

Lupin Mines Incorporated

A wholly owned indirect subsidiary of Mandalay Resources Corporation

Lupin Mine Site

Nunavut, Canada

Waste Management Plan (Solid and Hazardous)

(Care and Maintenance)

March 2016

Lupin Mines Incorporated
Mandalay Resources Corporation
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Document Control

Revision No	Date	Details	Author	Approver
1.0	20/03/12	<p>Reformatted to Lupin Mines standard</p> <p>Revised and updated to reflect new ownership and contact information</p> <p>Updated discussion of onsite waste management facilities to reflect current facility usage, and include burn pit, waste oil storage</p> <p>Removed reference to landfarm</p> <p>Added Figures, illustrating waste management facilities</p> <p>Removed discussion on hazardous material purchase; not relevant to current activities</p> <p>Updated discussion on aerosol can disposal</p> <p>Added comment on recycling</p> <p>Removed reference to drum storage building</p> <p>Added reference to waste generator number</p> <p>Updated section on records to reflect current status</p> <p>Addressed comments from AANDC (2010)</p>	S. Hamm	P. Downey
2.0	24/02/13	<p>Updated contact and general information</p> <p>Updated environmental policy</p> <p>Updated to reflect current site activities and procedures</p> <p>New incinerator operating installed in 2012 and operating procedures attached</p> <p>Proposed use of waste oil furnaces described</p>	D. Vokey	W. Osborne
3.0	25/03/16	<p>Updated to reflect new water licence</p> <p>Updated contact and general information</p> <p>Updated references to MSDS to Safety Data Sheets (SDS)</p> <p>Added information about the Landfill and Landfarm facility requirements</p> <p>Added open burning requirements</p> <p>Updated sections 7.2, 8.2 to reflect timing requirements to deal with materials contaminated with metals, scrap metal</p> <p>Removed reliance on the winter road from Section 8.1</p>	SRK	K. Lewis

Executive Summary

Lupin Mines Incorporated (LMI), a wholly owned indirect subsidiary of Mandalay Resources Corporation (Mandalay), has prepared this Waste Management Plan – Solid and Hazardous (the Plan).

A review of the Plan takes place and revisions are submitted as necessary with the annual report. The current Type A water licence 2AM-LUP1520 (Water Licence) for the Lupin Gold Mine (Lupin or the Lupin Mine or the Site) is valid until August 18, 2020.

Executive Summary Inuktitut

Awaiting translation – to be provided as soon as possible

Executive Summary Inuinnaqtun

Awaiting translation – to be provided as soon as possible

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1 Introduction

Lupin Mines Incorporated (LMI), a wholly owned indirect subsidiary of Mandalay Resources Corp., has prepared this Solid Waste Management Plan (the Plan).

An annual review of the Plan takes place and revisions are submitted as necessary with the annual report. The current Type A Water Licence 2AM-LUP1520 (Water Licence) for the Lupin Gold Mine (Lupin or the Lupin Mine or the Site) is valid until August 18, 2020.

1.1 Project and Company Information

Mandalay is a Canadian based company focused on producing assets in Australia, Chile and Sweden, a development project in Chile and the exploration and development of the past-producing Lupin Gold Mine and the Ulu gold project, both located in Nunavut, Canada.

Mandalay purchased Elgin Mining Inc., which owns LMI and the Lupin Mine, in September 2014. Lupin was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004. The mine resumed production in March 2004 until February 2005. Since 2005, the Site has remained in Care and Maintenance.

General site maintenance and facilities upgrades are underway at the Lupin Mine to assess operational requirements. The activities underway were screened by the Nunavut Impact Review Board under file 99WR053 and approved by the Nunavut Water Board under Water Licence 2AM-LUP1520. Surface exploration is conducted under Water Licence 2BE-LEP1217. All camp infrastructure required for the surface exploration program currently exists at the Lupin Mine

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Project:	Lupin Mine, Nunavut
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Effective Date: March 18, 2016

Distribution List:

Karyn Lewis	General Administration
Discovery Mining Services	Site Contractor
Golder Associates	Site Consultant
SRK Consulting	Site Consultant

Additional copies of this Plan are available from General Administration. This Plan will be posted in key locations at the site, and all employees and contractors will be made aware of its contents.

1.1 Site Location

The Lupin Mine is located in the Kitikmeot Region, Nunavut, 400 km north of Yellowknife, Northwest Territories and 285 km southeast of Kugluktuk, Nunavut. The airport serving this Site is at 65° 46'00" N and 111° 14'41" W. The Site is on the western shore of Contwoyto Lake, approximately 60 km south of the Arctic Circle (Figure 1).

1.2 Environmental and Sustainable Development Policy

Lupin Mine Incorporated (LMI) is committed to maintaining a safe, clean, compliant and respectful work environment. LMI looks to our employees, contractors and managers to adopt and grow a culture of social responsibility and environmental excellence. Together we achieve this by:

- Promoting environmental stewardship in all tasks. Nothing is too important that it cannot be done in a clean and responsible manner. We strive towards maintaining a zero-incident work place.
- Recognizing that we have a shared responsibility as stewards of the environment in which we operate. We will not walk away from a non-compliant act.
- Identifying, managing and mitigating environmental, business and social risks in an open, honest and transparent manner.
- Planning our work so it is done in the cleanest possible manner and executing work according to plan.
- Continually improving environmental and operational performance by setting and reviewing achievable targets.
- Providing appropriate and necessary resources in the form of training, personnel and capital, including that required for closure planning and reclamation.
- Managing our materials and waste streams, maintaining a high degree of emergency response preparedness and minimizing our operational footprint to maintain environmental protection at all stages of project development.
- Procuring goods and services locally, where available, and favouring suppliers with environmentally and socially responsible business practices.
- Seeking to understand, learn from and mitigate the root causes of environmental incidents and near misses when they do occur.
- Employing systems and technology to achieve compliance, increase efficiency and promote industry best practices in development, operations and environmental stewardship.
- Working with stakeholders to identify and pursue opportunities for sustainable social and economic development and capacity building.

- Conducting early and ongoing stakeholder engagement relevant to the stage of project and mine development and operation.
- Recognizing diversity in the workplace and building meaningful relationships with all stakeholders in a timely, collaborative and transparent manner.

Through implementation of this policy, LMI seeks to earn the public's trust and be recognized as a respectful and conscientious employer, neighbor and environmental steward.

1.3 Purpose and Scope

This Plan is an appendix to the Care and Maintenance Plan. This Plan is designed to address waste management criteria established in Water Licence 2AM-LUP1520 and Indigenous and Northern Affairs Canada (INAC) Surface Leases 76E/14-1-9(2) (mine site) and 76E/14-2-10 (airport). Waste management criteria established in surface exploration Water Licence 2BE-LEP1217 and associated Land Use Permit N2011C0026 relies on use of the Lupin Mine facilities and this Plan. The Plan provides information for identification, segregation, handling and disposal of solid and hazardous waste at Lupin during Care and Maintenance.

