          | 210,600           | 2 hrs/day        | \$41,750        |
| WestLand            | \$4,500,000        | 120,000           | 3 hrs/day        | \$35,000        |
| <b>Average</b>      | <b>\$3,610,000</b> | <b>176,100</b>    | <b>2 hrs/day</b> | <b>\$37,900</b> |

**Table 3.15:** Summary of capital costs for waste management Approach #2.

| Description                                    | Unit           | Quantity                            | Unit Rate   | Total               |
|------------------------------------------------|----------------|-------------------------------------|-------------|---------------------|
| <b>General Requirements &amp; Mobilization</b> |                | 10% of Site Works and Closure Costs |             | <b>\$849,399</b>    |
| <b>Site Works</b>                              |                |                                     |             | <b>\$2,676,341</b>  |
| Site Preparation                               | m <sup>2</sup> | 131,573                             | \$2.50      | \$328,933           |
| Solid Waste Disposal Cell                      | m <sup>3</sup> | 11,796                              | \$44.00     | \$522,480           |
| Thermal Destruction Residual Cell              | m <sup>3</sup> | 16,617                              | \$44.00     | \$734,592           |
| Bulky Waste Disposal Cell                      | m <sup>3</sup> | 8,053                               | \$15.00     | \$357,836           |
| Hazardous Material Cell                        | m <sup>2</sup> | 2,500                               | \$100.00    | \$250,000           |
| Burning Pit                                    | m <sup>2</sup> | 900                                 | \$10.00     | \$9,000             |
| Access Road within SWF                         | m              | 1,723                               | \$20.00     | \$34,500            |
| Discharge Ditch around SWF                     | m              | 1,573                               | \$50.00     | \$78,700            |
| Perimeter Chain Link Fence                     | m              | 1,676                               | \$175.00    | \$293,300           |
| Vehicle Double Gate                            | Lump sum       | 1                                   | \$25,000.00 | \$25,000            |
| Man Gate                                       | Lump sum       | 1                                   | \$2,000.00  | \$2,000             |
| Signage                                        | Lump sum       | 1                                   | \$40,000.00 | \$40,000            |
| <b>Equipment</b>                               |                |                                     |             | <b>\$3,822,300</b>  |
| Thermal Destruction Unit                       | Lump sum       | 1                                   | \$2,022,300 | \$2,022,300         |
| Building                                       | m <sup>2</sup> | 600                                 | \$3,000.00  | \$1,800,000         |
| <b>Closure Costs</b>                           |                |                                     |             | <b>\$1,995,350</b>  |
| Site Preparation/Grading                       | m <sup>2</sup> | 54,539                              | \$2.50      | \$199,335           |
| Soil cover                                     | m <sup>3</sup> | 38,517                              | \$45.00     | \$1,794,015         |
| Signage                                        | Lump sum       | 1                                   | \$2,000.00  | 2,000               |
| <b>Contingency</b>                             |                | 20% of Capital Costs                |             | <b>\$1,868,678</b>  |
| <b>Engineering</b>                             |                | 10% of Capital Costs                |             | <b>\$934,339</b>    |
| <b>Total Capital Costs</b>                     |                |                                     |             | <b>\$12,146,407</b> |



Table 3.16: Summary of O&M costs for waste management Approach #2.

| Year                    | Project Year | Mobile Equipment |           |           | Fuel        |           |          | Thermal facility |           |           | Labour   |              |           | Hazardous Waste |           |             | Hazardous Waste |           |          | O&M+Misc                                            |           |           | Total     |             |  |  |  |             |              |
|-------------------------|--------------|------------------|-----------|-----------|-------------|-----------|----------|------------------|-----------|-----------|----------|--------------|-----------|-----------------|-----------|-------------|-----------------|-----------|----------|-----------------------------------------------------|-----------|-----------|-----------|-------------|--|--|--|-------------|--------------|
|                         |              | Garbage truck    |           |           | Gas, liters |           |          | Fuel, liter      |           |           | Operator |              |           | Sea can         |           |             | Disposal Fee    |           |          | Vehicle (5%) + SWF site (0.5%)+Thermal Facility O&M |           |           |           |             |  |  |  |             |              |
|                         |              | Unit             | Unit Rate | Subtotal  | Unit        | Unit Rate | Subtotal | Unit             | Unit Rate | Subtotal  | Unit     | Unit Rate    | Subtotal  | Unit            | Unit Rate | Subtotal    | Unit            | Unit Rate | Subtotal | Unit                                                | Unit Rate | Subtotal  |           |             |  |  |  |             |              |
| 2011                    | 1            | 1                | \$100,000 | \$100,000 | 10,000      | \$1.20    | \$12,000 | 210,600          | \$1.20    | \$252,720 | 2.2      | \$66,000     | \$145,200 | 1               | \$7,500   | \$7,500     | 1               | \$28,300  | \$28,300 | 1                                                   | \$107,482 | \$107,482 | \$653,202 |             |  |  |  |             |              |
| 2012                    | 2            |                  |           | \$0       | 10,000      | \$1.22    | \$12,240 | 210,600          | \$1.22    | \$257,800 | 2.2      | \$67,320     | \$148,104 | 1               | \$7,650   | \$7,650     | 1               | \$28,866  | \$28,866 | 1                                                   | \$103,317 | \$103,317 | \$557,977 |             |  |  |  |             |              |
| 2013                    | 3            |                  |           | \$0       | 10,000      | \$1.25    | \$12,485 | 210,600          | \$1.25    | \$262,900 | 2.2      | \$68,666     | \$151,066 | 1               | \$7,803   | \$7,803     | 1               | \$29,443  | \$29,443 | 1                                                   | \$43,437  | \$43,437  | \$507,134 |             |  |  |  |             |              |
| 2014                    | 4            |                  |           | \$0       | 10,000      | \$1.27    | \$12,734 | 210,600          | \$1.27    | \$268,200 | 2.2      | \$70,040     | \$154,087 | 1               | \$7,959   | \$7,959     | 1               | \$30,032  | \$30,032 | 1                                                   | \$44,305  | \$44,305  | \$517,319 |             |  |  |  |             |              |
| 2015                    | 5            |                  |           | \$0       | 10,000      | \$1.30    | \$12,989 | 210,600          | \$1.30    | \$273,600 | 2.2      | \$71,441     | \$157,169 | 1               | \$8,118   | \$8,118     | 1               | \$30,633  | \$30,633 | 1                                                   | \$45,192  | \$45,192  | \$527,701 |             |  |  |  |             |              |
| 2016                    | 6            |                  |           | \$0       | 10,000      | \$1.32    | \$13,249 | 210,600          | \$1.32    | \$279,000 | 2.2      | \$72,869     | \$160,313 | 1               | \$8,281   | \$8,281     | 1               | \$31,245  | \$31,245 | 1                                                   | \$46,095  | \$46,095  | \$538,183 |             |  |  |  |             |              |
| 2017                    | 7            |                  |           | \$0       | 10,000      | \$1.35    | \$13,514 | 210,600          | \$1.35    | \$284,600 | 2.2      | \$74,327     | \$163,519 | 1               | \$8,446   | \$8,446     | 1               | \$31,870  | \$31,870 | 1                                                   | \$47,017  | \$47,017  | \$548,967 |             |  |  |  |             |              |
| 2018                    | 8            |                  |           | \$0       | 10,000      | \$1.38    | \$13,784 | 210,600          | \$1.38    | \$290,300 | 2.2      | \$75,813     | \$166,789 | 1               | \$8,615   | \$8,615     | 1               | \$32,508  | \$32,508 | 1                                                   | \$47,958  | \$47,958  | \$559,954 |             |  |  |  |             |              |
| 2019                    | 9            |                  |           | \$0       | 10,000      | \$1.41    | \$14,060 | 210,600          | \$1.41    | \$296,100 | 2.2      | \$77,330     | \$170,125 | 1               | \$8,787   | \$8,787     | 1               | \$33,158  | \$33,158 | 1                                                   | \$55,202  | \$55,202  | \$577,432 |             |  |  |  |             |              |
| 2020                    | 10           | 1                | \$119,509 | \$119,509 | 10,000      | \$1.43    | \$14,341 | 210,600          | \$1.43    | \$302,000 | 2.2      | \$78,876     | \$173,527 | 1               | \$8,963   | \$8,963     | 1               | \$33,821  | \$33,821 | 1                                                   | \$55,871  | \$55,871  | \$708,033 |             |  |  |  |             |              |
| 2021                    | 11           |                  |           | \$0       | 10,000      | \$1.46    | \$14,628 | 210,600          | \$1.46    | \$308,100 | 2.2      | \$80,454     | \$176,998 | 1               | \$9,142   | \$9,142     | 1               | \$34,498  | \$34,498 | 1                                                   | \$50,893  | \$50,893  | \$594,259 |             |  |  |  |             |              |
| 2022                    | 12           |                  |           | \$0       | 10,000      | \$1.49    | \$14,920 | 210,600          | \$1.49    | \$314,200 | 2.2      | \$82,063     | \$180,538 | 1               | \$9,325   | \$9,325     | 1               | \$35,187  | \$35,187 | 1                                                   | \$51,911  | \$51,911  | \$606,082 |             |  |  |  |             |              |
| 2023                    | 13           |                  |           | \$0       | 10,000      | \$1.52    | \$15,219 | 210,600          | \$1.52    | \$320,500 | 2.2      | \$83,704     | \$184,149 | 1               | \$9,512   | \$9,512     | 1               | \$35,891  | \$35,891 | 1                                                   | \$52,949  | \$52,949  | \$618,220 |             |  |  |  |             |              |
| 2024                    | 14           |                  |           | \$0       | 10,000      | \$1.55    | \$15,523 | 210,600          | \$1.55    | \$326,900 | 2.2      | \$85,378     | \$187,832 | 1               | \$9,702   | \$9,702     | 1               | \$36,609  | \$36,609 | 1                                                   | \$54,008  | \$54,008  | \$630,574 |             |  |  |  |             |              |
| 2025                    | 15           |                  |           | \$0       | 10,000      | \$1.58    | \$15,834 | 210,600          | \$1.58    | \$333,500 | 2.2      | \$87,086     | \$191,588 | 1               | \$9,896   | \$9,896     | 1               | \$37,341  | \$37,341 | 1                                                   | \$55,088  | \$55,088  | \$643,248 |             |  |  |  |             |              |
| 2026                    | 16           |                  |           | \$0       | 10,000      | \$1.62    | \$16,150 | 210,600          | \$1.62    | \$340,100 | 2.2      | \$88,827     | \$195,420 | 1               | \$10,094  | \$10,094    | 1               | \$38,088  | \$38,088 | 1                                                   | \$56,190  | \$56,190  | \$656,043 |             |  |  |  |             |              |
| 2027                    | 17           |                  |           | \$0       | 10,000      | \$1.65    | \$16,473 | 210,600          | \$1.65    | \$346,900 | 2.2      | \$90,604     | \$199,328 | 1               | \$10,296  | \$10,296    | 1               | \$38,850  | \$38,850 | 1                                                   | \$57,314  | \$57,314  | \$669,161 |             |  |  |  |             |              |
| 2028                    | 18           |                  |           | \$0       | 10,000      | \$1.68    | \$16,803 | 210,600          | \$1.68    | \$353,900 | 2.2      | \$92,416     | \$203,315 | 1               | \$10,502  | \$10,502    | 1               | \$39,627  | \$39,627 | 1                                                   | \$58,460  | \$58,460  | \$682,607 |             |  |  |  |             |              |
| 2029                    | 19           |                  |           | \$0       | 10,000      | \$1.71    | \$17,139 | 210,600          | \$1.71    | \$360,900 | 2.2      | \$94,264     | \$207,381 | 1               | \$10,712  | \$10,712    | 1               | \$40,419  | \$40,419 | 1                                                   | \$59,629  | \$59,629  | \$696,181 |             |  |  |  |             |              |
| 2030                    | 20           | 1                | \$145,681 | \$145,681 | 10,000      | \$1.75    | \$17,482 | 210,600          | \$1.75    | \$368,200 | 2.2      | \$96,150     | \$211,529 | 1               | \$10,926  | \$10,926    | 1               | \$41,228  | \$41,228 | 1                                                   | \$68,106  | \$68,106  | \$863,152 |             |  |  |  |             |              |
| 2031                    | 21           |                  |           | \$0       | 10,000      | \$1.78    | \$17,831 | 210,600          | \$1.78    | \$375,500 | 2.2      | \$98,073     | \$215,760 | 1               | \$11,145  | \$11,145    | 1               | \$42,052  | \$42,052 | 1                                                   | \$62,038  | \$62,038  | \$724,326 |             |  |  |  |             |              |
| 2032                    | 22           |                  |           | \$0       | 10,000      | \$1.82    | \$18,188 | 210,600          | \$1.82    | \$383,000 | 2.2      | \$100,034    | \$220,075 | 1               | \$11,367  | \$11,367    | 1               | \$42,893  | \$42,893 | 1                                                   | \$63,279  | \$63,279  | \$738,803 |             |  |  |  |             |              |
| 2033                    | 23           |                  |           | \$0       | 10,000      | \$1.86    | \$18,552 | 210,600          | \$1.86    | \$390,700 | 2.2      | \$102,035    | \$224,476 | 1               | \$11,595  | \$11,595    | 1               | \$43,751  | \$43,751 | 1                                                   | \$64,545  | \$64,545  | \$753,619 |             |  |  |  |             |              |
| 2034                    | 24           |                  |           | \$0       | 10,000      | \$1.89    | \$18,923 | 210,600          | \$1.89    | \$398,500 | 2.2      | \$104,075    | \$228,966 | 1               | \$11,827  | \$11,827    | 1               | \$44,626  | \$44,626 | 1                                                   | \$65,836  | \$65,836  | \$768,677 |             |  |  |  |             |              |
| 2035                    | 25           |                  |           | \$0       | 10,000      | \$1.93    | \$19,301 | 210,600          | \$1.93    | \$406,500 | 2.2      | \$106,157    | \$233,545 | 1               | \$12,063  | \$12,063    | 1               | \$45,519  | \$45,519 | 1                                                   | \$67,152  | \$67,152  | \$784,081 |             |  |  |  |             |              |
| 2036                    | 26           |                  |           | \$0       | 10,000      | \$1.97    | \$19,687 | 210,600          | \$1.97    | \$414,600 | 2.2      | \$108,280    | \$238,216 | 1               | \$12,305  | \$12,305    | 1               | \$46,429  | \$46,429 | 1                                                   | \$68,495  | \$68,495  | \$799,732 |             |  |  |  |             |              |
| 2037                    | 27           |                  |           | \$0       | 10,000      | \$2.01    | \$20,081 | 210,600          | \$2.01    | \$422,900 | 2.2      | \$110,446    | \$242,980 | 1               | \$12,551  | \$12,551    | 1               | \$47,358  | \$47,358 | 1                                                   | \$69,865  | \$69,865  | \$815,735 |             |  |  |  |             |              |
| 2038                    | 28           |                  |           | \$0       | 10,000      | \$2.05    | \$20,483 | 210,600          | \$2.05    | \$431,400 | 2.2      | \$112,655    | \$247,840 | 1               | \$12,802  | \$12,802    | 1               | \$48,305  | \$48,305 | 1                                                   | \$71,263  | \$71,263  | \$832,092 |             |  |  |  |             |              |
| 2039                    | 29           |                  |           | \$0       | 10,000      | \$2.09    | \$20,892 | 210,600          | \$2.09    | \$440,000 | 2.2      | \$114,908    | \$252,797 | 1               | \$13,058  | \$13,058    | 1               | \$49,271  | \$49,271 | 1                                                   | \$72,688  | \$72,688  | \$848,705 |             |  |  |  |             |              |
| 2040                    | 30           |                  |           | \$0       | 10,000      | \$2.13    | \$21,310 | 210,600          | \$2.13    | \$448,800 | 2.2      | \$117,206    | \$257,853 | 1               | \$13,319  | \$13,319    | 1               | \$50,256  | \$50,256 | 1                                                   | \$74,142  | \$74,142  | \$865,680 |             |  |  |  |             |              |
| Future Value            |              |                  |           | \$365,190 |             |           |          | \$486,817        |           |           |          | \$10,252,320 |           |                 |           | \$5,890,485 |                 |           |          | \$304,261                                           |           |           |           | \$1,148,077 |  |  |  | \$1,839,726 | \$20,286,876 |
| Net Present Value (NPV) |              |                  |           | \$238,148 |             |           |          | \$249,823        |           |           |          | \$5,261,253  |           |                 |           | \$3,022,855 |                 |           |          | \$156,139                                           |           |           |           | \$589,165   |  |  |  | \$1,004,084 | \$10,521,467 |

