City of Iqaluit

Iqaluit Solid Waste Management Plan
West 40 Landfill Decommissioning
Technical Memorandum

Prepared by:

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Project Number:

60196419

Date: January, 2014

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Septa Rundra	June 27, 2011	DRAFT
2	Septa Rundra	July 15, 2011	DRAFT REV 2
3	Jim Clare	January 30, 2014	FINAL

AECOM Signatures

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Signature
Date Jan 30, 2014
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1. Introduction

1.1 Background

Exp. Services Inc. (exp) and AECOM were retained by City of Iqaluit (the City) to develop a Decommissioning Plan for the West 40 Landfill. This landfill is currently at capacity and the City is working towards developing a new solid waste management site. When the new solid waste management facility opens, the West 40 landfill will be decommissioned. This Decommissioning Plan is a requirement of the City's Water License.

1.2 Scope of Work

The following tasks were completed in order to assess the site:

- Confirmation between exp./AECOM and the City regarding project scope, budget, and schedule;
- Established formal lines of communication;
- Collected, requested, and assembled all necessary and available information from the City in order to conduct the site assessment;
- Reviewed existing information;
- Used existing topographical data to produce conceptual closure design; and
- Conducted a landfill site visit.

Utilizing this information, a decommissioning plan was developed to address the following components:

- Final reclamation plans providing final contours and evaluating airspace volume;
- Final contour plans will be developed to allow final grades of 5% where possible to minimize the amount of fill material required to establish final grades;
- Final capping material design, including the possibility of using biosolids from the sewage treatment plant and gravel if available;
- Drainage management;
- Description of final cover;
- Ground water monitoring;
- Erosion control;
- Post closure care;
- Re-vegetation;
- Operation and maintenance checklist for final cover system to protect and maintain survey bench marks; and,
- A cost estimate for this decommissioning plan and care responsibilities.

2. Site Description

2.1 Location

Iqaluit is a growing Baffin Island community and is the Capital of Nunavut. It is located at the south end of Baffin Island, on Frobisher Bay at 64^0 44' N latitude and 68^0 31' E longitude. Access is provided by commercial aircraft year round and sea-lift from the port of Montreal in the summer. Annual precipitation in the Iqaluit area is approximately 255 cm of snowfall and 19.2 cm of rainfall. Average annual temperatures range from a low in January of approximately -29.7°C to a high of approximately 11.4°C in July.

The landfill site is located in West 40 approximately 4 km from the City center. This site was built in 1995 and was intended as a temporary disposal site until funding for a permanent solution could be allocated.

2.2 Operational History

Existing solid waste management practices at the site consist of placement of wastes into working face, compacting the wastes and covering with granular fill and/or mulch from shredded waste. The site accepts Municipal Solid Waste (MSW) which is either collected through a municipal collection or dropped off by the public. Scrap metal, tires, white goods, wood, sewage sludge, hazardous waste and end of life vehicles are collected and stored in designated areas of the landfill.

The site is operated using area method without engineered liner and leachate collection systems.

2.3 Site Facilities

All solid waste management facilities associated with the landfill are located generally within the site. These facilities include:

- A site office and garage located near the entrance to the landfill site;
- MSW pile;
- Scrap metal areas;
- Tires collection area;
- Wood waste processing area;
- Hazardous waste depot;
- Sewage sludge area;
- Composting; and
- Surface water management (berms, on-site and off-site retention ponds).

The site facilities are presented in Figure 1.1, Appendix A.

2.3.1 Recycling Storage Facilities

The site includes storage areas for recycling of bulky materials including:

- Scrap metals;
- Car bodies;
- Appliances/refrigerators and freezers; and
- Scrap tires.

Public sorting of waste or scavenging is not permitted within the disposal area of the landfill.

2.3.2 Hazardous Waste Depot

The site includes storage areas for hazardous waste materials. These wastes include but are not limited to:

- Automobile batteries;
- Lead acid batteries;
- Paint; and
- Waste oils.

3. Engineering Review and Design Consideration

Based on the "Operation and Maintenance Manual, May 2005", it was estimated that the site would reach its design capacities in November 2001. However, the site expansion was implemented for continuing operation of this site. [1] The expansion was developed in order to optimize daily operations and efficiently use airspace, while complying with the management of the runoff in and around the site in order to keep clean surface water out of the site and manage runoff on-site.

3.1 Solid Waste Generation

The landfill currently utilizes all of the available area designated for disposal and it has exceeded its capacity. However, there is an undisturbed area adjacent to the disposal footprint that can be used to dispose of waste until a new landfill is constructed. The remaining site life of undisturbed ground in years must be determined in order to plan for the final closure and post-closure management and costs.

To estimate the waste that will be generated over the lifetime of the site operation, the population data from City of Iqaluit General Plan[2] was used as a base for the projection. An average increase of 2.87% growth per year was applied to represent projected population and waste generation increases. A waste generation rate of 0.03 m^3/capita/day and a waste density of 100 kg/m^3 were used to estimate the volume of waste generation. Projected data describing the wastes generation is presented in Table 3.1.

Table 3.1 - Projected Waste Generation

Year	Accumulated Waste Generated (m^3)	Accumulated Waste Generated (tonnes)	Note
2011	83,412	8,314	
2012	169,218	16,922	
2013	257,486	25,749	
2014	348,288	34,829	
2015	441,713	44,171	New Solid Waste Site Scheduled to be Opened (Iqaluit Solid Waste Management Plan 2014) West 40 site closes and decommissioning begins.
2016	96,107		
2017	194,972		
2018	296,674		

3.2 Site Life

In order to establish the capacity requirements of the design, the expected future waste generation was calculated in order to predict the length of time the cell can viably service the site operations. Using the data provided in Table 3.1 the site life will be calculated.

The remaining capacity at year end is calculated by subtracting the waste accumulated for that year from the previous year's remaining site capacity. It is estimated that horizontal expansion to the north and south of existing waste, where the wood wastes and metals are placed, will accommodate waste disposal until approximately 2015-2016 (see Drawing 00-C-1003, Appendix B).

[1] Darcy Reist and Ken Johnson (2006). *Journal of the Northern Territories Water & Waste Association, pp. 10 – 13.*
[2] City of Iqaluit General Plan By Law 703, October 2010.

The site life of the landfill is calculated using the following assumptions:

- Development based on existing conditions of the site topography and area fill of the proposed disposal area;
- Calculation of disposal airspace based on the final elevation of the disposal area which is still to be determined; and
- Compacted waste density of 700 kg/m^3.

It is estimated that the new solid waste facility will be opened in 2015 and that the decommissioning of the West 40 Landfill will begin in 2015.

If the City needs to extend the lifespan of the West 40 landfill there are variations of options that can be developed. These options include:

- Increase compaction of the wastes:
  - It is estimated that current waste density at the site is approximately 400 kg/m^3 based on Operation and Maintenance Manual 2005 revision 2. The current compaction can be increased to 700 kg/m^3 by using new equipment and/or drive the compactor over the thin layer of the waste several times (more than 6 times over the waste). Table B.3 in Appendix B shows that increasing the waste density to 700 kg/m^3 could almost double the remaining airspace capacity.

- Remove metal waste (tires as well) and fill the area:
  - The Government of Nunavut has funded a scrap metal removal program in Iqaluit which has successfully removed significant amounts of metal from various waste management sites around Iqaluit. Although this program no longer has funding, the City may be able be able initiate a new project with a similar objective and possibly expand the objective to include landfilled tires.

- Relocate office and garage and fill the area:
  - The office and garage area would be useable fill areas for the landfill operation but would require relocation. The buildings could be relocated to the north using the entrance to the biosolids management area. This relocation would require a significant reorganization to the entire waste management site including consideration of using the community composting area as part of the City's waste management operations.