The objectives of the Plan are to:

- Provide guidance for solid and hazardous waste management at Lupin; and
- Describe the responsibility and tasks involved with waste management.

2 Waste Identification

Typical waste generated on site during Care and Maintenance includes domestic and hazardous waste, and, in the event of a spill, contaminated soils. In order to determine if a solid waste is a hazardous waste, LMI shall:

- Refer to the safety data sheets (SDS), previously referred to material safety data sheets (MSDS), for the material in question,
- Maintain an inventory of materials on site and their classification, and
- Review the materials inventory on an annual basis.

All wastes generated by LMI's activities are classified by appropriately trained personnel. Common knowledge can be used to determine that materials such as paper, untreated wood, concrete and food scraps are not hazardous waste. LMI conducts site inspections and observe waste periodically. All Site workers are instructed to call the on-site Environmental Coordinator or their on-site designate if uncertain about waste products and their storage and disposal methods.

3 Waste Segregation

After the waste is identified, it is segregated at the source. The following waste streams are currently being segregated: domestic waste; domestic recycling; scrap metal; oily waste; aerosols; combustibles; batteries; spent canisters (propane, acetylene). Each waste stream, with the exception of domestic waste, is stored on site for future removal or recycling.

4 Waste Diversion

Where possible, waste diversion, including material re-use and recycling, will occur; for example domestic drink containers. Where diversion is not an option, waste will be disposed of at onsite facilities or shipped offsite to a third party waste receiver.

5 Solid Waste Disposal Facilities

Waste management facilities at Lupin include an incinerator, a “boneyard” (for decommissioned tanks, buildings, and equipment), a landfill, a landfarm, two burn pits (annual applications to INAC are required for open burning) and waste oil storage (Figure 2). In the event that a waste management facility on site is not useable, waste is appropriately segregated, stored such that it is inaccessible to wildlife and shipped to a third party waste receiver in Yellowknife, NT.

5.1 Incinerator

An incinerator has been used to incinerate combustible, inert solids throughout the life of the Lupin Mine. A new incinerator was installed in 2012. The incinerator is a cinder block building that is secure from wildlife. The following types of material will be incinerated:

- Organic waste (such as kitchen waste),
- Wood,
- Paper,
- Cardboard,
- Air filters,
- Domestic waste,
- Light plastics (bags, thin plastics),
- Cooking waste oil (small amounts, used as incinerator fuel) and
- Poor grade diesel fuel (small amounts, used as incinerator fuel).

The Inciner8 Model A600X incinerator is a dual stage forced air commercial incinerator that will operate on diesel fuel or kerosene. The Operations and Maintenance Procedure for the incinerator is included as

Appendix A. The document was developed in accordance with *Technical Document for Batch Waste Incineration* (Environment Canada, 2010).

5.2 Landfill

Water Licence 2AM-LUP1520 authorizes LMI to use the existing on-site Landfill facility to dispose of non-hazardous and non-combustible waste generated by the Site. Landfill seepage management required under Part E(19) and Part E(25) of the Water Licence is described in the Lupin Mine *Liquid Waste Management Plan*. The waste items acceptable for landfilling are listed in the Lupin Mine *Landfill Management Plan* (Appendix B) along with the landfill deposition protocol.

5.3 Burn Pit

One burn pit is located on site adjacent to the landfill, and a second one is at the north end of the site (Figure 2). Historically, combustible non-hazardous, non-domestic waste was open-burned here. LMI would like to continue to utilize the burn pit accordingly. Permits to open burn are applied for on an annual basis through INAC. The waste items accepted for open burning are listed in the Lupin Mine *Landfill Management Plan* (Appendix B).

5.4 Waste Oil Storage

A waste oil tank farm, (two above ground storage tanks located in secondary containment), and a lube oil and grease storage area exist on site. The waste oil tank farm contains oil, but no oil is being transferred in or out of the tanks until the tanks and pipeline system is upgraded to meet the current Environment Canada Regulations. Used oil is currently placed in sealed containers and stored in a bermed area adjacent to the main tank farm. The waste oil is either shipped off-site for disposal or used in the waste oil furnaces are on site.

6 Solid (Non Hazardous) Waste Management

Routinely generated non-hazardous solid waste are collected and segregated, along with bulk liquids, or bulk petroleum products (waste solvents, used oil, oil filters, aerosol cans, batteries, mercury vapour lamps, mercury switches, used greases). Such wastes include:

- Kitchen wastes, paper, scrap metal (including non-returnable drums that have been crushed),
- Demolition debris (e.g.; scrap wood, scrap metal, concrete), and
- Maintenance shop wastes (e.g. drained and crushed oil filters, punctured and drained aerosol cans, floor clean-up, used spill absorbent pads and materials).

Demolition waste and maintenance shop waste are stored and backhauled, as opportunities arise to Yellowknife for disposal at a third party facility or disposed of in the landfill facility or burn pit as described in the *Landfill Management Plan* (Appendix A).

The new incinerator is operational and is used to burn the domestic and kitchen waste.

Used shop grease, which has been determined to be non-hazardous waste, shall be collected in drums for disposal offsite at a third party facility.

Heavy equipment tires and light vehicle tires that cannot be returned to the vendor are placed in the on-site landfill.

Recyclable containers, primarily food and beverage containers, are segregated and shipped off site for management by a third party waste receiver.

7 Contaminated Soil Management

7.1 Materials Contaminated with Petroleum Products

Hydrocarbon impacted soil, that has resulted from gasoline and diesel fuel spills during care and maintenance, will be remediated in the landfarm facility. Operating guidance for the landfarm is provided in the *Landfarm Management Plan* (Appendix C). For spills of oil and grease during care and maintenance; once spill response measures described in the *Spill Contingency Plan* have been completed the impacted soil will be remediated during final closure and reclamation of the site.

7.2 Materials Contaminated with Metals

Materials contaminated with metals require excavation only if the material would be considered a remnant of hazardous materials. These materials should be managed according to the procedures for hazardous materials. Metal-contaminated material that is not remnant of hazardous materials may be left buried in place, consolidated and covered and/or placed in the Tailings Containment Area during final closure and reclamation of the site.

7.3 Materials Contaminated with Solvents

Materials contaminated with solvents containing greater than 10% chlorinated and/or fluorinated hydrocarbons shall be excavated until there is no visible sign of contamination, containerized and disposed off-site as a hazardous material.

Material contaminated with solvents other than those containing greater than 10% chlorinated and/or fluorinated hydrocarbons shall be excavated until there is no visible sign of contamination, and managed as petroleum-contaminated soil.

8 Hazardous Waste Management

Hazardous waste is managed in accordance with the Government of Nunavut *Environmental Guideline for the General Management of Hazardous Waste* (2010), the Transport Canada's *Transportation of Dangerous Goods Regulations* and the Canadian Environmental Protection Act's *Inter-provincial Movement of Hazardous Waste Regulations*.