**Table 3.17:** Summary of capital costs for waste management Approach #3.

| Description                                    | Unit           | Quantity                            | Unit Rate      | Total              |
|------------------------------------------------|----------------|-------------------------------------|----------------|--------------------|
| <b>General Requirements &amp; Mobilization</b> |                | 10% of Site Works and Closure Costs |                | <b>\$652,393</b>   |
| <b>Site Works</b>                              |                |                                     |                | <b>\$2,891,680</b> |
| Site Preparation                               | m <sup>2</sup> | 152,457                             | \$2.50         | \$381,143          |
| Solid Waste Disposal Cell                      | m <sup>3</sup> | 32,823                              | \$44.00        | \$1,451,111        |
| Compost Pad                                    | m <sup>3</sup> | 7,476                               | \$45.00        | \$131,363          |
| Bulky Waste Disposal Cell                      | m <sup>3</sup> | 2,945                               | \$15.00        | \$201,063          |
| Hazardous Material Cell                        | m <sup>2</sup> | 2,500                               | \$100.00       | \$250,000          |
| Burning Pit                                    | m <sup>2</sup> | 900                                 | \$10.00        | \$9,000            |
| Access Road within SWF                         | m              | 1,869                               | \$20.00        | \$37,400           |
| Discharge Ditch around SWF                     | m              | 1,616                               | \$50.00        | \$80,800           |
| Perimeter Chain Link Fence                     | m              | 1,616                               | \$175.00       | \$282,800          |
| Vehicle Double Gate                            | Lump sum       | 1                                   | \$25,000.00    | \$25,000           |
| Man Gate                                       | Lump sum       | 1                                   | \$2,000.00     | \$2,000            |
| Signage                                        | Lump sum       | 1                                   | \$40,000.00    | \$40,000           |
| <b>Equipment</b>                               |                |                                     |                | <b>\$1,317,000</b> |
| Recycling Depot Facility                       | Lump sum       | 1                                   | \$1,300,000.00 | \$1,300,000        |
| Composting Crusher                             | Lump sum       | 1                                   | \$10,000.00    | \$10,000           |
| Waste Oil Burner                               | Lump sum       | 1                                   | \$7,000.00     | \$7,000            |
| <b>Closure Costs</b>                           |                |                                     |                | <b>\$2,315,248</b> |
| Site Preparation/Grading                       | m <sup>2</sup> | 62,426                              | \$2.50         | 231,325            |
| Soil cover                                     | m <sup>3</sup> | 45,015                              | \$45.00        | 2,081,923          |
| Signage                                        | Lump sum       | 1                                   | \$2,000.00     | 2,000              |
| <b>Contingency</b>                             |                | 20% of Capital Costs                |                | <b>\$1,435,264</b> |
| <b>Engineering</b>                             |                | 10% of Capital Costs                |                | <b>\$717,632</b>   |
| <b>Total Capital Costs</b>                     |                |                                     |                | <b>\$9,329,217</b> |



Table 3.18: Summary of O&M costs for waste management Approach #3.