- Fill the area further north into areas currently used for electronics, woodwaste and biosolids:
  - The landfill area may potentially expand further north than is currently delineated in the decommissioning plan. This area is significantly smaller than the current operating area because of the encroaching bedrock outcrops on either side. This expansion would require a significant reorganization to the entire waste management site including consideration of using the community composting area as part of the City's waste management operations.
  - Lateral expansion of the waste fill area may be developed by using undisturbed areas of the site or by re-purposing the existing wood waste area as indicated in Drawings 00-C-1001 to 00-C-1003, Appendix A.

- Bring in incineration unit for temporary operation:
  - The application of a portable incineration unit could provide the City with significant waste reduction opportunity if required. This would be the most expensive option for increasing the operating window of the West 40 landfill site.

4. Closure Plan

4.1 General

Closure activities should be considered as part of the landfill operations and routine working practices. As the waste disposal face is filled above ground to the proposed final elevations, the perimeter slopes and surfaces are reclaimed. In this way the landfill is closed and reclaimed progressively throughout the active landfill life.

For scheduled fill development and in preparation of final landfill closure, the site should be supervised when open. Equipment will be used to reshape and compact the waste on a regular basis. In this manner, most grading and reshaping of the landfill required prior to installing the final cap may be completed by judicious placement of incoming waste over the site life, therefore, minimizing re-contouring following closure.

4.2 Final Grading Plan

The proposed final grades of the landfill maintain a minimum slope of 3% across the top of the waste fill area to allow surface water drainage off of the site. The design is based on the following:

- Steeper slopes (to meet 5% grade) at this site would require a significant amount of earthwork to construct, as well as a large quantity of soil fill which there is not available on-site;
- Settlement is expected to be a significant issue due to assumed high waste thickness with low compaction; and
- Cover maintenance is included as part of post-closure care.

4.3 Final Cover Design

The final cover design provides a protective “cap” over the waste fill area. The objectives of the final cover design are to:

- Provide a barrier layer over the waste to minimize infiltration of precipitation into the landfill to minimize leachate generation;
- Create and maintain positive drainage of precipitation off of the landfill and minimize erosion; and
- Provide a layer of soil/gravel on which to establish an acceptable level of vegetative cover.

For the purpose of landfill closure, the entire disposal area will require capping. If the undisturbed ground identified throughout the site (under roads, areas not surveyed, etc) is not filled prior to re-grading, it will be included within the cover design in order to ensure proper drainage off of the cap. Otherwise, areas left uncapped within the final covered footprint may collect surface water and compromise the final cover system.

The final contours of the landfill should promote drainage away from the site to discourage infiltration and leachate production while also preventing erosion. To suit these criteria, a 3H:1V slope is proposed for the side slopes with a 3% grade upwards to the crown of the landfill, directing drainage to the northeast and southwest.

The construction of final cover, or “cap”, includes placement of “topsoil” and “subsoil” and needs to be constructed to satisfy the future management and integrity of the waste fill area. For “topsoil”, the City may use fine granular and/or sewage sludge or composted material and for “subsoil” the City may use granular fill and/or gravel from quarry area. While the topsoil layer should be constructed as soon as possible, it is not necessary to place it immediately after the subsoil layer has been constructed. The purpose of the “cap” is to prevent erosion of the landfill and maintain the integrity of the site.

Generally accepted best practices have been employed for the decommissioning requirements, and the following final cover design is recommended:

- "Topsoil" of fine granular or compost material of 200 mm over subsoil;
- "Subsoil" of 350 mm over barrier layer;
- Barrier layer that is constructed by compacting soils or gravel to a thickness of not less than 600 mm measured perpendicular to the compacted waste surface.
- Contoured such that no water pools on the disposal area; and
- Final cover material graded to achieve a minimum slope of 3% and not to exceed 30%.

A combined estimate of 16,146 m^3 of in place material for the barrier, subsoil and topsoil layer will required to cover the landfill site.

Alternative final cover systems, such as gravel, biosolids, and compost or high density polyethylene (HDPE) may be used due to unavailability of soils in the area. However, HDPE is likely too expensive to be used as cover. If biosolids are used for the purpose of topsoil it is anticipated that the City will require approximately 3 m^3 per day of biosolids or compost or a combination of biosolids and compost to be collected and stored for the period of 2014 to 2015 in order to provide the required amount of topsoil. However, if fine granular is substituted or combined with the material then less biosolids and/or compost will be required.

4.4 Drainage Restoration

The site was developed with surface water management infrastructure. The existing drainage systems include off-site and on-site surface water diversion ditches, on-site drainage pond and off-site retention pond. This drainage system can be seen in Figure 1.1, Appendix A.

Runoff and run-on surface water would be re-directed away from the cap via drainage ditching around the waste disposal area. The runoff drainage ditching will drain in a northern direction, and be further directed towards the off-site retention pond. Run-off collected in the retention pond will be tested and if found to be within acceptable parameters, can be discharged directly to the environment. If the water does not meet acceptable criteria it will be treated as required.

To maintain the integrity of the cover system, the entire fill area will be incorporated into a single cover design which will direct water toward the outer edges and off of the surface, allowing no accumulation on the surface. This translates into incorporating some undisturbed ground area into the footprint of the cover design in order to create smooth contours.

4.5 Re-vegetation

Following the completion of grading operations and the placement of final cover materials, vegetation of the surface will be required in order to prevent erosion of materials and also to integrate the area with the surrounding landscape. Vegetation of the cap should include native tundra species to ensure uptake and longevity of the plants.

A seed mix approved by the City will be selected, comprised of native species and low maintenance grasses to better acclimatize the vegetation to the natural environment and reduce the need for replacement over time.

4.6 Subsidence Remediation

The final cover design objectives include creating and maintaining positive drainage across the fill area. Areas where waste has subsided will be re-graded as part of the final cover installation.

Due to the high elevation of the landfill cell and low compaction, it is expected that future subsidence will occur. Inspection of the final cover for signs of subsidence, erosion or other damage will be performed annually by landfill operators. Should these inspections detect subsidence that interferes with the intended drainage of the site, maintenance will be performed to restore positive drainage while maintaining the final cover design over the site.

5. Post-Closure Plan

5.1 Overview

Best practise standards for decommissioned landfills suggest that, a post-closure plan should operate for a period no less than 25 years. Typically, the post-closure care period should continue until the following circumstances occur:

- Leachate quality performance standards are met at the points of compliance; and/or
- The leachate constituents are lower than the groundwater performance standard criteria concentrations.

During the post-closure care period, the City is responsible to complete the following activities:

- Protecting and maintaining the integrity of the final cover system;
- Providing repairs to the final cover system as necessary to correct settlement, subsidence, erosion, leachate break-out; and
- Monitoring surface water quality and taking corrective action where necessary.

During the post-closure care period the landfill operator should inspect the final cover system at least once per year, and complete an annual report that includes a record of:

- Annual surface water monitoring;
- Maintenance and repairs completed; and
- Any remedial or corrective action taken.

5.2 Post-Closure Care Activities

Post-closure care activities include the following:

- Final Cover Maintenance:
  - Monitoring final cover integrity
  - Prevention of erosion of cover soils
  - Maintenance of vegetation
  - Filling of low areas resulting from settlement or subsidence of the landfill
- Surface Water Monitoring:
  - Annual surface water monitoring
- Monitoring Records:
  - The post-closure care plan includes a program for maintaining records of surface water monitoring, site inspections, maintenance and repairs, and remedial actions.

Table 5.1 below summarizes the post-closure care activities and potential issues and solutions.