8.1 Batteries

All used batteries, including general purpose batteries (flashlight, lantern batteries); lithium, nickel cadmium, and lead acid batteries shall be collected and stored in order to prevent the release of any hazardous constituents to the environment. The batteries are to be transported off-site for disposal at an approved facility as opportunities arise to Yellowknife for disposal at a third party facility.

8.2 Empty Drums and Scrap Metal

Metal drums are in high demand at Site, as clean-up continuously progresses. Waste oil and/or suspect fuel is kept in barrels for future use as fuel for the waste oil furnaces. The tops are removed from drums being used to store waste materials pending future disposal in accordance with this Plan. Only badly damaged drums are crushed. To the maximum extent practical (e.g., when the winter road is open), scrap metal generated at Lupin is removed from site and sold for metal recycling. Scrap metal that cannot be recycled is either removed from site, disposed of within the landfill or stored pending disposal within the mine workings at final closure.

8.3 Emptying of Containers that Contain Hazardous Waste

The following sections apply to all non-latex paints, solvents and aerosol cans at Lupin with the exception of non-solvent cleaners such as glass cleaner, and other non-hazardous materials.

8.3.1 Non- Aerosol Cans (except acute hazardous waste)

During use, containers will be emptied of all material by normal means (e.g. pouring, pumping); until 1% of the container's original capacity remains. If more than this amount of materials remains in the container, it must be used or emptied into a satellite accumulation drum prior to disposal. Inner liners, if present, are removed. Once emptied by this procedure, the container can be disposed of as solid, non-hazardous waste.

8.3.2 Aerosol Cans (except acute hazardous waste)

Aerosol cans emptied of all products are currently being segregated from the waste stream, stored in a lined Mega-bag, and shipped off site for disposal by a third party waste receiver. The Site has an aerosol can puncture unit to drain the cans for easier and safer disposal.

8.4 Hazardous Wastes that are Compressed Gases

Gas cylinders for acetylene and propane and oxygen are returned and refilled as required. Cylinders are considered empty when the tank pressure approaches atmospheric pressure.

9 Transportation and Documentation

Transportation of dangerous goods within the Site and shipping to and from Lupin requires conformance with transportation regulatory requirements, including Dangerous Goods Regulations and International Air Transport Association.

Emergency Response Information for hazardous materials, shipped from Site, shall be maintained on site. Workers involved in transportation of hazardous materials shall receive proper training.

9.1 Labeling

Appropriate labeling of all hazardous waste shall be conducted as the waste is generated. Drums must be labeled as 'Hazardous Waste' and the label must include the date of the start of the accumulation and the contents of the drum. A log tracking the amount, accumulation date and nature of all hazardous wastes placed in the storage area, including any used solvent or antifreeze generated at Lupin which is determined to be hazardous.

9.2 Storage and Packing of Hazardous Waste Prior to Shipment

LMI shall ensure that the total amount of hazardous waste temporarily stored in any one location or building does not exceed more than one drum. In the event that a total of more than 45 gallons of hazardous waste are accumulated in any one satellite accumulation area, the drums must be moved to the storage area immediately.

Within 24 hours of reaching the 45 gallon total, LMI shall ensure this waste is entered into the Hazardous Waste Log, regardless of whether the waste has been transferred to the storage area or not. Appropriate placards, as required under the transport of hazardous materials, must be supplied by the transporter. Only licensed waste handlers shall be used. A copy of the license shall be kept in the files.

9.3 Manifests

LMI has a Waste Generator Number, and proper manifesting will accompany all waste shipments. The manifest form must be signed by one of the following:

- Site Manager,
- Environmental Coordinator, or
- Their designate.

The transporter must sign and date the manifest upon accepting the waste for shipment. A copy of the signed manifest shall be retained for at least three years. The returned copy of the manifest with the handwritten signature of the owner or operator of the recycling or disposal facility shall be retained on site for at least three years.

9.4 *Record Keeping and Reporting*

Copies of each manifest form shall be retained on site for at least three years.

LMI shall retain all records of any test results, waste analysis or other determinations made in evaluating whether wastes generated at the Lupin site are hazardous wastes for at least three years after the waste(s) were last sent off-site for treatment or disposal.

Records containing data used to determine treatment requirements for land disposal shall be retained for at least five years after the waste(s) were last sent off-site for treatment or disposal.

The Site shall retain records of any arrangements made with local police, fire, hospitals or emergency response teams, emergency response contractors, and with the local health department, as appropriate, for the types of hazardous wastes handled at Lupin and the potential need for the services of these agencies.



Legend



Project Location

Coordinate System: NAD_1983_UTM_Zone_12N

Map Sources/Notes:
Various Canadian Government Websites - Feb 2012



1:15,000,000

Approved By: SH Prepared By: PW
Project No.: LUP Date Revised: 21 Mar 2012
File Name: Lup-12-10-01-LocationMap-A.mxd

Project:

Lupin Project

Location: Kitikmeot Region, Nunavut, Canada

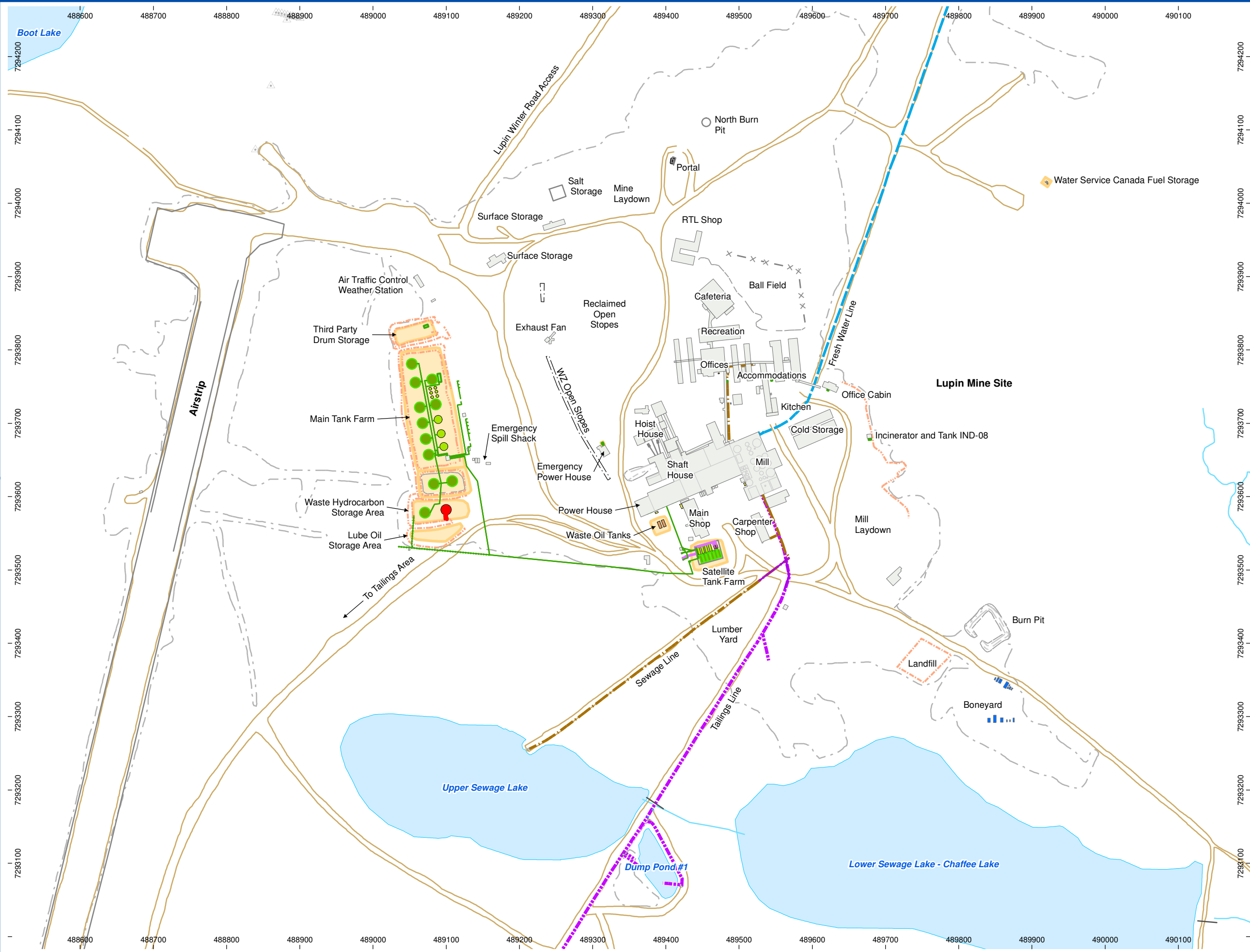
Lupin Mine Annual Report - Water Licence 2AM-LUP0914