| Year              |    | Equipment               |           |           | Fuel        |           |           | Labour   |           |             | Recycling |           |             | Scrap Metal |           |             | Hazardous Waste |           |           | Hazardous Waste |           |             | O&M+Misc                                                        |           |             | Total        |
|-------------------|----|-------------------------|-----------|-----------|-------------|-----------|-----------|----------|-----------|-------------|-----------|-----------|-------------|-------------|-----------|-------------|-----------------|-----------|-----------|-----------------|-----------|-------------|-----------------------------------------------------------------|-----------|-------------|--------------|
|                   |    | Garbage truck + crusher |           |           | Gas, liters |           |           | Operator |           |             | O&M       |           |             | Shipping    |           |             | Sea can         |           |           | Disposal Fee    |           |             | Vehicle (5%) + SWF site<br>(0.5%) + Compost Equipment<br>Rental |           |             |              |
|                   |    | Unit                    | Unit Rate | Subtotal  | Unit        | Unit Rate | Subtotal  | Unit     | Unit Rate | Subtotal    | Unit      | Unit Rate | Subtotal    | Sea cans    | Unit Rate | Subtotal    | Unit            | Unit Rate | Subtotal  | Unit            | Unit Rate | Subtotal    | Unit                                                            | Unit Rate | Subtotal    |              |
| 2011              | 1  | 1                       | \$100,000 | \$100,000 | 12000       | \$1.20    | \$14,400  | 2.9      | \$66,000  | \$191,400   | 1         | \$36,800  | \$36,800    | 7           | \$6,500   | \$45,500    | 1               | \$7,500   | \$7,500   | 1               | \$28,300  | \$28,300    | 1                                                               | \$73,246  | \$73,246    | \$497,146    |
| 2012              | 2  |                         |           | \$0       | 12000       | \$1.22    | \$14,700  | 2.9      | \$67,320  | \$195,228   | 1         | \$37,536  | \$37,536    | 7           | \$6,630   | \$46,410    | 1               | \$7,650   | \$7,650   | 1               | \$28,866  | \$28,866    | 1                                                               | \$68,678  | \$68,678    | \$399,068    |
| 2013              | 3  |                         |           | \$0       | 12000       | \$1.25    | \$15,000  | 2.9      | \$68,666  | \$199,133   | 1         | \$38,287  | \$38,287    | 7           | \$6,763   | \$47,338    | 1               | \$7,803   | \$7,803   | 1               | \$29,443  | \$29,443    | 1                                                               | \$69,119  | \$69,119    | \$406,123    |
| 2014              | 4  |                         |           | \$0       | 12000       | \$1.27    | \$15,300  | 2.9      | \$70,040  | \$203,115   | 1         | \$39,052  | \$39,052    | 7           | \$6,898   | \$48,285    | 1               | \$7,959   | \$7,959   | 1               | \$30,032  | \$30,032    | 1                                                               | \$69,568  | \$69,568    | \$413,312    |
| 2015              | 5  |                         |           | \$0       | 12000       | \$1.30    | \$15,600  | 2.9      | \$71,441  | \$207,178   | 1         | \$39,834  | \$39,834    | 7           | \$7,036   | \$49,251    | 1               | \$8,118   | \$8,118   | 1               | \$30,633  | \$30,633    | 1                                                               | \$70,027  | \$70,027    | \$420,639    |
| 2016              | 6  |                         |           | \$0       | 12000       | \$1.32    | \$15,900  | 2.9      | \$72,869  | \$211,321   | 1         | \$40,630  | \$40,630    | 7           | \$7,177   | \$50,236    | 1               | \$8,281   | \$8,281   | 1               | \$31,245  | \$31,245    | 1                                                               | \$70,494  | \$70,494    | \$428,107    |
| 2017              | 7  |                         |           | \$0       | 12000       | \$1.35    | \$16,200  | 2.9      | \$74,327  | \$215,547   | 1         | \$41,443  | \$41,443    | 7           | \$7,320   | \$51,240    | 1               | \$8,446   | \$8,446   | 1               | \$31,870  | \$31,870    | 1                                                               | \$70,971  | \$70,971    | \$435,718    |
| 2018              | 8  |                         |           | \$0       | 12000       | \$1.38    | \$16,500  | 2.9      | \$75,813  | \$219,858   | 1         | \$42,272  | \$42,272    | 7           | \$7,466   | \$52,265    | 1               | \$8,615   | \$8,615   | 1               | \$32,508  | \$32,508    | 1                                                               | \$71,458  | \$71,458    | \$443,476    |
| 2019              | 9  |                         |           | \$0       | 12000       | \$1.41    | \$16,900  | 2.9      | \$77,330  | \$224,256   | 1         | \$43,117  | \$43,117    | 7           | \$7,616   | \$53,311    | 1               | \$8,787   | \$8,787   | 1               | \$33,158  | \$33,158    | 1                                                               | \$71,954  | \$71,954    | \$451,483    |
| 2020              | 10 | 1                       | \$119,509 | \$119,509 | 12000       | \$1.43    | \$17,200  | 2.9      | \$78,876  | \$228,741   | 1         | \$43,979  | \$43,979    | 7           | \$7,768   | \$54,377    | 1               | \$8,963   | \$8,963   | 1               | \$33,821  | \$33,821    | 1                                                               | \$78,436  | \$78,436    | \$585,026    |
| 2021              | 11 |                         |           | \$0       | 12000       | \$1.46    | \$17,600  | 2.9      | \$80,454  | \$233,316   | 1         | \$44,859  | \$44,859    | 7           | \$7,923   | \$55,464    | 1               | \$9,142   | \$9,142   | 1               | \$34,498  | \$34,498    | 1                                                               | \$72,976  | \$72,976    | \$467,855    |
| 2022              | 12 |                         |           | \$0       | 12000       | \$1.49    | \$17,900  | 2.9      | \$82,063  | \$237,982   | 1         | \$45,756  | \$45,756    | 7           | \$8,082   | \$56,574    | 1               | \$9,325   | \$9,325   | 1               | \$35,187  | \$35,187    | 1                                                               | \$73,503  | \$73,503    | \$476,227    |
| 2023              | 13 |                         |           | \$0       | 12000       | \$1.52    | \$18,300  | 2.9      | \$83,704  | \$242,741   | 1         | \$46,671  | \$46,671    | 7           | \$8,244   | \$57,705    | 1               | \$9,512   | \$9,512   | 1               | \$35,891  | \$35,891    | 1                                                               | \$74,040  | \$74,040    | \$484,861    |
| 2024              | 14 |                         |           | \$0       | 12000       | \$1.55    | \$18,600  | 2.9      | \$85,378  | \$247,596   | 1         | \$47,605  | \$47,605    | 7           | \$8,408   | \$58,859    | 1               | \$9,702   | \$9,702   | 1               | \$36,609  | \$36,609    | 1                                                               | \$74,588  | \$74,588    | \$493,559    |
| 2025              | 15 |                         |           | \$0       | 12000       | \$1.58    | \$19,000  | 2.9      | \$87,086  | \$252,548   | 1         | \$48,557  | \$48,557    | 7           | \$8,577   | \$60,036    | 1               | \$9,896   | \$9,896   | 1               | \$37,341  | \$37,341    | 1                                                               | \$75,147  | \$75,147    | \$502,526    |
| 2026              | 16 |                         |           | \$0       | 12000       | \$1.62    | \$19,400  | 2.9      | \$88,827  | \$257,599   | 1         | \$49,528  | \$49,528    | 7           | \$8,748   | \$61,237    | 1               | \$10,094  | \$10,094  | 1               | \$38,088  | \$38,088    | 1                                                               | \$75,717  | \$75,717    | \$511,663    |
| 2027              | 17 |                         |           | \$0       | 12000       | \$1.65    | \$19,800  | 2.9      | \$90,604  | \$262,751   | 1         | \$50,519  | \$50,519    | 7           | \$8,923   | \$62,462    | 1               | \$10,296  | \$10,296  | 1               | \$38,850  | \$38,850    | 1                                                               | \$76,298  | \$76,298    | \$520,975    |
| 2028              | 18 |                         |           | \$0       | 12000       | \$1.68    | \$20,200  | 2.9      | \$92,416  | \$268,006   | 1         | \$51,529  | \$51,529    | 7           | \$9,102   | \$63,711    | 1               | \$10,502  | \$10,502  | 1               | \$39,627  | \$39,627    | 1                                                               | \$76,891  | \$76,891    | \$530,466    |
| 2029              | 19 |                         |           | \$0       | 12000       | \$1.71    | \$20,600  | 2.9      | \$94,264  | \$273,366   | 1         | \$52,559  | \$52,559    | 7           | \$9,284   | \$64,985    | 1               | \$10,712  | \$10,712  | 1               | \$40,419  | \$40,419    | 1                                                               | \$77,496  | \$77,496    | \$540,138    |
| 2030              | 20 | 1                       | \$145,681 | \$145,681 | 12000       | \$1.75    | \$21,000  | 2.9      | \$96,150  | \$278,834   | 1         | \$53,611  | \$53,611    | 7           | \$9,469   | \$66,285    | 1               | \$10,926  | \$10,926  | 1               | \$41,228  | \$41,228    | 1                                                               | \$85,397  | \$85,397    | \$702,961    |
| 2031              | 21 |                         |           | \$0       | 12000       | \$1.78    | \$21,400  | 2.9      | \$98,073  | \$284,410   | 1         | \$54,683  | \$54,683    | 7           | \$9,659   | \$67,611    | 1               | \$11,145  | \$11,145  | 1               | \$42,052  | \$42,052    | 1                                                               | \$78,743  | \$78,743    | \$560,043    |
| 2032              | 22 |                         |           | \$0       | 12000       | \$1.82    | \$21,800  | 2.9      | \$100,034 | \$290,099   | 1         | \$55,777  | \$55,777    | 7           | \$9,852   | \$68,963    | 1               | \$11,367  | \$11,367  | 1               | \$42,893  | \$42,893    | 1                                                               | \$79,384  | \$79,384    | \$570,283    |
| 2033              | 23 |                         |           | \$0       | 12000       | \$1.86    | \$22,300  | 2.9      | \$102,035 | \$295,901   | 1         | \$56,892  | \$56,892    | 7           | \$10,049  | \$70,342    | 1               | \$11,595  | \$11,595  | 1               | \$43,751  | \$43,751    | 1                                                               | \$80,039  | \$80,039    | \$580,820    |
| 2034              | 24 |                         |           | \$0       | 12000       | \$1.89    | \$22,700  | 2.9      | \$104,075 | \$301,819   | 1         | \$58,030  | \$58,030    | 7           | \$10,250  | \$71,749    | 1               | \$11,827  | \$11,827  | 1               | \$44,626  | \$44,626    | 1                                                               | \$80,707  | \$80,707    | \$591,457    |
| 2035              | 25 |                         |           | \$0       | 12000       | \$1.93    | \$23,200  | 2.9      | \$106,157 | \$307,855   | 1         | \$59,190  | \$59,190    | 7           | \$10,455  | \$73,184    | 1               | \$12,063  | \$12,063  | 1               | \$45,519  | \$45,519    | 1                                                               | \$81,388  | \$81,388    | \$602,400    |
| 2036              | 26 |                         |           | \$0       | 12000       | \$1.97    | \$23,600  | 2.9      | \$108,280 | \$314,012   | 1         | \$60,374  | \$60,374    | 7           | \$10,664  | \$74,648    | 1               | \$12,305  | \$12,305  | 1               | \$46,429  | \$46,429    | 1                                                               | \$82,083  | \$82,083    | \$613,451    |
| 2037              | 27 |                         |           | \$0       | 12000       | \$2.01    | \$24,100  | 2.9      | \$110,446 | \$320,292   | 1         | \$61,582  | \$61,582    | 7           | \$10,877  | \$76,141    | 1               | \$12,551  | \$12,551  | 1               | \$47,358  | \$47,358    | 1                                                               | \$82,792  | \$82,792    | \$624,815    |
| 2038              | 28 |                         |           | \$0       | 12000       | \$2.05    | \$24,600  | 2.9      | \$112,655 | \$326,698   | 1         | \$62,813  | \$62,813    | 7           | \$11,095  | \$77,663    | 1               | \$12,802  | \$12,802  | 1               | \$48,305  | \$48,305    | 1                                                               | \$83,515  | \$83,515    | \$636,396    |
| 2039              | 29 |                         |           | \$0       | 12000       | \$2.09    | \$25,100  | 2.9      | \$114,908 | \$333,232   | 1         | \$64,070  | \$64,070    | 7           | \$11,317  | \$79,217    | 1               | \$13,058  | \$13,058  | 1               | \$49,271  | \$49,271    | 1                                                               | \$84,252  | \$84,252    | \$648,199    |
| 2040              | 30 |                         |           | \$0       | 12000       | \$2.13    | \$25,600  | 2.9      | \$117,206 | \$339,897   | 1         | \$65,351  | \$65,351    | 7           | \$11,543  | \$80,801    | 1               | \$13,319  | \$13,319  | 1               | \$50,256  | \$50,256    | 1                                                               | \$85,004  | \$85,004    | \$660,228    |
| Future Value      |    |                         |           | \$365,190 |             |           | \$584,500 |          |           | \$7,764,730 |           |           | \$1,492,905 |             |           | \$1,845,848 |                 |           | \$304,261 |                 |           | \$1,148,077 |                                                                 |           | \$2,635,669 | \$15,799,423 |
| Net Present Value |    |                         |           | \$238,148 |             |           | \$299,940 |          |           | \$3,984,672 |           |           | \$766,123   |             |           | \$947,24    |                 |           | \$156,139 |                 |           | \$589,165   |                                                                 |           | \$1,230,513 | \$8,211,945  |