Table 5.1 - Post-Closure Activities and Potential Issues and Solutions

Item	Activities	Possible Issues	Response Actions
Final Cover Maintenance	• Monitoring final cover integrity (min 1 time per year) • Maintenance of vegetation (seed, cut, fertilize) as required	• Erosion of final cover • Ponding of water after precipitation in settlement areas	• Replace top and subsoil, vegetate, and apply erosion control product such as mulch and/or erosion matting • Fill settled areas with topsoil, grade to drain. and vegetate
Surface Water Monitoring	• Conduct water sampling program as required by the City's Water License.	• Exceed regulatory requirements	Follow groundwater monitoring plan response which may include: • Resample and confirm • Increase monitoring frequency • Expand monitoring program • Identify potential risks/risk analysis • Investigate possible causes and mitigate
Leachate Management	• Monitor waste fill area for seeps or stains	• Surface springs of leachate	• Prevent drainage to surface water ditches • Investigate cause and design and implement appropriate remediation measures • Fill and grade settlement areas • Maintain final cover vegetation where possible • Increase frequency of site inspections until resolved

For purposes of closure, it is assumed that the entire cleared area will require capping.

6. Implementation Schedule and Cost Estimate

6.1 Closure Schedule

The closure schedule is contingent on the timing for the development of the City's new waste management facility and the waste filling option(s) selected by the City. The closure of the landfill may be initiated as early as 2015, but is subject to confirmation by additional surveying of the area.

Following closure, the landfill must be covered and seeded (it will take a couple of years to become vegetated) within the subsequent summer period. Upon completion of the closure, post-closure care will commence directly following and a closure report will be submitted to the Nunavut Water Board and Nunavut Department of Environment as required.

6.2 Post-Closure Schedule

Post-Closure monitoring will be required for a minimum of 25 years and shall include annual, surface water monitoring and management, and inspections of the final cover. Environmental remediation or cover repair activities shall be scheduled as necessary following detection of groundwater impacts or damage to the landfill cap.

6.3 Closure Cost Estimates

Closure costs for the landfill consist of the capital costs required to grade the existing site to meet minimum slope guidelines and construct the necessary final cap, installation of monitoring wells and re-vegetation. The total cost to carry out the closure plan is approximately $894,000, in 2011 dollars excluding GST.

A representation of the cost structure has been included within Table B.5, Appendix B. The cover material cost is based on a unit cost per square metre. It has been assumed that a 600 mm barrier layer, 350 mm of "substrate", and 200 mm of "topsoil" will be used to cap the existing landfill, based on standard best practice.

6.4 Post-Closure Cost Estimates

It is estimated that annual cost of the post-closure is approximately $65,000 (in 2011) and total post-closure cost for 25 years is approximately $2,820,466 (with 3% annual inflation).

A representation of the cost structure (annual and total costs) has been included within Table B.6, Appendix B.

Appendix A

Figure and Drawings

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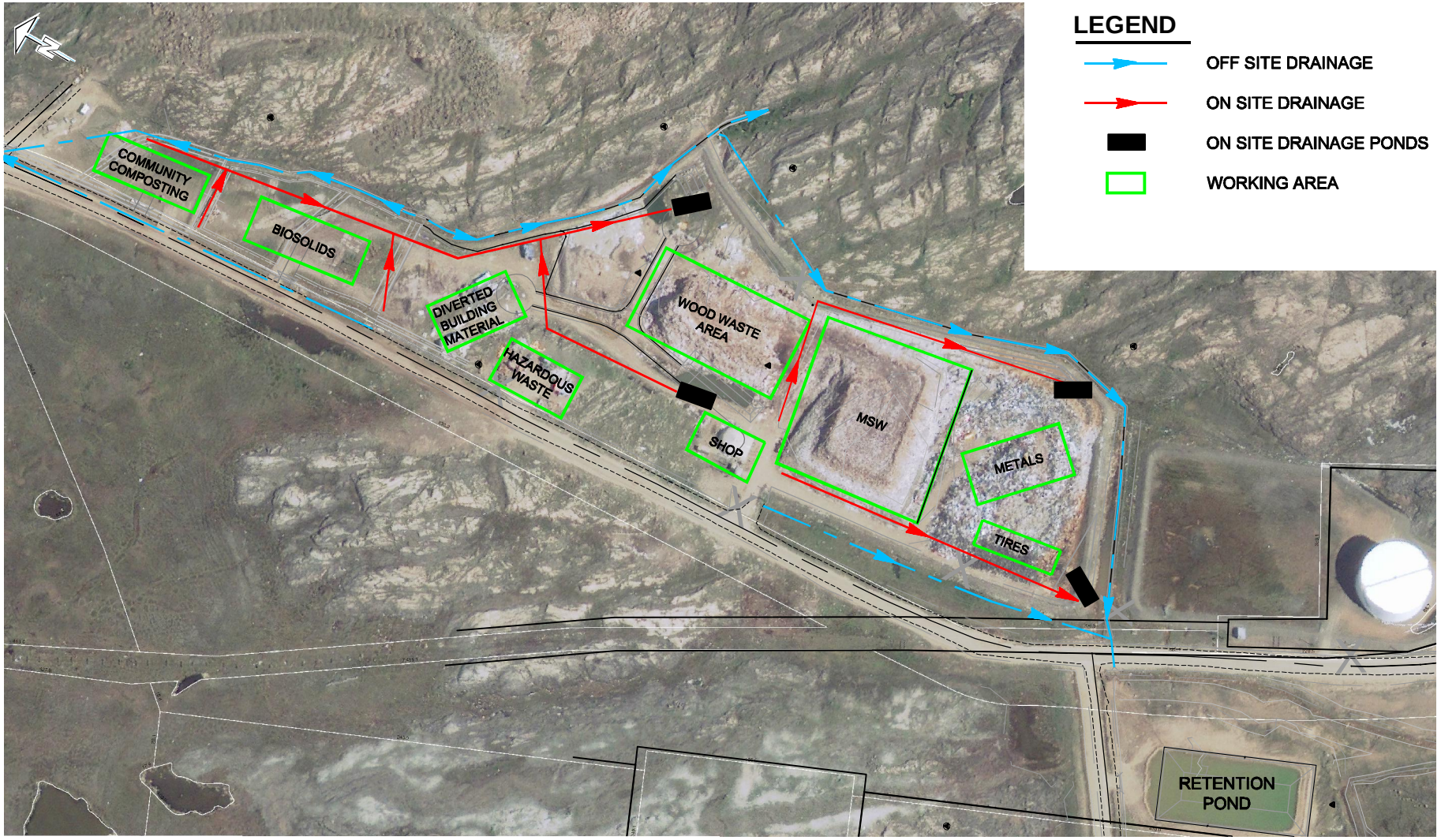

NOTES

1. FOUR ON SITE PONDS ARE EMPTIED BY PUMPING TO RETENTION POND; RETENTION POND IS CONTROLLED BI ANNUAL DISCHARGE AFTER LAB TESTING AND REGULATORY REVIEW.
2. COMMUNITY COMPOSTING IS AN AREA SET ASIDE FOR A FUTURE COMMUNITY PROGRAM.
3. BIOSOLID MANAGEMENT INCLUDES FREEZE THAW DE-WATERING AND COMPOSTING.