Location Map - Lupin Mine

**Lupin Mines
Incorporated**



Figure: **1**
Rev: 120321



Legend

Building

Tank Farm Berm Outline

Lake

Edge of Disturbed Area

Stream

Road

Sewage Pipeline (6 in Diam)

Tailings Line Route

Water Pipeline (8 in Diam)

Pipe - Fuel Type, Status

Diesel, Active

Diesel, Abandoned

Diesel, Uncertain

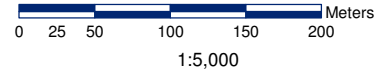
Gasoline, Active

Jet A, Active

Location of Tank - FuelTypeDiesel P-40Diesel P-50DieselWaterJet-AGasGlycolWaste OilEmptyUnknownC

Map Sources/Notes:
Topographic features and site layout from Satellite image dated Aug 21, 2012
Fuel tank and Fuel Containment layouts adapted from drawings by Emerson Engineering dated Oct 17, 2011 and from data updated to March 01 2013

Coordinate System: NAD_1983_UTM_Zone_12N



Approved By: JCB Prepared By: PW
Project No.: LUP Date Revised: 01 Apr 2013
File Name: Lup-13-04-01-SiteFacilities-B.mxd

Project: **Lupin Gold Mine**
Location: Kitikmeot Region, Nunavut, Canada

Care and Maintenance Plan

General Site Map - Lupin Mine

Appendices

Appendix 1 Incinerator Operation and Maintenance Procedure

INCINER8 Model A600X Operation and Maintenance Procedure

WASTE MANAGEMENT

A properly documented and effective waste management program is a requirement of LMI's permits, licences and authorizations. Proper incineration is an effective and environmentally sound method to deal with most domestic waste generated at the Site. Organic waste is collected and incinerated daily to avoid interactions with wildlife.

The INCINER8 Model A600X waste incinerator installed at Lupin in 2012 to replace the outdated Site incinerator. The system operates on diesel or kerosene. The charge rate is up to 270 kg per charge of typical waste (BTU/lb rating of 1000). Batch loaded allowing complete burn-out in approximately 6 to 8 hours, cool down and ash removal before reloading. The burn rate is approximately 45 kg/hr.

The incinerator was installed in the existing Site incinerator building by the vendor, Discovery Mining Services on May 11, 2012. Discovery Mining Service operates and performs maintenance on the incinerator.

INCINERATOR OPERATION

ACCEPTABLE FOR INCINERATION

- Organic waste (such as kitchen waste),
- Wood,
- Paper,
- Cardboard,
- Air filters,
- Domestic waste,
- Light plastics (bags, thin plastics),
- Cooking waste oil (small amounts, used as incinerator fuel), and
- Poor grade diesel fuel (small amounts, used as incinerator fuel).