**Table 3.19:** Example of ferrous and non-ferrous prices.

| <b>Ferrous Metals</b>              | <b>\$ Revenue Per Tonne</b> |
|------------------------------------|-----------------------------|
| Car                                | 140                         |
| Steel #1                           | 150                         |
| Steel #1 O/S                       | 115                         |
| Mixed Steel                        | 140                         |
| Bushelling #2                      | 150                         |
| Cast Iron #1                       | 150                         |
| Cast Iron #2                       | 140                         |
| <b>AVERAGE</b>                     | <b>141</b>                  |
| <b>Non Ferrous Metals</b>          | <b>\$ Revenue Per kg</b>    |
| Aluminum- mixed                    | 0.19                        |
| Aluminum-extrusion                 | 0.26                        |
| Aluminum-casting                   | 0.19                        |
| Aluminum-siding                    | 0.20                        |
| Brass                              | 0.73                        |
| Copper #1- unsoldered wires        | 1.32                        |
| Copper #2                          | 1.22                        |
| Copper Wire- insulated             | 0.32                        |
| Aluminum Copper Radiator-<br>clean | 0.45                        |
| Stainless Steel                    | 0.32                        |
| Lead                               | 0.18                        |
| Lead Tire Weights                  | 0.14                        |
| Aluminum Wheel                     | 0.27                        |
| Insulated Copper Wire #1           | 0.39                        |
| Aluminum Cast BBQ                  | 0.19                        |
| Copper #3                          | 1.00                        |
| <b>AVERAGE</b>                     | <b>0.46</b>                 |

Note: The prices of scrap are subjected to change (see SWF Best Practice Guide for more information)



Table 3.20: Summary of revenue for waste management Approach #3.

| Year              | Project Year | Garbage Collection Services | Compost |                   |           | Non-Refundable Recycling Fee + Sale of Product to Market |                 |             | Scrap Metal |                   |             | Total       |
|-------------------|--------------|-----------------------------|---------|-------------------|-----------|----------------------------------------------------------|-----------------|-------------|-------------|-------------------|-------------|-------------|
|                   |              | Total                       | Tonnes  | Revenue per tonne | Subtotal  | Number of cans recycled                                  | Revenue per can | Subtotal    | Tonnes      | Revenue per tonne | Subtotal    |             |
| 2011              | 1            | \$70,615                    | 66.7    | \$76              | \$5,069   | 616,000                                                  | \$0.11          | \$67,760    | 190         | \$173             | \$32,870    | \$359,899   |
| 2012              | 2            | \$72,984                    | 67.6    | \$78              | \$5,200   | 624,183                                                  | \$0.11          | \$70,033    | 193         | \$176             | \$33,973    | \$371,906   |
| 2013              | 3            | \$75,433                    | 68.5    | \$79              | \$5,400   | 632,477                                                  | \$0.11          | \$72,383    | 195         | \$180             | \$35,113    | \$384,496   |
| 2014              | 4            | \$77,965                    | 69.4    | \$81              | \$5,600   | 640,884                                                  | \$0.12          | \$74,812    | 198         | \$184             | \$36,291    | \$397,403   |
| 2015              | 5            | \$80,588                    | 70.3    | \$82              | \$5,800   | 649,458                                                  | \$0.12          | \$77,329    | 200         | \$187             | \$37,512    | \$410,741   |
| 2016              | 6            | \$83,297                    | 71.3    | \$84              | \$6,000   | 658,125                                                  | \$0.12          | \$79,929    | 203         | \$191             | \$38,773    | \$424,602   |
| 2017              | 7            | \$86,086                    | 72.2    | \$86              | \$6,200   | 666,830                                                  | \$0.12          | \$82,605    | 206         | \$195             | \$40,071    | \$438,777   |
| 2018              | 8            | \$88,959                    | 73.2    | \$87              | \$6,400   | 675,572                                                  | \$0.13          | \$85,362    | 208         | \$199             | \$41,409    | \$453,471   |
| 2019              | 9            | \$91,905                    | 74.1    | \$89              | \$6,600   | 684,258                                                  | \$0.13          | \$88,189    | 211         | \$203             | \$42,780    | \$468,469   |
| 2020              | 10           | \$94,931                    | 75.0    | \$91              | \$6,800   | 692,925                                                  | \$0.13          | \$91,092    | 214         | \$207             | \$44,188    | \$483,880   |
| 2021              | 11           | \$98,035                    | 76.0    | \$93              | \$7,000   | 701,556                                                  | \$0.13          | \$94,071    | 216         | \$211             | \$45,633    | \$499,605   |
| 2022              | 12           | \$101,210                   | 76.9    | \$94              | \$7,300   | 710,074                                                  | \$0.14          | \$97,118    | 219         | \$215             | \$47,111    | \$515,929   |
| 2023              | 13           | \$104,478                   | 77.8    | \$96              | \$7,500   | 718,629                                                  | \$0.14          | \$100,254   | 222         | \$219             | \$48,632    | \$532,486   |
| 2024              | 14           | \$107,814                   | 78.7    | \$98              | \$7,700   | 727,036                                                  | \$0.14          | \$103,455   | 224         | \$224             | \$50,185    | \$549,440   |
| 2025              | 15           | \$111,242                   | 79.6    | \$100             | \$8,000   | 735,442                                                  | \$0.15          | \$106,744   | 227         | \$228             | \$51,781    | \$567,025   |
| 2026              | 16           | \$114,761                   | 80.5    | \$102             | \$8,200   | 743,830                                                  | \$0.15          | \$110,121   | 229         | \$233             | \$53,419    | \$584,840   |
| 2027              | 17           | \$118,385                   | 81.5    | \$104             | \$8,500   | 752,274                                                  | \$0.15          | \$113,598   | 232         | \$237             | \$55,106    | \$603,404   |
| 2028              | 18           | \$122,111                   | 82.4    | \$106             | \$8,800   | 760,736                                                  | \$0.15          | \$117,174   | 235         | \$242             | \$56,840    | \$622,414   |
| 2029              | 19           | \$125,942                   | 83.3    | \$109             | \$9,000   | 769,217                                                  | \$0.16          | \$120,849   | 237         | \$247             | \$58,623    | \$641,873   |
| 2030              | 20           | \$129,880                   | 84.2    | \$111             | \$9,300   | 777,717                                                  | \$0.16          | \$124,629   | 240         | \$252             | \$60,457    | \$661,985   |
| 2031              | 21           | \$133,945                   | 85.1    | \$113             | \$9,600   | 786,328                                                  | \$0.16          | \$128,529   | 243         | \$257             | \$62,349    | \$682,677   |
| 2032              | 22           | \$138,133                   | 86.1    | \$115             | \$9,900   | 795,014                                                  | \$0.17          | \$132,547   | 245         | \$262             | \$64,298    | \$704,045   |
| 2033              | 23           | \$142,461                   | 87.0    | \$117             | \$10,200  | 803,849                                                  | \$0.17          | \$136,701   | 248         | \$267             | \$66,313    | \$726,114   |
| 2034              | 24           | \$146,928                   | 88.0    | \$120             | \$10,500  | 812,796                                                  | \$0.17          | \$140,987   | 251         | \$273             | \$68,392    | \$748,779   |
| 2035              | 25           | \$151,533                   | 89.0    | \$122             | \$10,900  | 821,837                                                  | \$0.18          | \$145,406   | 253         | \$278             | \$70,536    | \$772,342   |
| 2036              | 26           | \$156,296                   | 90.0    | \$125             | \$11,200  | 831,045                                                  | \$0.18          | \$149,976   | 256         | \$284             | \$72,752    | \$796,628   |
| 2037              | 27           | \$161,188                   | 91.0    | \$127             | \$11,600  | 840,252                                                  | \$0.18          | \$154,670   | 259         | \$290             | \$75,030    | \$821,600   |
| 2038              | 28           | \$166,214                   | 92.0    | \$130             | \$11,900  | 849,460                                                  | \$0.19          | \$159,493   | 262         | \$295             | \$77,369    | \$847,162   |
| 2039              | 29           | \$171,376                   | 93.0    | \$132             | \$12,300  | 858,668                                                  | \$0.19          | \$164,446   | 265         | \$301             | \$79,772    | \$873,518   |
| 2040              | 30           | \$176,678                   | 94.0    | \$135             | \$12,700  | 867,876                                                  | \$0.20          | \$169,533   | 268         | \$307             | \$82,240    | \$900,473   |
| Future Value      |              | \$3,501,375                 |         |                   | \$251,169 |                                                          |                 | \$3,359,795 |             |                   | \$1,629,818 | \$8,742,200 |
| Net Present Value |              | \$1,725,046                 |         |                   | \$123,751 |                                                          |                 | \$1,655,293 |             |                   | \$802,973   | \$4,307,063 |