AECOM

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City of Iqaluit
Iqaluit SWMP 2011

Landfill Decommissioning Plan
Existing Condition Plan
Figure - 1.1

D SIZE: 22" x 34" (558.8mm x 863.6mm)

City of Iqaluit
Iqaluit SWMP 2011

Landfill Decommisioning Plan

LIST OF PROJECT DRAWINGS

Issued for Report

Issue Date: **11-07-14**

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Set No.: _____

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
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SURVEY CONTROL POINTS			
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500	7067499.11	522878.29	24.06
501	7067621.70	522931.68	31.03
502	7067448.16	523026.42	26.38
503	7067381.56	523040.90	21.35
504	7067188.35	523048.72	19.10
505	7067149.11	522792.72	24.24
UNIVERSAL TRANSVERSE MERCATOR COORDINATES ZONE 16, CENTRAL MERIDIAN 69° WEST (NAD83)			

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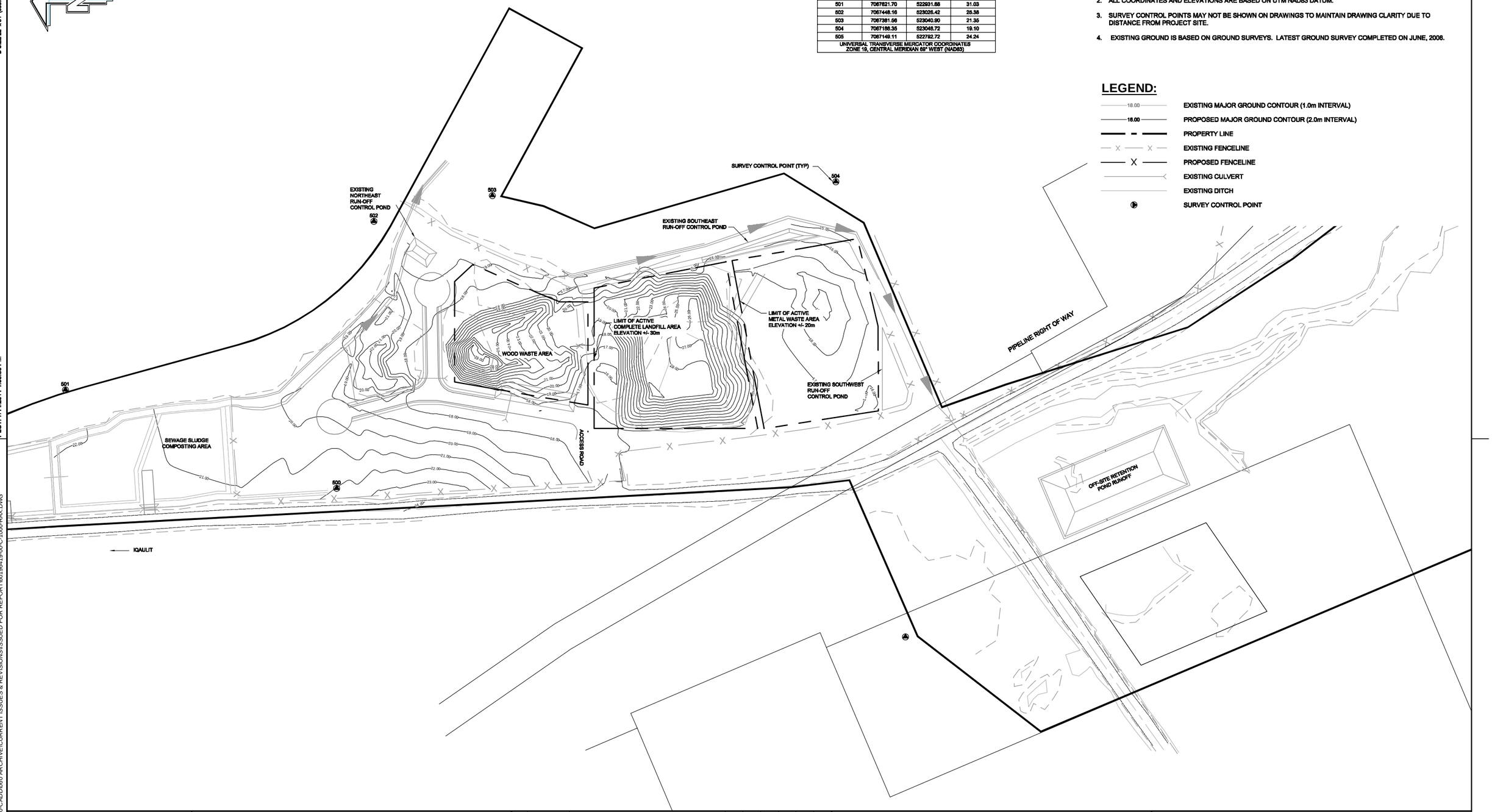
3. SURVEY CONTROL POINTS MAY NOT BE SHOWN ON DRAWINGS TO MAINTAIN DRAWING CLARITY DUE TO DISTANCE FROM PROJECT SITE.
4. EXISTING GROUND IS BASED ON GROUND SURVEYS. LATEST GROUND SURVEY COMPLETED ON JUNE, 2006.

LEGEND:

- EXISTING MAJOR GROUND CONTOUR (1.0m INTERVAL)
- PROPOSED MAJOR GROUND CONTOUR (2.0m INTERVAL)
- PROPERTY LINE
- EXISTING FENCELINE
- PROPOSED FENCELINE
- EXISTING CULVERT
- EXISTING DITCH
- SURVEY CONTROL POINT



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City of Iqaluit
Iqaluit SWMP 2011
Landfill Decommissioning Plan

Existing Conditions Plan

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60196419	00-C-1000	A

D SIZE: 22" x 34" (558.8mm x 863.6mm)
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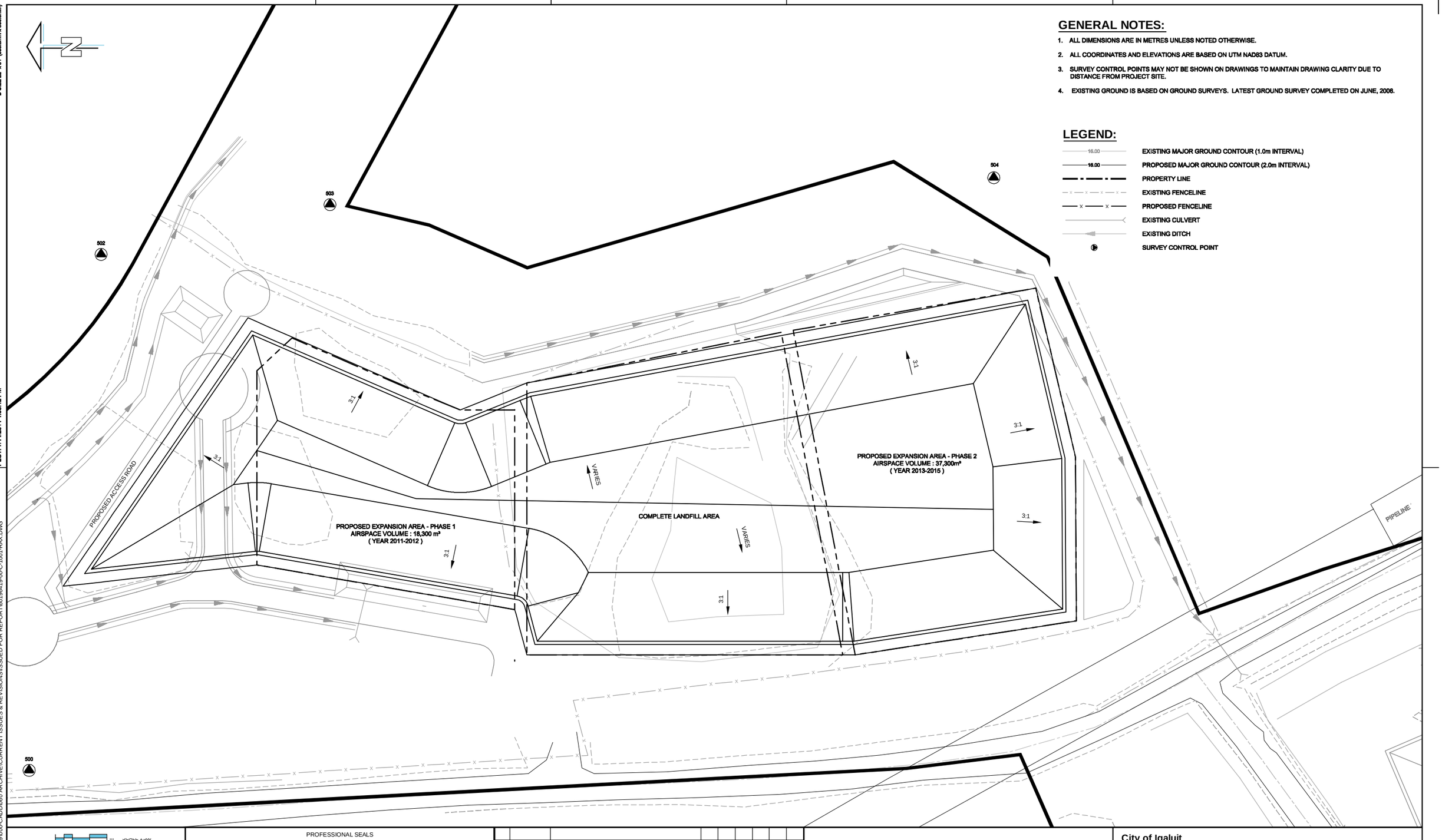
LEGEND:

- 16.00 — EXISTING MAJOR GROUND CONTOUR (1.0m INTERVAL)
- 16.00 — PROPOSED MAJOR GROUND CONTOUR (2.0m INTERVAL)
- PROPERTY LINE
- EXISTING FENCELINE
- PROPOSED FENCELINE
- EXISTING CULVERT
- EXISTING DITCH
- SURVEY CONTROL POINT



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AECOM

City of Iqaluit
Iqaluit SWMP 2011
Landfill Decommissioning Plan

Proposed Site Modification

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60196419	00-C-1001	A

D SIZE: 22" x 34" (558.8mm x 863.6mm)
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GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ALL COORDINATES AND ELEVATIONS ARE BASED ON UTM NAD83 DATUM.
3. SURVEY CONTROL POINTS MAY NOT BE SHOWN ON DRAWINGS TO MAINTAIN DRAWING CLARITY DUE TO DISTANCE FROM PROJECT SITE.
4. EXISTING GROUND IS BASED ON GROUND SURVEYS. LATEST GROUND SURVEY COMPLETED ON JUNE, 2006.

LEGEND:

- EXISTING MAJOR GROUND CONTOUR (1.0m INTERVAL)
- PROPOSED MAJOR GROUND CONTOUR (2.0m INTERVAL)
- PROPERTY LINE
- EXISTING FENCELINE
- PROPOSED FENCELINE
- EXISTING CULVERT
- EXISTING DITCH
- SURVEY CONTROL POINT

PROPOSED PUMP PAD

PROPOSED EXPANSION AREA - PHASE 1
AIRSPACE VOLUME : 18,300 m³
(YEAR 2011-2012)

PROPOSED EXPANSION AREA - PHASE 2
AIRSPACE VOLUME : 37,300m³
(YEAR 2013-2015)

COMPLETE LANDFILL AREA

PROPOSED ACCESS ROAD

500 501 502 503 504

A 00-C-1003 | B 00-C-1003 | C 00-C-1003 | D 00-C-1003

0 5 10 15

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City of Iqaluit
Iqaluit SWMP 2011
Landfill Decommissioning Plan

Proposed Final Contour

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60196419	00-C-1002	A

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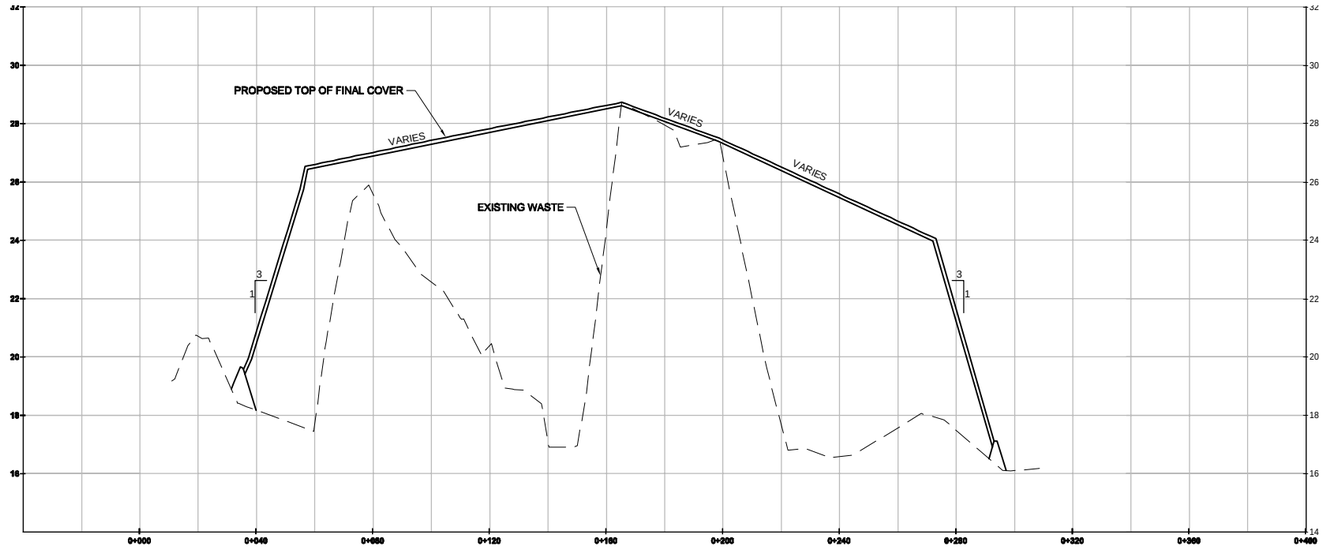

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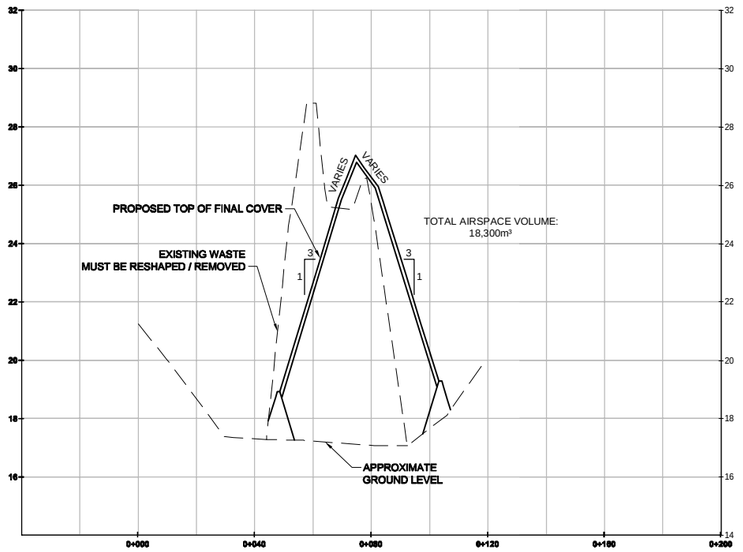

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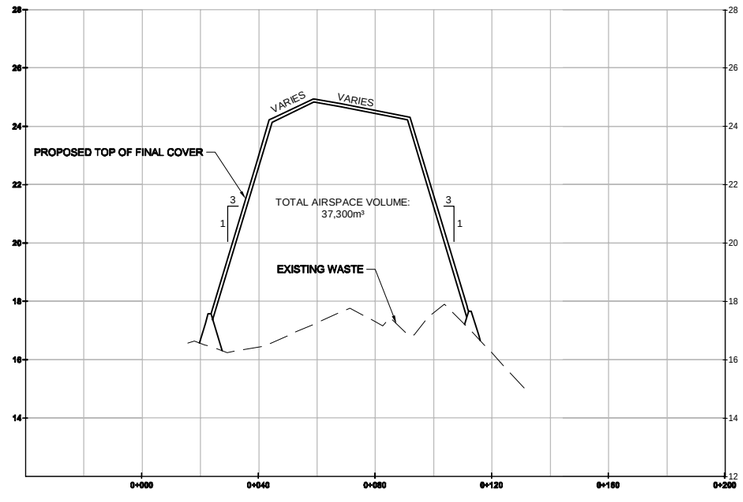