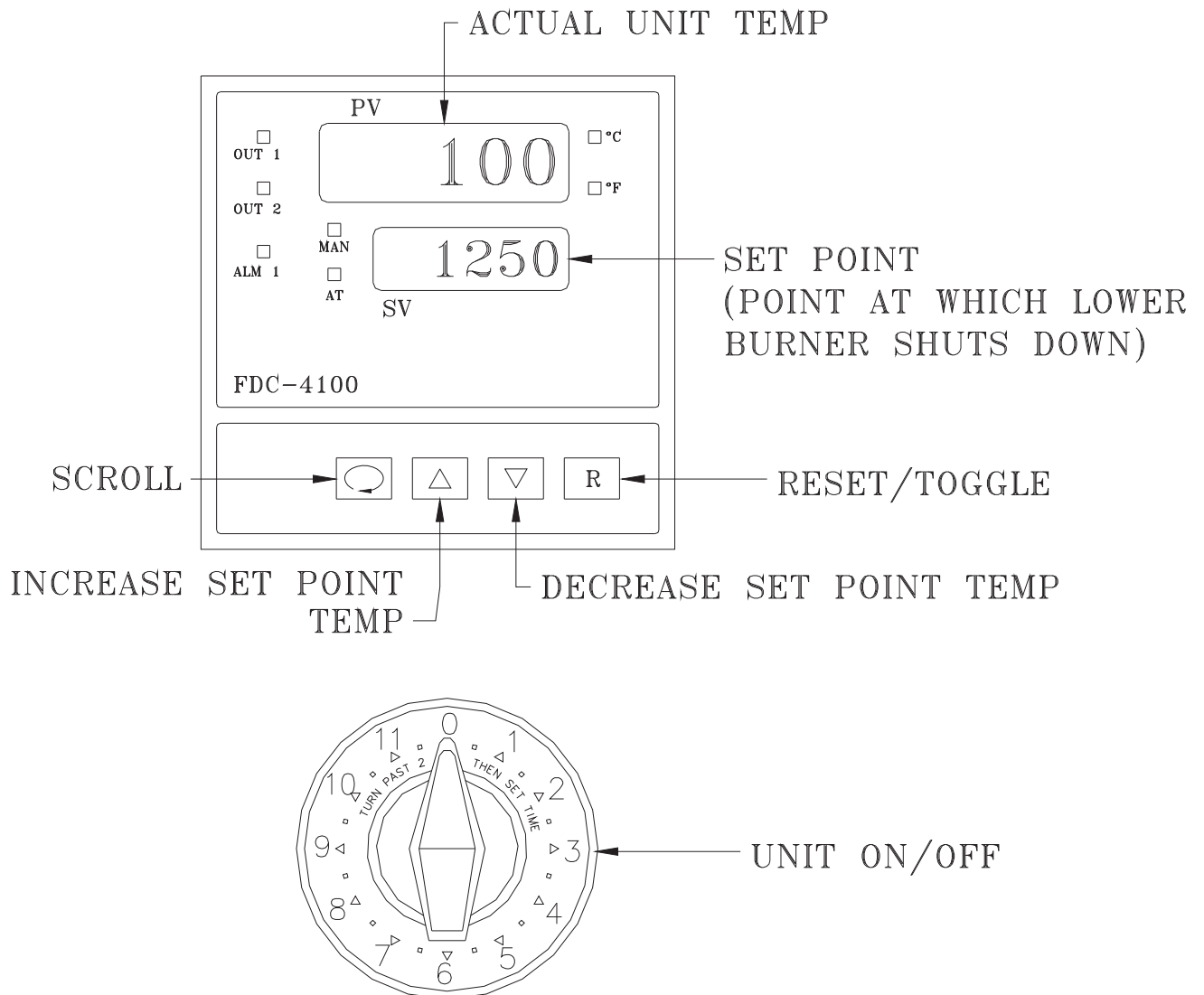
PROHIBITED FROM INCINERATION

The following items are **not** to be disposed of by incineration:

- Used oil or fuel filters,
- Absorbent materials used to clean up spoiled petroleum products
- Waste grease of any kind (empty pails or cartridges, greasy rags, etc.),
- Batteries of any kind,
- Aerosol cans, compressed air cans, propane cylinders,
- Plastic containers, packaging, other than described as acceptable above, and
- Flammable accelerants.

Operating Instructions

1. Remove ashes before loading the incinerator.
2. Load incinerator. **Keep the waste 6"-8" away from the burner port.**
3. Start burner by setting the timer for the desired burn time. A full load will normally burn out in 6-8 hours.
4. The incinerator will automatically shut off when the burn is completed.
5. For best results, burn to a white ash.



Ash Removal and Loading Instructions

1. Clean out the ash from the previous day. Any unburned material found in the ash should be recharged to the primary chamber. Put ash in a container suitable for shipment to an approved landfill.
2. Load with waste. Cardboard boxes should be broken down or ripped into manageable pieces. Do not over fill with cardboard because it blocks the burner inlet. Small volumes of wet waste (e.g. organic waste) are to be mixed with more combustible paper and cardboard materials to ensure total elimination during incineration.

Do's and Don'ts

1. Remember -----the unit is producing **HIGH HEAT. USE CAUTION!**
2. **NEVER** introduce any type of petroleum products directly into the fire box.
3. **ALWAYS** wear protective gear while operating the incinerator (fire retardant coveralls or apron, gloves and face shield).
4. **NEVER** open the loading door after loading the fire-box and igniting the load (there is always a danger that someone has carelessly thrown an aerosol can or battery into the garbage).
5. **NEVER** hit on or scrape the interior of the fire-box (this finish is refractory cement and it will crack). The door guard must always be in place when the load door is open.
6. **NEVER** make any adjustments to the unit without the consent or presence of the Site Manager.
7. **NEVER** overload the fire-box-----If material is pushed too far into the burn chamber it restricts the operation of the burner and slows down the burn time.
8. **NEVER** have clutter in the building / area (you should always have access and a clear path on all 4 sides of the unit).
9. **NEVER—NEVER** use unfiltered fuel (always make sure that the fuel being fed to the burners passes through a fuel oil filter).
10. The only tools that should be required are...a square mouth shovel...a round mouth shovel.....and a scrap drum for ash AND A FIRE EXTINGUISHER.
11. **NEVER OPERATE THE INCINERATOR WITHOUT THE FIRE ROPE SEAL IN PLACE IN THE DOOR!!**
Doing so will cause permanent damage to the refractory cement.

Used filters must be retained in appropriate containers and shipped off-site for disposal at an approved handling facility. Used oil is stored appropriately for use in the waste oil furnace.

Ash from the incinerator can contain materials that are deleterious to human health and the environment. The ash must be disposed on in an approved disposal site. Ash residue is currently backhauled to Yellowknife for disposal. Approval from the Nunavut Water Board is required before it can be landfilled at Site.

PERSONAL PROTECTIVE EQUIPMENT

Proper PPE is to be worn at all times while operating the incinerator. This includes, but is not limited to, fire retardant coverall or apron heat resistant gloves, and full face shield for face.

RECORD KEEPING

An Operating Log is to be maintained on a daily basis while the incinerator is in operation. Date and operators name are to be recorded. All waste to be incinerated is to be recorded by general type and weight (i.e. 50 pound bag camp kitchen waste. 20 pound bag office waste, etc). The weight of ash produced is also to be recorded. Electronic records of operation are required.

TROUBLE SHOOTING

No spark at electrodes

1. Be sure there is no obstruction in the end of the burner tube and there is no soot build-up on the retention head, electrodes or nozzle.
2. Check all electrical connections.
3. Transformer may be burned out. Listen or look to see if there is an arc across the electrodes. Replace transformer if no spark is present.
4. Check for damage to electrodes.
5. Improper firing head adjustment. See Beckett burner installation manual.

No oil spray through nozzle

1. Defective motor. Check to see if blower wheel is turning. If not, check electrical connections and voltage to motor.
2. Air in fuel line. Check all fittings between burners and at fuel tank for tightness. Air may be bled from the fuel line at the fuel pump.
3. Dirt or water in oil tank.
4. Check the plastic coupling between motor and pump for tight fit.
5. Check for clogged filter at tank or on nozzle.
6. Be sure there are no kinks in the oil line.
7. Check the tubing between the pump and nozzle for blockage.
8. Defective pump.

If incinerator does not burn properly

1. Have the ashes been removed at the beginning of the day?
2. Be sure there is no obstruction blocking the burner tube.
3. Are the air bands adjusted correctly?
4. Is No. 1 Fuel Oil (Kerosene) or No. 2 Fuel Oil (Diesel) being used as fuel?

INCINERATOR MAINTENANCE

DAILY CHECKS BEFORE INCINERATION BEGINS WILL HELP PROLONG THE LIFE THE INCINERATOR.

ADVICE In order to have your unit in good working condition, check daily for:

- Damage to the fire rope under the lid. Replace if necessary,
- Abnormal damage to the refractory lining,
- Scorch damage to the external steelwork,
- Check all fuel and power connections, and
- Visible damage to the chimney.

Monthly maintenance procedures

In order to have your unit in good working condition, every month it has to be checked for:

- Damage to the fire rope under the lid,
- Visible damage to the chimney,
- Visible damages to the outside body of the incinerator (corrosion of metal parts, discolorations, leaks),
- Condition of temperature probe , and
- Condition of fuel and electrical installation.