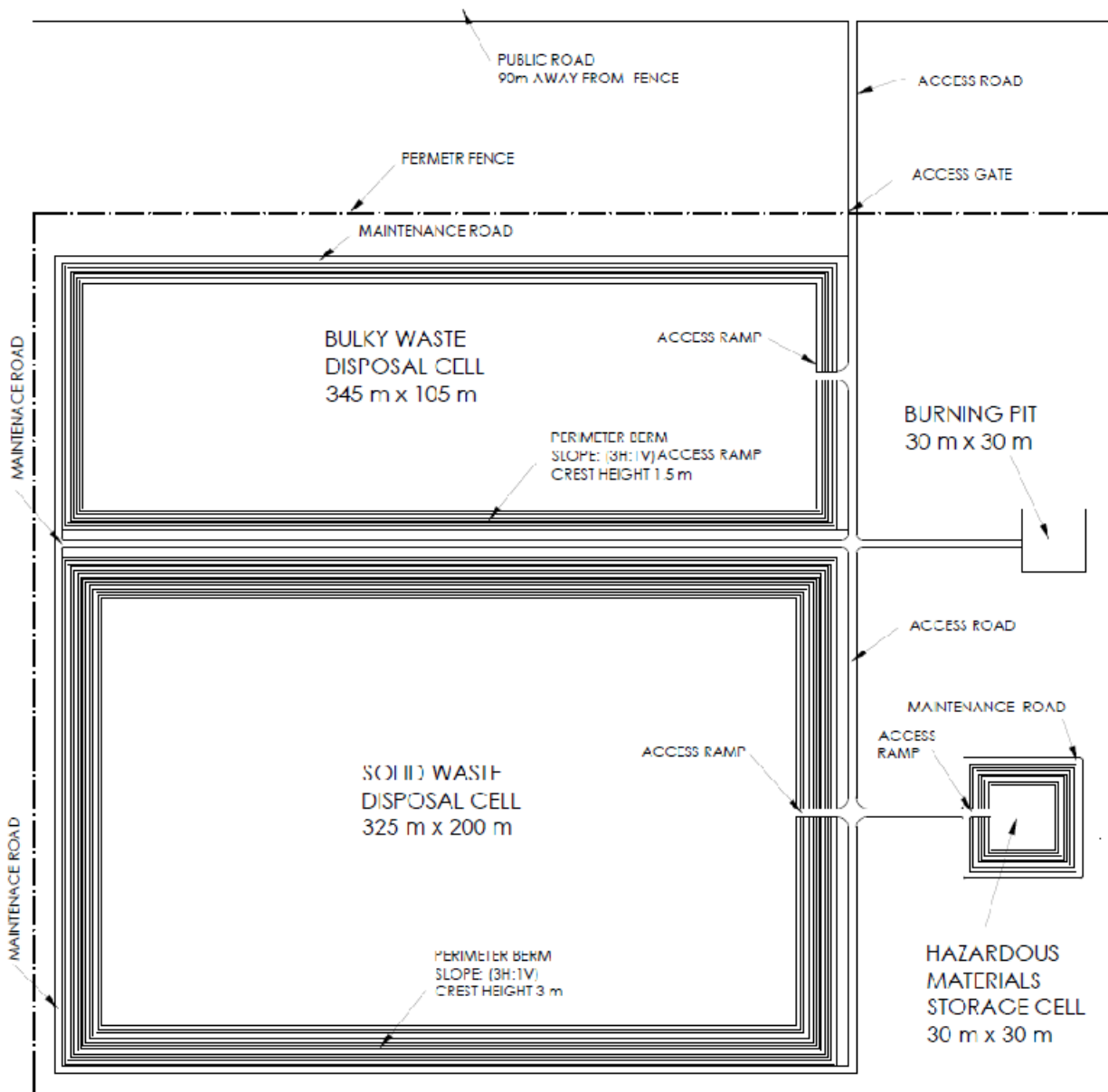


**Figure 3.1:** Schematic layout of a SWF for waste management Approach #1 (modified landfill).

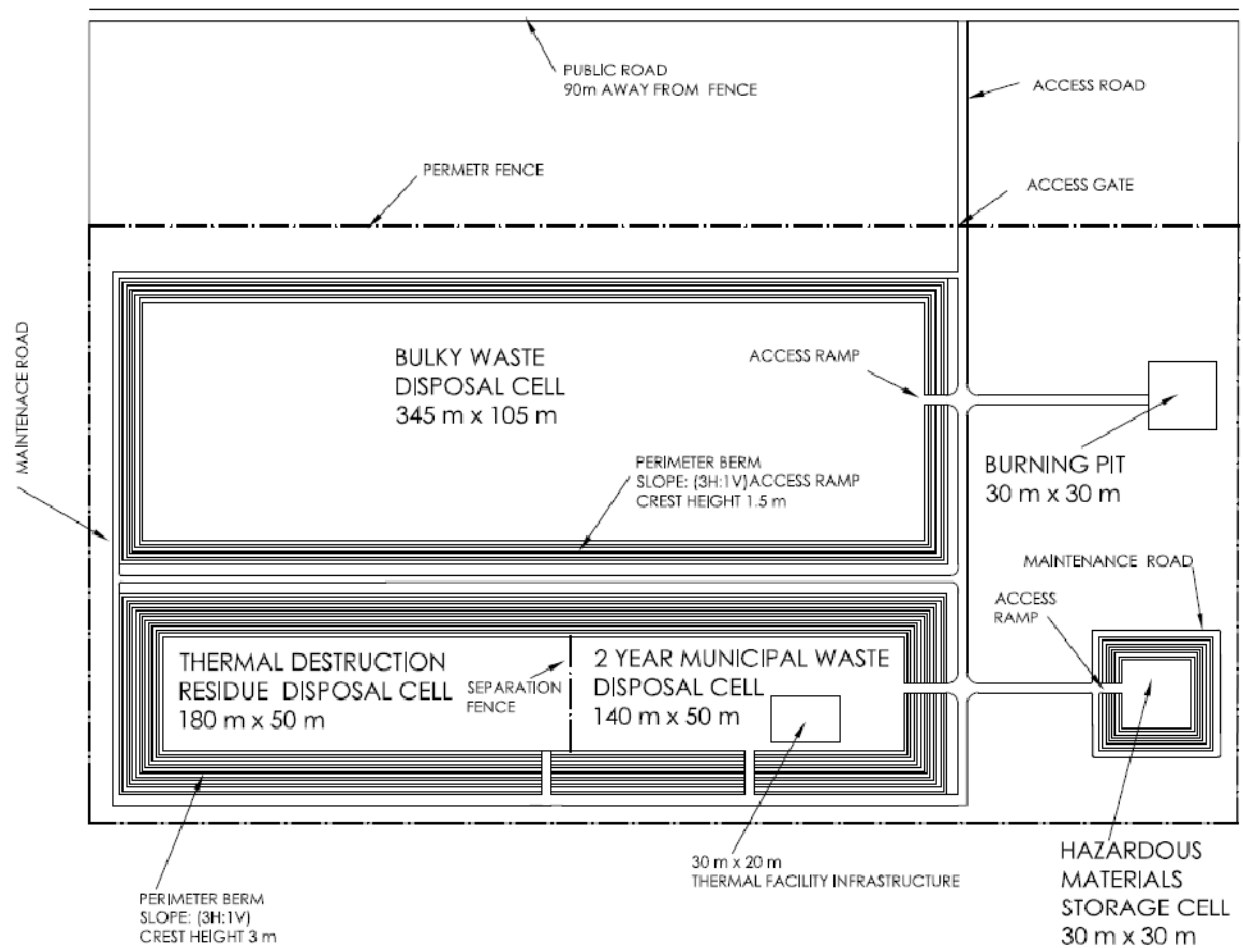


**Figure 3.2:** Schematic layout of a SWF for waste management Approach #2 (thermal destruction).

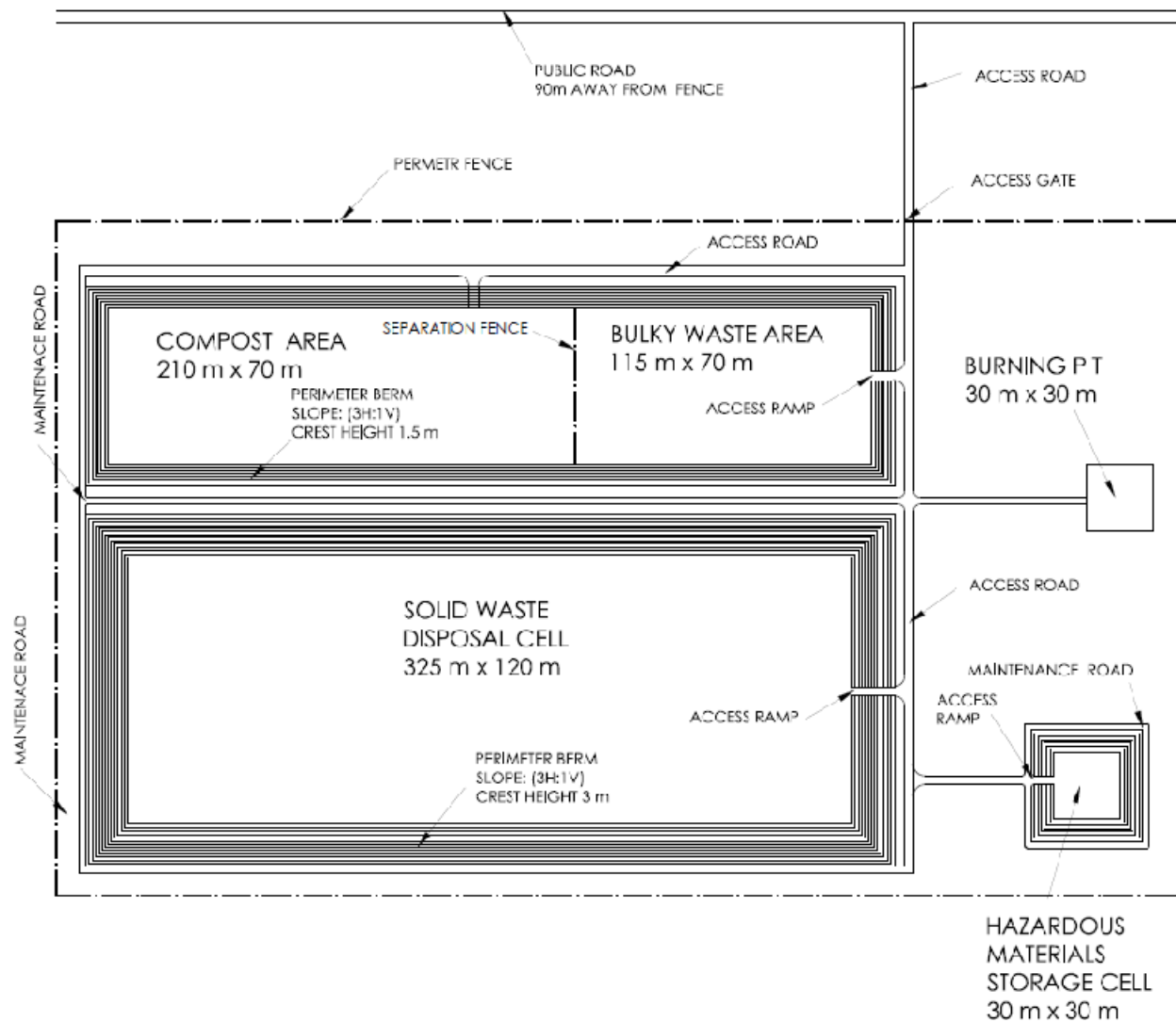


**Figure 3.3:** Schematic layout of a SWF for waste management Approach #3 (shift and separate)



## 4.0 WASTE MANAGEMENT APPROACHES TECHNICAL EVALUATION

### 4.1 Objective

The objective of this section is to:

- Provide recommendations on the most beneficial and sustainable approach to solid waste management.

### 4.2 Design Approaches Summary

A comparative summary of the three waste management approaches outlined in **Section 3.0** to the current conditions (i.e status quo) in **Section 2.0** was completed. Provided below is a summary of the key design features in each evaluated approach.

#### 4.2.1 Current Conditions

- Typically uncontrolled to minimal waste separation and disposal within a disposal area.
- Typically open burning of domestic waste.
- Typically minimal separation of bulky waste from municipal waste, and limited hazardous waste management.
- Facility has no to limited facility operations and maintenance.
- Facility is typically not design or constructed to acceptable engineering standards.
- Facility may or may not be fenced.

#### 4.2.2 Approach #1- Modified Landfill

- Facility is fenced and access can be controlled.
- The solid waste facility is separated into separate cells (bulky waste, municipal waste and hazardous waste).
- Each cell is enclosed in a berm and self-contained.
- Separate controlled burn pit is maintained for suitable waste.
- Solid waste facility has regular operation and maintenance activities completed.
- Solid waste facility is design and constructed to acceptable engineering standards.

#### 4.2.3 Approach #2- Thermal Destruction

- Incinerator/ gasification system is used to burn waste and thereby reduce the volume of waste for disposal within a solid waste facility.
- Disposal of ash generated from thermal destruction, as well as, bulky waste requires disposal in a modified landfill as described in Approach #1.
- Incineration allows the presence of oxygen during the burning process, gasification does not.
- Gasification generally produces less harmful air emissions.
- A modified landfill similar to Approach #1 is used to store waste ash and waste that is not suitable for incineration/gasification.

#### 4.2.4 Approach #3- Shift and Separate

- Waste is separated into several streams for diversion. The diversion activities include temporary storage, reuse, and recycling.
- A wide variety of materials can be diverted. These materials can include scrap metal, waste wood and organic waste (compostable materials).



- Materials that are not suitable for diversion are separated and stored in a modified landfill as described in Approach # 1.
- A composting area can be included in the landfill design for this approach.

#### 4.3 Technical Evaluation

To evaluate the three waste management approaches to the current practices, the following evaluation criteria were selected:

- Waste management and operations:
  - Solid waste management;
  - Bulky waste management;
  - Hazardous waste management;
  - Odour and litter control; and,
  - Site security and signage.
- Environmental considerations:
  - Air quality;
  - Surface water protection;
  - Leachate management;
  - Hazardous waste contamination; and,
  - Nunavut Water Board Licensing.
- Financial implications:
  - Capital costs;
  - Operation and maintenance costs;
  - Revenue potential; and,
  - Financial risk.

The evaluation of the waste management approaches is summarised in **Tables 4.1 to 4.3**. Each table includes the evaluation criteria, ARKTIS' comments and evaluation, and a numerical rank for each criterion. The numerical rank represents an evaluation according to the following descriptors: poor, average, good, or excellent. The ranking is based on a scale of one to four, with a value of 1 representing poor evaluation, and a value of 4 representing excellent evaluation (i.e., excellent=4, good=3, average=2 and poor=1). The goal of the numerical ranking scale is to calculate a single value or "grade" to assign to each waste management approach for relative comparison purposes.

The only exception to this grading system is the financial risk criteria. This criterion is a qualitative representation of how likely an approach is either going to cost more than estimated, or bring in less revenue than estimated. The financial risk value is subtracted from the total financial considerations ranking and is rated on a scale from 0 to 3, where 0 represents an insignificant risk and 3 represents a high risk (i.e., insignificant risk=0, low risk=1, medium risk=2, and high risk=3).

A weighting system was adopted to place emphasis on key factors (such as the relative financial costs) when producing the final comparative rankings. The weighting assigned to each ranking category is detailed in below. The weighting factor results in greater emphasis on financial considerations compared to environmental and waste management and operations within the analysis. This weighting factors selected were considered by ARKTIS to be reasonable.



| Criteria                        | Weighting Factor |
|---------------------------------|------------------|
| Waste Management and Operations | 2                |
| Environmental Considerations    | 3                |
| Financial Considerations        | 5                |

#### 4.4 Conclusions and Recommendations

Based on discussions with the GN-CGS and the content provided in the original *Request for Proposal Services*, ARKTIS understands the preferred solid waste management approach must be compatible with the following:

- Financial feasible to community municipal governments;
- Able to provide environmental protection and limit the potential contamination of water, soil and the air; and,
- Able to provide safe and efficient waste management operations with limited odour and litter nuisances.

A summary of the total numerical ranking for each category group is provided in **Table 4.4**. Provided below is a summary of the weighted rank scores for the current conditions and the three waste management approaches. The maximum ranking would have a score of 140.