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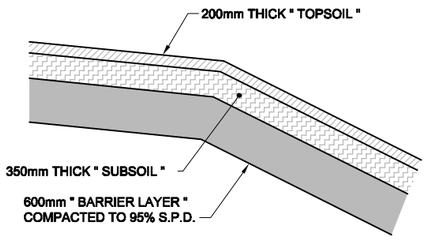

TYPICAL FINAL COVER DETAIL

SCALE: NTS

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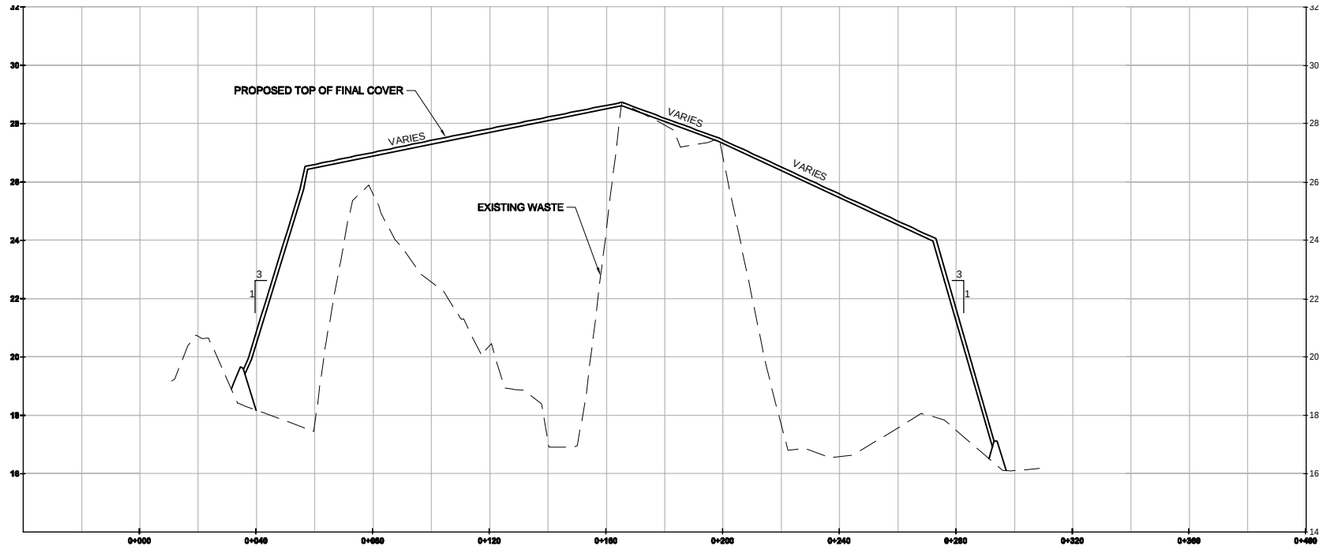
Iqaluit SWMP 2011
Landfill Decommissioning Plan

Cross Sections and Detail

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60196419	00-C-1003	A

D SIZE: 22" x 34" (558.8mm x 863.6mm)



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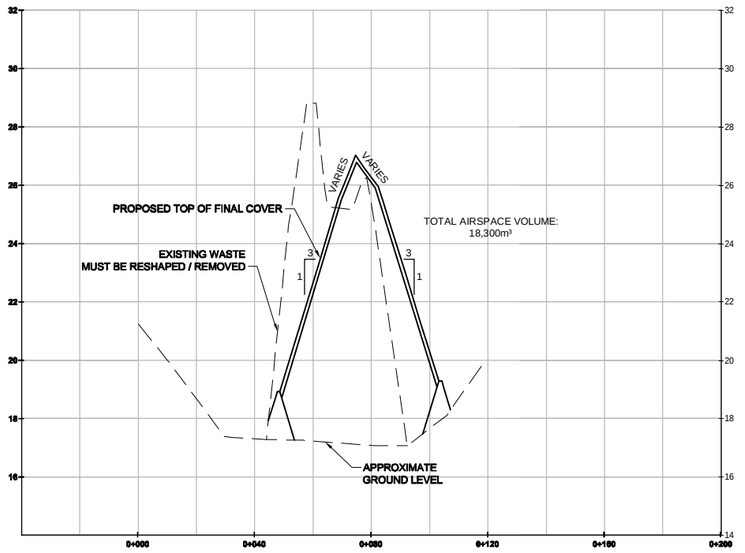

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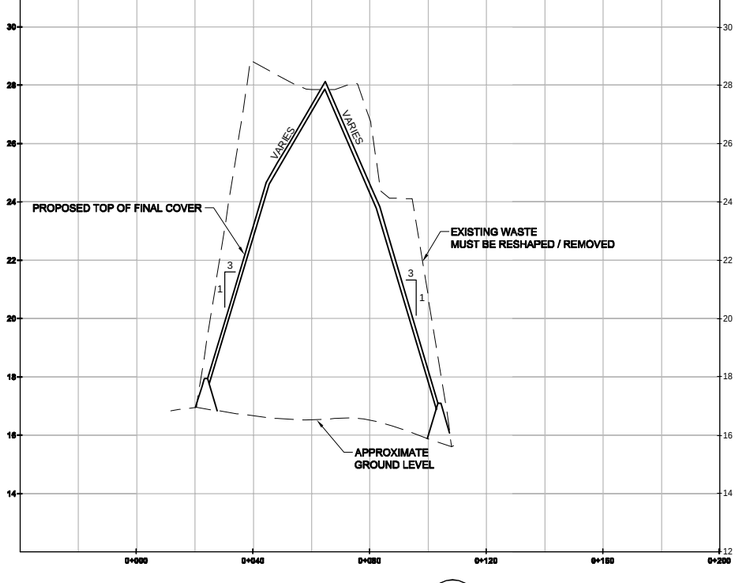

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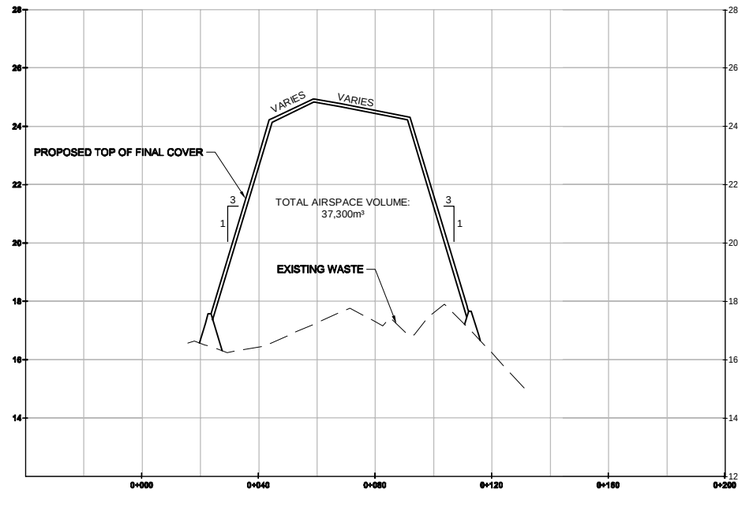

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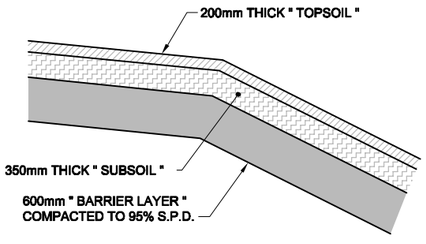

TYPICAL FINAL COVER DETAIL

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City of Iqaluit
Iqaluit SWMP 2011
Landfill Decommissioning Plan