The operator must keep logs about all maintenance procedures, with his comments. Electronic records of maintenance are to be maintained by LMI.

Yearly service procedures

In order to have unit in good working condition it has to be serviced once per year (or every 1000 hours, whatever comes first):

- Replace fire rope under the lid,
- Adjust counterbalance so lid is balanced and sealed,
- Do parallel measurement of temperature probe (if regulated by law),
- The burner should be serviced by an approved professional, and
- Check sealing between each individual part of chimney (including secondary chamber).

The operator must keep logs about all service procedures, with his comments. Electronic records of maintenance are to be maintained by LMI.

A sample log is as follows:

Maintenance Log

Action	Date	Comments	Operator
Installation			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Monthly Check			
Service			
Service			
Service			

Appendix 2 Landfill Management Plan

Lupin Mines Incorporated

A wholly owned subsidiary of Mandalay Resources Corporation

Lupin Mine

Nunavut, Canada

Landfill Management Plan

(Care and Maintenance)

March 2016

Lupin Mines Incorporated
Mandalay Resources Corporation
76 Richmond Street East, Suite 330
Toronto, Ontario M5C 1P1

Document Control

Revision No	Date	Details	Author	Approver
1.0	20/07/14	Initial Plan	Tunaley and Lines	K. Lewis
2.0	25/03/16	Updated to reflect new water licence Updated contact and general information Added open burning requirements Added additional links plan to the Liquid Waste Management Plan and the Waste Management Plan (Solid and Hazardous)	SRK	K. Lewis

Executive Summary

This Landfill Management Plan (LMP) has been prepared by Lupin Mines Incorporated (LMI), a wholly owned subsidiary of Mandalay Resources Corporation (Mandalay) for the Lupin Gold Mine to support the Water Licence 2AM-LUP1520 (Licence). The Project site is located in the Kitikmeot Region, Nunavut, 400 km north of Yellowknife, Northwest Territories and 285 km southeast of Kugluktuk, Nunavut. The site is on the western shore of Contwoyto Lake, approximately 60 km south of the Arctic Circle. The site has been in a state of care and maintenance since 2006. LMI continues to evaluate the feasibility of returning to operations.

The LMP has been developed to provide the operating and closure parameters for the landfill, which has been used since the Mine opened in the 1980s. It details the materials that are suitable for landfilling, materials suitable for open burning, approach to covering the landfill on a regular basis to prevent wind-blown debris, and the closure approach for the landfill.

Executive Summary Inuktitut

Awaiting translation – to be provided as soon as possible

Executive Summary Inuinnaqtun

Awaiting translation – to be provided as soon as possible

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Appendices

Appendix A – Lupin Mine Site Figure with Landfill and Burn Pit Locations

Appendix B – Applicable Guidelines

1. Introduction

Lupin Mines Incorporated (LMI), a wholly owned indirect subsidiary of Mandalay Resources Corporation (Mandalay), has prepared this Landfill Management Plan (LMP) for the Lupin Mine (Mine) to provide operational and closure details of the existing landfill at the Mine.

The Mine is located in the Kitikmeot Region, Nunavut, 400 km north of Yellowknife, Northwest Territories and 285 km southeast of Kugluktuk, Nunavut. The airport serving this Site is at 65° 46'00" N and 111° 14'41" W. The Site is on the western shore of Contwoyto Lake, approximately 60 km south of the Arctic Circle (Appendix A).

The landfill is required for the disposal of non-salvageable, non-hazardous wastes from standard mining activities that cannot be incinerated or openly burned. Landfills are a common requirement of remote mining operations and help mitigate effects of wind-blown debris. The landfill at the Mine has operated since the early 1980s when mining commenced and continued to operate periodically through to 2005 when the Mine was last put in care and maintenance. In the past, it is understood that non-hazardous items were designated as landfill waste and buried within the surface waste rock piles. The landfill is required during operations, care and maintenance, and closure phases. Once the Mine commences permanent closure and reclamation, demolition materials will also be deposited in the underground workings as noted in the Interim Abandonment and Restoration Plan. The landfill will be closed and restored towards the end of closure activities.

Waste management in Nunavut is regulated under the Nunavut Public Health Act, the Nunavut Environmental Protection Act and the federal Environmental Protection Act. In addition to mandatory requirements, a number of waste management guidelines are commonly used in Nunavut and Northwest Territories. Those guidelines are provided in Appendix B.

An annual review of the LMP will take place and revisions will be submitted as necessary with the Annual Report to the Nunavut Water Board (NWB). The Landfill Management Plan, dated July 2014 was approved by the NWB under Part E(18) of Type A water licence 2AM-LUP1520 (Water Licence).

2. Background

Mandalay is a Canadian based company focused on producing assets in Australia, Chile and Sweden, a development project in Chile and the exploration and development of the past-producing Lupin Gold Mine and the Ulu gold project, both located in Nunavut, Canada.

Mandalay purchased Elgin Mining Inc., which owns LMI and the Lupin Mine, in September 2014. Lupin was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004. The mine resumed production in March 2004 until February 2005. Since 2005, the Site has remained in Care and Maintenance.

General site maintenance and facilities upgrades are underway at the Lupin Mine to assess operational requirements. The activities underway were screened by the Nunavut Impact Review Board under file 99WR053 and approved by the Nunavut Water Board under Water Licence 2AM-LUP1520. Surface exploration is conducted under Water Licence 2BE-LEP1217. All camp infrastructure required for the surface exploration program currently exists at the Lupin Mine

Company:	LMI
Project:	Lupin Mine, Nunavut
Company Address:	Suite 330, 76 Richmond Street East, Toronto, ON M5C 1P1
Telephone:	778-386-7340
Email:	klewis@elginmining.com
Attention:	Karyn Lewis, General Administration

Effective Date: March 18, 2016

Distribution List:

Karyn Lewis	General Administration
Discovery Mining Services	Site Contractor
Golder Associates	Site Consultant
SRK Consulting	Site Consultant

Additional copies of this Plan are available from General Administration. This Plan will be posted in key locations at the site, and all employees and contractors will be made aware of its contents.

3. Environmental and Sustainable Development Policy

Lupin Mine Incorporated (LMI) is committed to maintaining a safe, clean, compliant and respectful work environment. LMI looks to our employees, contractors and managers to adopt and grow a culture of social responsibility and environmental excellence. Together we achieve this by:

- Promoting environmental stewardship in all tasks. Nothing is too important that it cannot be done in a clean and responsible manner. We strive towards maintaining a zero-incident work place.
- Recognizing that we have a shared responsibility as stewards of the environment in which we operate. We will not walk away from a non-compliant act.
- Identifying, managing and mitigating environmental, business and social risks in an open, honest and transparent manner.
- Planning our work so it is done in the cleanest possible manner and executing work according to plan.
- Continually improving environmental and operational performance by setting and reviewing achievable targets.
- Providing appropriate and necessary resources in the form of training, personnel and capital, including that required for closure planning and reclamation.
- Managing our materials and waste streams, maintaining a high degree of emergency response preparedness and minimizing our operational footprint to maintain environmental protection at all stages of project development.
- Procuring goods and services locally, where available, and favouring suppliers with environmentally and socially responsible business practices.
- Seeking to understand, learn from and mitigate the root causes of environmental incidents and near misses when they do occur.
- Employing systems and technology to achieve compliance, increase efficiency and promote industry best practices in development, operations and environmental stewardship.
- Working with stakeholders to identify and pursue opportunities for sustainable social and economic development and capacity building.
- Conducting early and ongoing stakeholder engagement relevant to the stage of project and mine development and operation.
- Recognizing diversity in the workplace and building meaningful relationships with all stakeholders in a timely, collaborative and transparent manner.