- Weighted rank of **70** for the status quo current conditions;
- Weighted rank of **97** for Approach #1 Modified Landfill;
- Weighted rank of **79** for Approach #2 Thermal Destruction; and,
- Weighted rank of **82** for Approach #3 Shift and Separate.

The evaluation results indicate that the status quo conditions are inferior to the other three waste management approaches considered in the analysis. Approach #1, the Modified Landfill, was ranked the highest. This ranking took into account waste management and operations, environmental considerations and financial considerations, and weighted them in accordance with factors considered important to the public, community, and territorial government.

**Based on the listed preference and the calculated ranking for each approach, ARKTIS concludes that Approach #1 is the most financially feasible approach that provides environmental protection and safe and efficient waste management operations. ARKTIS recommends that waste Approach #1 is selected as the preferred strategy to sustainably manage waste materials in the territory of Nunavut.**



**Table 4.1:** Evaluation of waste management and operations criteria for each waste management approach

**Bulky Waste Management**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                           | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                 | Approach #2<br>Thermal Destruction                                                                                                                                                          | Approach #3<br>Shift And Separate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 1                                                                                                                                                                                                                                                                                                                 | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                       | Ranking: 3                                                                                                                                                                                  | Ranking: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"><li>Bulky waste has been poorly segregated, and generally consists of multiple waste piles located at various locations.</li><li>The lack of bulky waste segregation and organization hinders daily landfill operations and can make public salvaging difficult and dangerous.</li></ul> | <ul style="list-style-type: none"><li>Bulky waste materials are segregated and deposited into a dedicated bermed waste cell. Within the waste cell bulky waste materials are organised to various types including metals, used snowmobiles, etc.</li><li>Proper segregation and organisation of bulky waste materials results in efficient daily operations and safe public salvaging.</li></ul> | <ul style="list-style-type: none"><li>Incineration/gasification generally cannot process bulky wastes, as such, bulky waste is managed using the method described in Approach #1.</li></ul> | <ul style="list-style-type: none"><li>Bulky waste materials are segregated and deposited into a dedicated bermed waste cell. Within the waste cell bulky waste materials are organised to various types. Bulky waste materials such as end -of-life vehicles, used tanks and scrap metal are backhauled once a stockpiled volume is reached.</li><li>While similar to approaches #1 in the management of bulky waste, the periodic backhauling results a smaller bulky cell footprint compared to Approach #1.</li></ul> |



**Hazardous Waste Management**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                                                                         | Approach #3<br>Shift And Separate                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Ranking: 4                                                                                                                                                                                                                                                                                                                                 | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"><li>• Hazardous waste materials have been observed to be mixing with municipal solid waste and bulky waste materials.</li><li>• This mixing greatly increases the possibility of the contamination of the soil, surface water and groundwater.</li><li>• The infrastructure currently in place is not adequate to protect the environment from contamination resulting from contact with hazardous waste or hazardous waste products.</li><li>• Hazardous waste has accumulated with no to limited records of removal from site for disposal in a proper facility.</li><li>• Hazardous waste containers are not designed for prolonged containment. The longer hazardous waste is stored on site without periodic removal, the greater the possibility of environmental contamination.</li></ul> | <ul style="list-style-type: none"><li>• Hazardous waste materials are segregated and stored in a waste cell that is bermed and lined with a geomembrane.</li><li>• The waste cell greatly decreases the chances that hazardous waste will enter the environment.</li><li>• After a designated storage time or total volume is reached, the hazardous waste materials are backhauled for proper disposal in a southern facility.</li><li>• This removal decreases the chances of storage container degradation, and lowers the chances of hazardous waste entering the environment.</li></ul> | <ul style="list-style-type: none"><li>• Hazardous waste storage and removal similar to Approach #1</li><li>• Thermal destruction has the added benefit of being able to destroy selected hazardous materials in small quantities, thereby reducing the volume of hazardous waste that has to be stored and periodically removed.</li></ul> | <ul style="list-style-type: none"><li>• Hazardous waste storage and removal similar to Approach #1.</li><li>• The shift and separate approach will use an on-site waste oil burner to destroy waste oil and fuels, thereby reducing the volume of hazardous waste that has to be stored and periodically removed. Waste oil burners are typically problematic for long term operation due to inadequate operations. Therefore there may be limited benefit to their use.</li></ul> |