Cross Sections and Detail

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60196419	00-C-1003	A

Appendix B

Design Calculations and Cost Estimate

Table B.1 - Population and Waste Projections

Year	Population	Waste Generated (m^3)[b]	Accumulated Waste (m^3)	Waste Generated (tonnes)[c]	Accumulated Waste (tonnes)
2006[a]	**6,520**	71,394		7,139	
2007[a]	**6,802**	74,482		7,448	
2008	6,997	76,620		7,662	
2009[a]	7,198	78,818		7,882	
2010[a]	7,405	81,085		8,108	
2011[a]	**7,618**	**83,412**	**83,412**	**8,341**	**8,341**
2012	7,836	85,806	169,218	8,581	16,922
2013	8,061	88,268	257,486	8,827	25,749
2014	8,292	90,802	348,288	9,080	34,829
2015[a]	**8,532**	**93,425**	**441,713**	**9,343**	**44,171**
2016	8,777	96,107	96,107	9,611	9,611
2017	9,029	98,865	194,972	9,886	19,497
2018	9,288	101,702	296,674	10,170	29,667
2019	9,554	104,621	401,295	10,462	40,130
2020[a]	**9,830**	**107,639**	**508,934**	**10,764**	**50,893**
2021	10,112	110,728	619,662	11,073	61,966
2022	10,402	113,906	733,567	11,391	73,357
2023	10,701	117,175	850,742	11,717	85,074
2024	11,008	120,538	971,279	12,054	97,128
2025[a]	**11,326**	**124,020**	**1,095,299**	**12,402**	**109,530**
2026	11,651	127,579	1,222,878	12,758	122,288
2027	11,985	131,241	1,354,119	13,124	135,412
2028	12,329	135,007	1,489,126	13,501	148,913
2029	12,683	138,882	1,628,008	13,888	162,801
2030[a]	**13,050**	**142,898**	**1,770,905**	**14,290**	**177,091**
2031	13,425	146,999	1,917,904	14,700	191,790
2032	13,810	151,218	2,069,122	15,122	206,912
2033	14,206	155,557	2,224,679	15,556	222,468
2034	14,614	160,022	2,384,701	16,002	238,470
2035	**15,033**	**164,615**	**2,549,316**	**16,461**	**254,932**
2036	15,465	169,339	2,718,655	16,934	271,865

a Calculation based on available airspace for accepted waste, determined by design

[a] Source : City of Iqaluit General Plan By Law 703, October 2010. Table 1 - Medium Projection, page 16.

[a] Average annual rate of 2.87% was used to estimate the population (General Plan By Law 703)

[b] Assumed waste generation rate is 0.03 m^3/person/day or 1,095 m^3/person/year

[c] Density of uncompacted waste is 100 kg/m^3

Table B.2 - Estimate of Total Air Space Required

Year	Design of waste disposal		Waste disposal volume (density of 700 kg/m^3)		Soil cover volume required (waste to soil cover ratio12:1)		Total air space required		Total air space required	
	Yearly	Accumulated	Yearly	Accumulated	Yearly	Accumulated	Yearly	Accumulated	Yearly	Accumulated
	tonnes	tonnes	m^3	m^3	m^3	m^3	m^3	m^3	Tonnes	Tonnes
2011	8,341	8,341	11,916	11,916	993	993	12,909	12,909	9,036	9,036
2012	8,581	16,922	12,258	24,174	1,021	2,014	13,279	26,188	9,296	18,332
2013	8,827	25,749	12,610	36,784	1,051	3,065	13,661	39,849	9,562	27,894
2014	9,080	34,829	12,972	49,755	1,081	4,146	14,053	53,902	9,837	37,731
2015	9,343	44,171	13,346	63,102	1,112	5,258	14,459	68,360	10,121	47,852
2016[a]	**9,611**	**9,611**	**13,730**	**13,730**	**1,144**	**1,144**	**14,874**	**14,874**	**10,412**	**10,412**
2017	9,886	19,497	14,124	27,853	1,177	2,321	15,301	30,174	10,710	21,122
2018	10,170	29,667	14,529	42,382	1,211	3,532	15,740	45,914	11,018	32,140
2019	10,462	40,130	14,946	57,328	1,245	4,777	16,191	62,105	11,334	43,474
2020	10,764	50,893	15,377	72,705	1,281	6,059	16,658	78,764	11,661	55,134
2021	11,073	61,966	15,818	88,523	1,318	7,377	17,136	95,900	11,996	67,130
2022	11,391	73,357	16,272	104,795	1,356	8,733	17,628	113,528	12,340	79,470
2023	11,717	85,074	16,739	121,535	1,395	10,128	18,134	131,662	12,694	92,164
2024	12,054	97,128	17,220	138,754	1,435	11,563	18,655	150,317	13,058	105,222
2025	12,402	109,530	17,717	156,471	1,476	13,039	19,194	169,511	13,435	118,657
2026	12,758	122,288	18,226	174,697	1,519	14,558	19,744	189,255	13,821	132,478
2027	13,124	135,412	18,749	193,446	1,562	16,120	20,311	209,566	14,218	146,696
2028	13,501	148,913	19,287	212,732	1,607	17,728	20,894	230,460	14,626	161,322
2029	13,888	162,801	19,840	232,573	1,653	19,381	21,494	251,954	15,046	176,368
2030	14,290	177,091	20,414	252,986	1,701	21,082	22,115	274,069	15,481	191,848
2031	14,700	191,790	21,000	273,986	1,750	22,832	22,750	296,818	15,925	207,773
2032	15,122	206,912	21,603	295,589	1,800	24,632	23,403	320,221	16,382	224,155
2033	15,556	222,468	22,222	317,811	1,852	26,484	24,074	344,296	16,852	241,007
2034	16,002	238,470	22,860	340,672	1,905	28,389	24,765	369,061	17,336	258,343
2035	16,461	254,932	23,516	364,188	1,960	30,349	25,476	394,537	17,833	276,176
2036	16,934	271,865	24,191	388,379	2,016	32,365	26,207	420,744	18,345	294,521

[a] New landfill is expected to be constructed in 2015. Thus, waste generated in 2016 will be disposed at the new landfill.

Table B.3 - Area Required

Description	Quantity	Quantity	Unit
Total waste generation 2016 to 2036 (20 years)	2,718,655		m^3
Total waste generation until 2036 with the density of 100 kg/m^3	271,865		tonnes
Airspace requirement until 2036 with a density of 400 and 700 kg/m^3		**Density**	
for future landfill	700	400	kg/m^3
Total airspace for requirement for accepted waste	388,379	679,664	m^3
Total "soil" requirement for cover material (waste to soil ratio of 12:1)	32,365	56,639	m^3
Total airspace for the future landfill (in m^3)	420,744	736,302	m^3
Total airspace for the future landfill (in tonnes)	294,521	294,521	tonnes
Area requirement for the future landfill with average height of 15 m			
Determined by design; H =	15	15	m
Determined by design; L =	400	500	m
Calculated; W =	220	350	m
Landfill Cell Area =	**88,000**	**175,000**	**m^2**
Additional space for utilities, road, temporary recycle compound, etc. is assumed 30% of the area required			
Additional Area =	**26,400**	**52,500**	**m^2**
Total Area required =	**114,400**	**227,500**	**m^2**
L =	500	500	m
W =	229	455	m
Area requirement determined by design for 20 years lifespan:			
L =	**500**	**500**	**m**
W =	**250**	**500**	**m**
A =	**125,000**	**250,000**	**m^2**