Through implementation of this policy, LMI seeks to earn the public's trust and be recognized as a respectful and conscientious employer, neighbor and environmental steward.

4. Waste Management Practices

In accordance with the Waste Management Plan (2013) approved by the NWB, the approach for the disposal of solid waste is to first identify and segregate waste streams for appropriate handling. Acceptable items that can be landfilled are those that are non-hazardous, non-putrescible, with a low leachate and heat generation potential. All other materials will either be incinerated, open burned, placed in the underground working, or backhauled offsite. Limiting the materials that can be placed in the landfills greatly reduces the concentration of constituents in leachate. Water Licence requirements for seepage management from the landfill is described in the *Liquid Waste Management Plan*.

Wastes that may contain food products, including packaging waste or other organic waste that could attract wildlife will be incinerated in the Mine's incinerator commissioned in 2012. This includes all garbage from the camp, kitchen, site lunchrooms and offices. The ash from the incinerator is placed in drums and disposed of at the landfill. Incinerator ash samples can be collected and tested for metals to confirm suitability for landfilling in accordance with Part E(27) of the Water Licence. In the event ash is not suitable for landfilling, drums are backhauled to a licensed waste disposal facility in the south as described in the *Waste Management Plan (Solid and Hazardous)*.

In addition to the incinerator, the Mine has two open burn pits as shown in Appendix A. Non-hazardous oversized materials, including untreated wood products, are burned in the burn pits to reduce the volume of waste entering the landfill. Open burning is conducted in accordance with the Government of Nunavut and Government of Northwest Territories guidelines provided in Appendix B, and as outlined in Section 6.0.

Non-hazardous waste suitable for landfilling, as detailed in Section 5.0, will be deposited in the existing landfill in an orderly manner to reduce surface area and the potential for wind-blown debris as described in Section 7.0.

5. Waste Items Acceptable for Landfilling

Historically, non-combustible, non-hazardous materials were historically placed within the landfill area and constantly kept covered. In the past, it is understood that the following items were designated as landfill waste and buried within the surface waste rock piles:

- Wood;
- Iron products;
- Plumbing piping (copper, steel, etc.);
- Electrical wiring;
- Compressed gas containers;
- Rubber products;
- Tires;
- Heavy plastics (pails, etc.);
- Plexiglass;
- Glass;
- Vehicle lights;
- Fibreglass;
- Styrofoam boards;
- Insulation;
- Plaster and plaster boards;
- Hydraulic rubber hoses;
- Rock resin; and
- Ash produced from incinerator.

The following additional materials will be acceptable for disposal at the landfill:

- Plastic (except expanded polystyrene);
- Wire;
- Roofing;
- Asphalt;
- Concrete;
- Carpet;
- Bricks;
- Ceramics;
- Tires;
- Caulking;
- Clothing;
- Plexiglass
- Light bulbs:

- Not including fluorescent tubes which can contain mercury phosphor powder and traces of lead and cadmium, which are considered environmental contaminants under the Nunavut Environmental Protection Act (EPA). The only disposal method for fluorescent tubes is through an approved hazardous waste recycling or disposal facility in accordance with the Waste Management Plan (Solid and Hazardous).
- The Disposal Guidelines for Fluorescent Lamp Tubes are included in Appendix B.
- Waste Asbestos:
 - Asbestos that has been immersed or fixed in a natural or artificial binder or included in a manufactured product is not considered waste asbestos, it is considered a hazardous waste (and will be disposed of accordingly). Waste asbestos can either be backhauled off-site for disposal in an approved facility or it can be landfilled. The following are guidelines for landfilling waste asbestos:
 - Immediately buried and covered with 0.5 m of cover material
 - Buried where it will not be disturbed
 - The location should be maintained on a map or diagram for future reference
 - The complete Environmental Guideline for Waste Asbestos is included in Appendix B.
- Small appliances (with batteries removed);
- Plaster and Gyproc; and
- Vehicles and machinery provided all liquids, grease, batteries, and electronics have been removed:
 - Ozone depleting substances (ODSs) include chlorofluorocarbons (CFCs) or halons and common sources include refrigeration equipment, air conditioning equipment, motor vehicle air conditioners and fire extinguishing equipment. These materials are hazardous in nature; consequently, all disposal of ODS will take place by backhaul to an approved facility. Equipment containing ozone depleting substances should have the ODS removed by a certified technician prior to disposal in the landfill.
 - The Environmental Guideline for Ozone Depleting Substances is included in Appendix B.

All other items shall be disposed of in accordance with the *Waste Management Plan (Solid and Hazardous)*, or as approved by the Inspector on an as needed basis.

6. Waste Items Acceptable for Open Burning

Controlled open burning is an efficient method of reducing the volume of certain waste types at remote sites, and minimizing landfill requirements. One burn pit is located on site adjacent to the landfill, and a second one is located at the north end of the site. Historically, combustible non-hazardous, non-domestic waste were open-burned at these locations, downwind of camp and away from waterbodies. The burn pits are also founded on previously burned areas and cited away from the landfill to mitigate the potential spread of fire.

To divert wastes from the landfill and minimize the overall volume of waste, LMI will carry out periodic controlled burns of clean wood, paper and cardboard materials using the guidance found in the Government of Nunavut Guideline for the Burning and Incineration of Solid Waste, and Government of the Northwest Territories guidance on Municipal Solid Wastes Suitable for Open Burning upon receipt of a permit from INAC. Measures to be implemented for controlled open burning include:

- Only paper, paperboard packing, untreated wood waste and natural fiber textiles are burned.
- The waste is burned in a controlled manner and at a location which is separate from combustible vegetation and other materials or areas including the existing landfill.
- Burning takes place only on days when winds are light and blowing away from camp and waterbodies (east – northeast).
- Waste is burned in manageable volumes so the fire does not get out of control.
- The burn pile will be maintained to create an efficient hot burn using consistent feed rates and mixtures.
- The fire is started, attended and monitored at all times by authorized and qualified personnel with resources to control the fire (shovels, rakes, water, fire extinguisher).
- Fires will be extinguished to ensure smoldering material does not persist.
- The waste is kept dry or covered to the extent practicable prior to burning.
- Building demolition wastes should not be burned unless they have been sorted to remove non-wood wastes such as roofing materials, electrical wire, plastics, asbestos and other non-wood wastes.