**Odour and Litter Control**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                             | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                          | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                  | Approach #3<br>Shift And Separate                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Ranking: 3                                                                                                                                                                                                                                                                                                                | Ranking: 4                                                                                                                                                                                                                                                                          | Ranking: 2                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"><li>Regular application of soil to cover waste is typically not applied.</li><li>A lack of regular waste cover material can result in the emission of foul odours and the spreading of windblown litter.</li><li>Limited use of fencing to control windblown litter.</li><li>A lack of litter collection fencing can result in windblown litter to leave the site and undesirably enter into the community or into water bodies.</li></ul> | <ul style="list-style-type: none"><li>Regular application of soil to cover waste</li><li>Installation of perimeter fence to control windblown litter.</li><li>The regular application cover material and the installation of perimeter fence will reduce foul smelling odours and undesirable windblown litter.</li></ul> | <ul style="list-style-type: none"><li>85% of the solid waste materials will be destroyed using incineration/gasification processes.</li><li>The reduction in solid waste volume reduces the volume of waste that may cause foul odours or contribute to windblown litter.</li></ul> | <ul style="list-style-type: none"><li>The management of non-organic solid waste materials is similar to Approach #1.</li><li>Waste that can decompose is managed by composting. Odours from compost can occur. If the compost pad is not operated as required, it could result in the emission of strong smelling foul odours.</li></ul> |



**Site Security and Signage**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Approach #2<br>Thermal Destruction                                                                | Approach #3<br>Shift And Separate                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Ranking:1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Ranking: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Ranking: 4                                                                                        | Ranking: 4                                                                                        |
| <ul style="list-style-type: none"><li>Non-existent, limited, or non-functioning infrastructure (fencing and gates) exists. Typically uncontrolled access to the site. Limited signage is in place to provide warning and/or instruction to the public and staff.</li><li>Uncontrolled site access, and improper or broken signage can result in the following potential impacts:<ul style="list-style-type: none"><li>Improper segregation of waste materials;</li><li>Increased risk to public health and safety;</li><li>Increased fire hazard; and,</li><li>Inefficient public salvaging.</li></ul></li></ul> | <ul style="list-style-type: none"><li>Site security and signage implemented.</li><li>A perimeter fence with a gated entrance and proper signage is incorporated into designs.</li><li>The installation of a perimeter fence with a gated entrance will attempt to limit uncontrolled access to the site, and reduce the risks of improper dumping and public health risk from improper salvaging.</li><li>Proper signage will provide warning and/or instruction to the public and staff, thereby increasing safety.</li></ul> | <ul style="list-style-type: none"><li>Site security and signage similar to Approach #1.</li></ul> | <ul style="list-style-type: none"><li>Site security and signage similar to Approach #1.</li></ul> |



**Table 4.2:** Evaluation of environmental criteria for each waste management approach

**Air Quality**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                          | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                               | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                                                     | Approach #3<br>Shift And Separate                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Ranking: 1                                                                                                                                                                                                                                                                                | Ranking: 2                                                                                                                                                                                                                                                                                                                     | Ranking: 3                                                                                                                                                                                                                                                                                                             | Ranking: 2                                                                          |
| <ul style="list-style-type: none"><li>Open burning of non-suitable waste materials is conducted in the majority of the communities studied.</li><li>Uncontrolled burning can release toxic contaminants into the air, which are hazardous to the environment and public health.</li></ul> | <ul style="list-style-type: none"><li>A burn pit area is available to open burn acceptable waste products (paper, cardboard and untreated wood).</li><li>Burning of approved waste materials decreases the risk of harmful contaminants being released to the air and becoming a risk to the health and environment.</li></ul> | <ul style="list-style-type: none"><li>Incineration/gasification burns waste at a much higher temperature than an open burn. This increase in temperature decreases the amount of air pollution that occurs from burning waste. Proper thermal destruction operations required to attain desired air quality.</li></ul> | <ul style="list-style-type: none"><li>Air quality similar to Approach #1.</li></ul> |



**Surface Water Management**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Approach #2<br>Thermal Destruction                                        | Approach #3<br>Shift And Separate                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Ranking: 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Ranking: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Ranking: 4                                                                | Ranking: 4                                                                |
| <ul style="list-style-type: none"><li>• Most communities have installed water management infrastructure including ditches, berms, or culverts.</li><li>• The current surface water infrastructure does not adequately limit the amount of surface water that enters the site and comes into contact with waste materials.</li><li>• Surface water that comes into contact with waste materials becomes leachate, and can contaminate surface waters, groundwater and the soil.</li></ul> | <ul style="list-style-type: none"><li>• Design features implemented to adequately manage surface water through the use of drainage ditches, culverts, and/or perimeter containment berms. Surface water is managed to limit the amount of water that enters the site and comes into contact with waste materials.</li><li>• The proper design and installation of surface water infrastructure will minimise the amount of leachate that is generated and thereby limit the potential contamination of surface and subsurface waters and the underlying soil.</li></ul> | <ul style="list-style-type: none"><li>• Similar to Approach #1.</li></ul> | <ul style="list-style-type: none"><li>• Similar to Approach #1.</li></ul> |



**Leachate Management**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                       | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                                       | Approach #2<br>Thermal Destruction                                      | Approach #3<br>Shift And Separate                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Ranking:1                                                                                                                                                                                                                                                              | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ranking: 3                                                              | Ranking: 3                                                              |
| <ul style="list-style-type: none"><li>Only a few communities had infrastructure for leachate containment.</li><li>If leachate is not properly contained, collected and properly disposed of it has the potential to contaminate the surrounding environment.</li></ul> | <ul style="list-style-type: none"><li>Design of facility includes the ability to adequately manage leachate. This is accomplished through the combined use of waste perimeter berms, sumps, and base contouring the cell. Leachate collects in a sump where it can be collected for proper disposal.</li><li>The containment and collection of leachate and its proper disposal, limits the potential of leachate contaminating the surrounding environment.</li></ul> | <ul style="list-style-type: none"><li>Similar to Approach #1.</li></ul> | <ul style="list-style-type: none"><li>Similar to Approach #1.</li></ul> |



**Water License**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                                                                                                                                                                                                             | Approach #2<br>Thermal Destruction                                      | Approach #3<br>Shift And Separate                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Ranking:1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Ranking: 3                                                              | Ranking: 3                                                              |
| <ul style="list-style-type: none"><li>Some communities have either expired water licenses. Based on an evaluation of the current conditions, communities will face challenges in obtaining a new water license licence from the Nunavut Water Board (NWB) due to inadequate waste management facilities and/or lack of design and operation information.</li><li>Municipalities will require allocation of labour, financial and administrative resources to complete the water license application and obtain approval from the NWB.</li><li>If a water license is not obtained in a timely fashion the solid waste facility may operate out of compliance with regulatory requirements.</li></ul> | <ul style="list-style-type: none"><li>The solid waste facility is appropriately engineered and meets typical water licence requirements for design and operation. As such, there should be limited challenges with obtaining a new or renewal water licence.</li><li>A less exhaustive water license application process will result in less overall financial, labour and administrative savings to the community compared to current conditions.</li></ul> | <ul style="list-style-type: none"><li>Similar to Approach #1.</li></ul> | <ul style="list-style-type: none"><li>Similar to Approach #1.</li></ul> |



**Table 4.3:** Evaluation of financial criteria for each waste management approach

**Capital Costs**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                              | Approach #1<br>Modified Landfill                                                                                                                                                                                                                                           | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                                                                       | Approach #3<br>Shift And Separate                                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 4                                                                                                                                                                                                                                                                                                                    | Ranking: 3                                                                                                                                                                                                                                                                 | Ranking: 1                                                                                                                                                                                                                                                                                                                               | Ranking: 3                                                                                                                                                                                                            |
| <ul style="list-style-type: none"><li>Solid waste capital costs have not been determined for comparison; however, given the limited engineering design and infrastructure that is typical for existing facilities, it is reasonable to assume that the costs would be low in comparison to Approach #1, #2, and #3.</li></ul> | <p><b>Capital Cost: \$9,559,311</b></p> <ul style="list-style-type: none"><li>The footprint size for the solid waste facility for Approach #1 is larger than Approach #2, and #3.</li><li>Requires less equipment for operations compared to Approach #2 and #3.</li></ul> | <p><b>Capital Cost: \$12,146,407</b></p> <ul style="list-style-type: none"><li>The footprint size for solid waste facility is the smallest compared to Approach #1 and #3.</li><li>The capital cost for the thermal destruction equipment is high and does not offset the benefits gained for having a smaller footprint size.</li></ul> | <p><b>Capital Cost: \$9,329,217</b></p> <ul style="list-style-type: none"><li>The footprint size is smaller than Approach #1 and larger than Approach #2.</li><li>Requires more equipment than Approach #1.</li></ul> |



**Operation and Maintenance (O&M) Costs**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                                                                   | Approach #1<br>Modified Landfill                                                                                                                                          | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                                                                         | Approach #3<br>Shift And Separate                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 4                                                                                                                                                                                                                                                                                                                                                                                         | Ranking: 3                                                                                                                                                                | Ranking: 1                                                                                                                                                                                                                                                                                                                                 | Ranking: 1                                                                                                                                                                                                    |
| <ul style="list-style-type: none"><li>The O&amp;M costs for current conditions have not been determined for comparison; however, based on information gained throughout this study it is reasonable to conclude that current O&amp;M costs will be lower than that recommended in approaches #1, #2, and #3. This is a result of typically inadequate O&amp;M currently being completed.</li></ul> | <p><b>O&amp;M Costs: \$ 5,524,232</b></p> <ul style="list-style-type: none"><li>Lowest O&amp;M requirements for fuel, labour and other site related activities.</li></ul> | <p><b>O&amp;M Costs: \$ 10,521,467</b></p> <ul style="list-style-type: none"><li>Highest O&amp;M requirements for fuel demand to operate the thermal destruction equipment. Requires O&amp;M of the solid waste facility, thermal destruction equipment, as well as, the building that houses the thermal destruction equipment.</li></ul> | <p><b>O&amp;M Costs: \$ 8,211,945</b></p> <ul style="list-style-type: none"><li>Most labour intensive approach due to the added effort required to divert waste and manage the composting of waste.</li></ul> |