Table B.4 - Construction Sequence and Site Utilization

Year	Waste disposed[a] (tonnes)	Accumulated Waste (tonnes)	Created Airspace Capacity (tonnes)	Accumulated Airspace Capacity (tonnes)	Capacity Remaining at year end[b] (tonnes)	Estimated Airspace Remaining at year end[c] (m^3)	Note
2011	9,036	9,036					Utilized Stage 1
2012	9,296	18,332					Utilized Stage 1
2013	9,562	27,894					Utilized Stage 2
2014	9,837	37,731					Utilized Stage 2
2015	10,121	47,852					Utilized Stage 2 and closed entire West 40 landfill; and Construct New Landfill in New Site
2016	10,412	10,412	294,521	284,109	284,109	405,871	Open and Operate New Landfill
2017	10,710	21,122		284,109	273,399	390,570	
2018	11,018	32,140		273,399	262,381	374,830	
2019	11,334	43,474		262,381	251,047	358,639	
2020	11,661	55,134		251,047	239,386	341,981	
2021	11,996	67,130		239,386	227,391	324,844	
2022	12,340	79,470		227,391	215,051	307,216	
2023	12,694	92,164		215,051	202,357	289,082	
2024	13,058	105,222		202,357	189,299	270,427	
2025	13,435	118,657		189,299	175,864	251,234	
2026	13,821	132,478		175,864	162,042	231,489	
2027	14,218	146,696		162,042	147,825	211,178	
2028	14,626	161,322		147,825	133,199	190,284	
2029	15,046	176,368		133,199	118,153	168,791	
2030	15,481	191,848		118,153	102,673	146,675	
2031	15,925	207,773		102,673	86,748	123,926	
2032	16,382	224,155		86,748	70,366	100,523	
2033	16,852	241,007		70,366	53,514	76,449	
2034	17,336	258,343		53,514	36,178	51,683	
2035	17,833	276,176		36,178	18,345	26,207	
2036	18,345	294,521		18,345	0	(0)	Landfill Closed

[a] Waste to be disposed include soil cover

[b] Calculation based on airspace for accepted waste determined by design

[c] Conversion from metric tonnes to cubic meters using a compacted waste density of 700 kg/m^3

Table B.5 - Estimated Cost of West 40 Landfill Decommissioning Plan

No	Description	Unit	Approx. Quantity	Unit Price	Amount
A	**DECOMMISSIONIONG (CLOSURE) COST**				
1	Reporting: closure and post-closure plan	Lump Sum	1	$50,000	$50,000
2	General Requirements Includes: - Mobilization and demobilization - All other works for construction intent	Lump Sum	1	$200,000	$200,000
3	Surveying	Cash Allowance	1	$50,000	$50,000
4	Final Cover Construction				
a)	Barrier Layer: 600 mm gravel/shales from nearest quary				
	- Not Available onsite	m^2	5,382	$20	$107,640
	- QA/QC	day	30	$1,200	$36,000
b)	Subsoil 350 mm thick mulch: supply and placement	m^2	5,382	$10	$53,820
c)	Topsoil 200 mm thick biosolid: supply, placement and seeding	m^2	5,382	$10	$53,820
5	Monitoring Wells Construction - six wells	Lump Sump	6	$1,000	$6,000
6	Miscellaneous Activities Removal of:				
	- Site Building	Lump Sum	1	$20,000	$20,000
	- Recycle area	Lump Sum	1	$10,000	$10,000
	- Tire, Wood, Metal, and Appliance Piles	Lump Sum	1	$50,000	$50,000
	Sub Total Closure Cost				**$637,280**
	Professional Service (Design and Construction)			**10%**	**$63,728**
	Contingency Plan			**20%**	**$127,456**
	TOTAL CLOSURE COST				**$828,464**
B	**POST-CLOSURE COST**				
1	Annual Groundwater Monitoring include inspection of: - Inspection of Cover, Vegetation, Site Security, and Surface Drainage - Lab Analysis - Reporting	Times/Year	2	$20,000	$40,000
2	Annual Report	Lump Sump	1	$10,000	$10,000
	Sub Total Post Closure Cost				**$50,000**
	Professional Service			**10%**	**$5,000**
	Contingency Plan			**20%**	**$10,000**
	TOTAL POST-CLOSURE COST PER YEAR				**$65,000**

Note:
Assumed inflation rate of 3%.
Calculated in July 14, 2011

Table B6 - Estimated Maintenance Cost for 25 Years Post-Closure

Year	Initial Cost	Years	Annual Cost	Accumulated Cost	Note
2011	$65,000	0	$65,000		
2012		1	$66,950		
2013		2	$68,959		
2014		3	$71,027		
2015		4	$73,158	$73,158	Landfill Closed
2016		5	$75,353	$148,511	
2017		6	$77,613	$226,124	
2018		7	$79,942	$306,066	
2019		8	$82,340	$388,406	
2020		9	$84,810	$473,216	
2021		10	$87,355	$560,571	
2022		11	$89,975	$650,546	
2023		12	$92,674	$743,221	
2024		13	$95,455	$838,675	
2025		14	$98,318	$936,994	
2026		15	$101,268	$1,038,262	
2027		16	$104,306	$1,142,567	
2028		17	$107,435	$1,250,003	
2029		18	$110,658	$1,360,661	
2030		19	$113,978	$1,474,639	
2031		20	$117,397	$1,592,036	
2032		21	$120,919	$1,712,955	
2033		22	$124,547	$1,837,502	
2034		23	$128,283	$1,965,785	
2035		24	$132,132	$2,097,916	
2036		25	$136,096	$2,234,012	
2037		26	$140,178	$2,374,190	
2038		27	$144,384	$2,518,574	
2039		28	$148,715	$2,667,290	
2040		29	$153,177	$2,820,466	

Note:
Assumed inflation rate of 3%.
Calculated in June 20, 2011

Appendix C

Monitoring and Inspection Forms

Closed Landfill Inspection Report

Section 1:

Facility:		
Owner:		
Location:		
Legal Land Description:		
Approximate closure date:	Approximate size	
Inspector:	Inspection date:	
Other people present:		

Section 2 Vegetation:

Type(s) of growth (check all that apply): □ grasses □ herbaceous plants □ moss	Remarks:
Condition of growth: □ Excellent (thick growth) □ Good □ Poor (thin growth, bare soil, mosses)	Remarks:
Invasive plants present? □ Yes □ No	Remarks:
Dead spots present? □ Yes □ No	Remarks:

Section 3 Final Cover Condition:

Is there subsidence (depressions in the cap)? □ Yes □ No	Remarks:
Is there any evidence of water ponding on the cap? □ Yes □ No	Remarks:
Are there colored leachate seeps through the cap? □ Yes □ No	Remarks:
Are there colored leachate seeps at toe slope? □ Yes □ No	Remarks:
Are there signs of burrowing animals? □ Yes □ No	Remarks:
Is there any waste pushing through the cap? □ Yes □ No	Remarks:
Does the cap cover all of the solid waste? □ Yes □ No	Remarks:
Is there evidence of erosion? □ Yes □ No	Remarks:
Is there ATV damage to the cap or vegetation? □ Yes □ No	Remarks:

Section 4 Drainage and Surface Water:

Conditions/Stability of streams/swales/ditches etc. □ Excellent (unobstructed) □ Good □ Poor (overgrown or sediment filled)	Remarks:
Is there evidence of colored leachate in surface waters? □ Yes □ No	Remarks:
Is there surface water monitoring? □ Yes □ No	Remarks:

Section 5 Other Facility Conditions:

Access road condition: □ Excellent □ Good □ Poor	Remarks:
Gates and fences: □ Present □ Not present	Remarks:
Gate and fence condition: □ Excellent □ Good □ Poor	Remarks:

Section 6 Structures:

Are there man made structures on the cover? □ Yes □ No	Remarks

Section 7 General cleanliness of the site:

Is there litter present? □ Yes □ No	Remarks:
Is there evidence of unauthorized dumping? □ Yes □ No	Remarks

Section 8 Maintenance:

Is there an ongoing maintenance program? □ Yes □ No	Remarks:
Comments on the effectiveness:	

Section 9 Other Information:

- Attach a hand drawn site sketch made on plain paper 8 1/2" x 11"
- Attach labeled photographs of landfill conditions and any nearby development
- Describe any corrective actions planned or taken as a result of conditions noted during the inspection (attached additional pages if necessary):