**Potential Revenue**

| Status Quo<br>Current Conditions                                                                                                                                                             | Approach #1<br>Modified Landfill                                                                                                                                                                                                                             | Approach #2<br>Thermal Destruction                                                                          | Approach #3<br>Shift And Separate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 2                                                                                                                                                                                   | Ranking: 2                                                                                                                                                                                                                                                   | Ranking: 2                                                                                                  | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <ul style="list-style-type: none"><li>Revenue can be generated from the collection of garbage service fees. The current conditions do not have any other distinct revenue sources.</li></ul> | <p><b>Revenue: \$ 1,725,046</b></p> <ul style="list-style-type: none"><li>Revenue can be generated from the collection of garbage service fees. Potential exists to implement tipping fees associated by waste type (i.e., domestic, bulky, etc.).</li></ul> | <p><b>Revenue: \$ 1,725,046</b></p> <ul style="list-style-type: none"><li>Similar to Approach #1.</li></ul> | <p><b>Revenue: \$4,307,063</b></p> <ul style="list-style-type: none"><li>This approach calls for the segregation of waste materials including scrap metal, beverage containers, and organic solid waste for composting.</li><li>Segregated waste materials provide potential revenue streams by selling composted soil, scrap metals and recyclables.</li><li>The overall profitability of this approach is dependent on the size of the community. In order to evaluate the feasibility of each revenue stream communities may need to conduct a break even analysis.</li></ul> |



**Financial Risk**

| Status Quo<br>Current Conditions                                                                                                                                                                                                                                                                                                                              | Approach #1<br>Modified Landfill                                                                                                                                                 | Approach #2<br>Thermal Destruction                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Approach #3<br>Shift And Separate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ranking: 0                                                                                                                                                                                                                                                                                                                                                    | Ranking: 1                                                                                                                                                                       | Ranking: 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Ranking: 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"><li>If there is limited investment in upgrading infrastructure and O&amp;M, than there is less financial risk compared to approaches #1, #2, and #3. It is important to note however, that this evaluation does not take into account any improvements or changes that may be required to obtain a water license.</li></ul> | <ul style="list-style-type: none"><li>Facility design and operation is utilizes typical engineering design methods and standard construction equipment for operations.</li></ul> | <ul style="list-style-type: none"><li>Thermal destruction equipment and building has high capital and O&amp;M costs compared to technologies applied in Approach #1 and #2. The thermal destruction equipment requires operation by trained personnel to achieve the potential environmental benefits. Regular O&amp;M of the equipment is required.</li><li>Engineering design and equipment use for the remainder of the solid waste facility is similar to Approach #1.</li></ul> | <ul style="list-style-type: none"><li>High community involvement is necessary to complete waste separation in order to achieve the potential revenue benefits.</li><li>Higher operations requirement to separate and divert waste into different streams at the solid waste facility.</li><li>The assumption of a revenue stream from the sale of scrap materials is dependent on fluctuating commodity costs and the ability to find a cost effective method to ship materials to buyers in the south. This introduces a significant margin of error in the calculation of revenue streams.</li><li>Engineering design and equipment use for the remainder of the solid waste facility is similar to Approach #1.</li></ul> |

REPORT ON CURRENT STATE OF SOLID WASTE MANAGEMENT AND FACILITIES IN NUNAVUT AND COST-BENEFIT ANALYSIS OF SELECTED SOLID WASTE MANAGEMENT APPROACHES

GN-CGS Project #2010-27

**Table 4.4:** Summary of total rankings for each criterion group

| Evaluation Criteria                    | Maximum Ranking Value | Status Quo Current Conditions | Approach #1 Modified Landfill | Approach #2 Thermal Destruction | Approach #3 Shift And Separate |
|----------------------------------------|-----------------------|-------------------------------|-------------------------------|---------------------------------|--------------------------------|
| <b>Waste Management and Operations</b> |                       |                               |                               |                                 |                                |
| Bulky waste management                 | 4                     | 1                             | 3                             | 3                               | 4                              |
| Hazardous waste Management             | 4                     | 1                             | 3                             | 4                               | 3                              |
| Odour and litter control               | 4                     | 1                             | 3                             | 4                               | 2                              |
| Site security and signage              | 4                     | 3                             | 4                             | 4                               | 4                              |
| <b>Total</b>                           | <b>16</b>             | <b>4</b>                      | <b>13</b>                     | <b>15</b>                       | <b>13</b>                      |
| <b>Weighted total (factor x2)</b>      | <b>32</b>             | <b>8</b>                      | <b>26</b>                     | <b>30</b>                       | <b>26</b>                      |
| <b>Environmental Considerations</b>    |                       |                               |                               |                                 |                                |
| Air quality                            | 4                     | 1                             | 2                             | 3                               | 2                              |
| Surface water management               | 4                     | 1                             | 4                             | 4                               | 4                              |
| Leachate management                    | 4                     | 1                             | 3                             | 3                               | 3                              |
| Water License                          | 4                     | 1                             | 3                             | 3                               | 3                              |
| <b>Total</b>                           | <b>16</b>             | <b>4</b>                      | <b>12</b>                     | <b>13</b>                       | <b>12</b>                      |
| <b>Weighted total (factor x3)</b>      | <b>48</b>             | <b>12</b>                     | <b>36</b>                     | <b>39</b>                       | <b>36</b>                      |
| <b>Financial Considerations</b>        |                       |                               |                               |                                 |                                |
| Capital costs                          | 4                     | 4                             | 3                             | 1                               | 3                              |
| Operation and maintenance              | 4                     | 4                             | 3                             | 1                               | 1                              |
| Revenue                                | 4                     | 2                             | 2                             | 2                               | 3                              |
| Risk                                   | 0                     | 0                             | -1                            | -2                              | -3                             |
| <b>Total</b>                           | <b>12</b>             | <b>10</b>                     | <b>7</b>                      | <b>2</b>                        | <b>4</b>                       |
| <b>Weighted total (factor x5)</b>      | <b>60</b>             | <b>50</b>                     | <b>35</b>                     | <b>10</b>                       | <b>20</b>                      |
| <b>UNWEIGHTED TOTAL RANKING</b>        | <b>44</b>             | <b>18</b>                     | <b>32</b>                     | <b>30</b>                       | <b>29</b>                      |
| <b>WEIGHTED TOTAL RANKING</b>          | <b>140</b>            | <b>70</b>                     | <b>97</b>                     | <b>79</b>                       | <b>82</b>                      |



## 5.0 CONCLUSIONS

Fourteen communities within the Territory of Nunavut were targeted to gather information on the current state of solid waste management and associated facilities. The information gathered during the community visits is one component of a larger study regarding sustainable management of solid waste in Nunavut. For each community, information was gathered through the following means: community presentation and meeting, interviews with community staff involved with solid waste management, and a visual inspection of the solid waste facility. Information gathered during the community visits were presented in this report.

A variety of information was gathered through a community consultation program. Probably, the most relevant information pertained to the current state of SWFs and public's perception of available solid waste services. It was found that the residents of many communities felt several aspects of the current solid waste management required improvement. Recurring examples included windblown litter, health and safety hazards, and the impact of the SWF on the environment. At the same time, many communities expressed their interest in participating in several improvement initiatives proposed during this study that included: recycling, waste segregation or waste backhauling. This suggests that improvements in solid waste management would be welcomed by the residents of the communities visited.

This report completed a cost-benefit analysis for the following three waste management approaches:

- Approach #1 - modified landfill;
- Approach #2 - thermal destruction; and,
- Approach #3 - shift and separate.

The outcome from the analysis was to provide recommendations on the sustainability of each approach on a Nunavut-wide basis. For each waste management approach, the capital and O&M costs were consolidated, and the revenue was deduced for a 30 year life cycle. The following are the overall results of the cost-benefit analysis ranked from highest to lowest:

- Capital costs – Approach #2 > Approach #1 > Approach #3
- O&M costs – Approach #2 > Approach #3 > Approach #1
- Revenue – Approach #3 > Approach #1 and Approach #2
- Total life cycle cost – Approach #2 > Approach #1 and Approach #3

A technical evaluation of the three waste management approaches compared to the current conditions was completed. The rankings took into account waste management and operations, environmental considerations and financial considerations, and weighted them in accordance with factors considered important to the public, community and territorial government. Provided below is a summary of the final ranking scores:

- Weighted rank of **70** for the status quo current conditions;
- Weighted rank of **97** for Approach #1 Modified Landfill;
- Weighted rank of **79** for Approach #2 Thermal Destruction; and,
- Weighted rank of **82** for Approach #3 Shift and Separate.

**Based on the completed technical evaluation ARKTIS concludes that Approach #1 is the most financially feasible approach that provides environmental protection and safe and efficient waste management operations. ARKTIS recommends that waste Approach #1 is selected as the preferred strategy to sustainably manage waste materials in the territory of Nunavut.**



## 6.0 LIMITATIONS OF LIABILITY

This report has been prepared for the exclusive use of the Government of Nunavut, Community and Government Services for the specific application described in **Section 1.0** of this report. Information gathered through interviews has not been verified to be correct. Further, information gathered may be restricted due to the short period of time present at each site. The information contained in this report are not to be considered as ARKTIS' engineering or professional opinions with regards, but not limited to, the details of design, costs, management, and operation of the solid waste disposal facilities.

## 7.0 CLOSURE

We trust that this report meets your present requirements. Please contact the undersigned should there be any questions.

**ARKTIS SOLUTIONS INC.**

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*ORIGINAL SIGNED BY*

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Jamie VanGulck, Ph.D., P.Eng.  
Chief Technical Officer

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Lukas Novy, M.Sc., P.Eng.  
Geo-Environmental Engineer