7. Landfill Deposition Protocol

Landfill operations will involve the clearing of snow cover as needed, placement of mine rock over the summer period, and placement of a graded cover as needed prior to the winter season when snow accumulation occurs.

Trucks will haul waste to the landfill and a dozer, or similar type of compacting equipment, will spread and level the waste. Waste materials will be deposited in rows or designated areas on a systematic basis and covered regularly. Wastes will be deposited directly on the landfill surface located within the mine rock pile and compacted with heavy equipment against the mine rock. Waste will be placed at one end of the designated area at full height followed by a progressive advancement of the deposition area. Areas where the waste has been placed to full height and levelled will be progressively covered by placement of a minimum 0.3 m thickness of rock fill on top of the waste to prevent wind-blown debris.

The landfill does not require a full-time attendant. The Mine Manager or acting designate will appoint a landfill inspector to undertake periodic inspections of the Landfill operations to identify deposition sequencing based on volumes of waste, verify compliance with the LMP, including observations of unsuitable materials and corrective actions, wildlife sign, evidence of erosion, ponding or unusual landfill settlement, and adequacy of safety measures.

The leachate from the landfill is anticipated to be clean due to the controls on materials placed in the landfills. Monitoring requirements for seepage from the landfill are described in the *Liquid Waste Management Plan*.

8. Landfill Closure

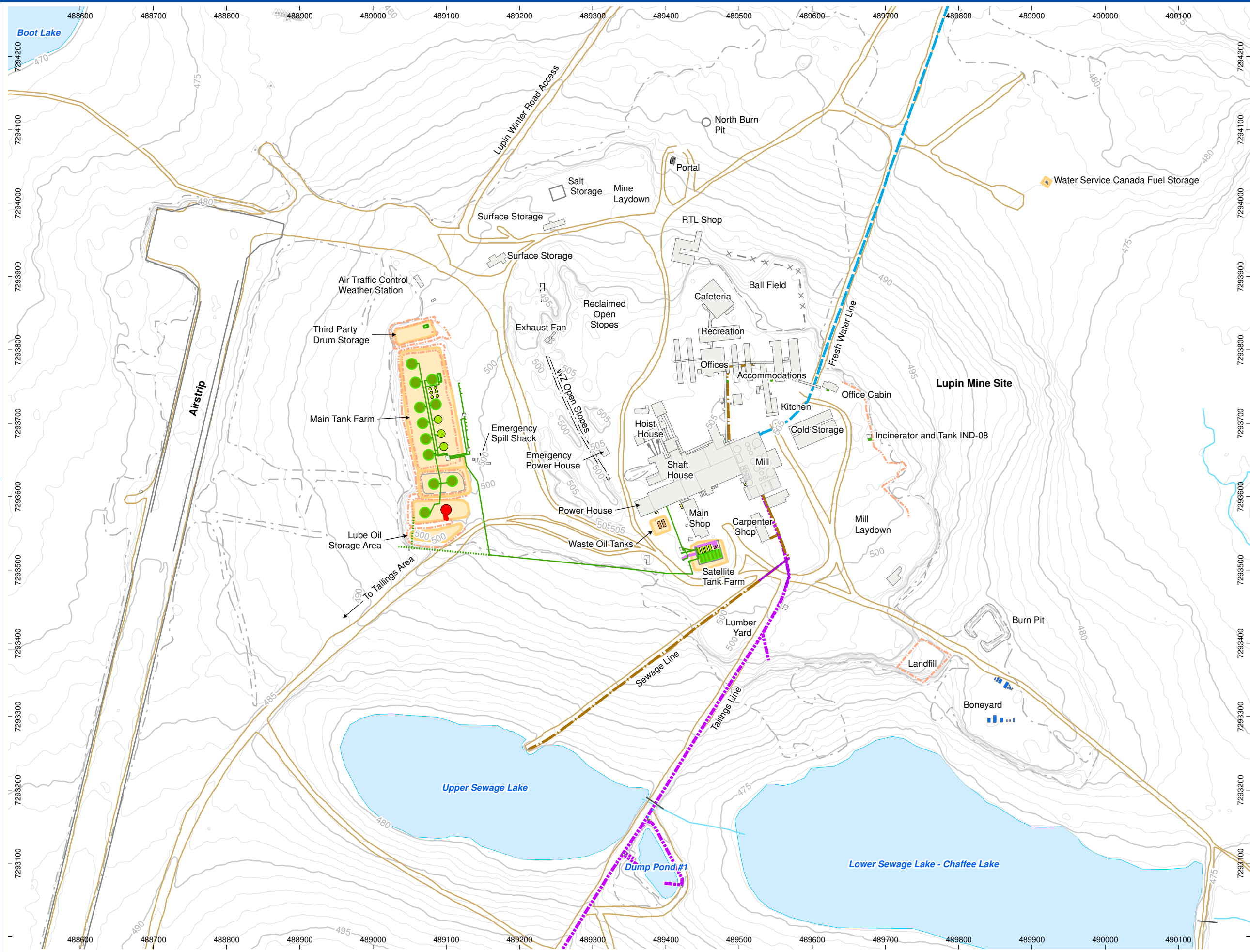
No future end use of the landfill post-closure is planned. The landfill will become part of the mine rock pile, anticipated to be closed permanently towards the end of the active closure phase. The waste in the landfill will be covered progressively during operations and a minimum 1 m final thickness of rockfill will be placed above the waste material at closure to fill potential voids. The final surface will be contoured to blend with the mine rock pile.

Additional details on the closure and reclamation of the landfill area will be incorporated into a final closure and reclamation plan for the Mine in accordance with Part I of the Licence.

9. References

Waste Management Plan (2013). Lupin Mine Site Nunavut, Canada. Waste Management Plan (Solid and Hazardous) (Care and Maintenance) March 2013.

Appendix A – Lupin Mine Site Figure with Landfill and Burn Pit Locations



Legend

Building

Tank Farm Berm Outline

Lake

Edge of Disturbed Area

Stream

Road

Topographic Contour (5m)

Topographic Contour (1m)

Sewage Pipeline (6 in Diam)

Tailings Line Route

Water Pipeline (8 in Diam)

Pipe - Fuel Type, Status

Diesel, Active

Diesel, Abandoned

Diesel, Uncertain

Gasoline, Active

Jet A, Active

Location of Tank - FuelTypeDiesel P-40Diesel P-50DieselWaterJet-AGasGlycolWaste OilEmptyUnknown

N

W

E

S

Map Sources/Notes:
Topographic features and site layout from Satellite image dated Aug 21, 2012
Fuel tank and Fuel Containment layouts adapted from drawings by Emerson Engineering dated Oct 17, 2011 and from data updated to March 01 2013

Coordinate System: NAD_1983_UTM_Zone_12N

0

50

100

200

Meters

1:5,000

Approved By: AL

Project No.: LUP

File Name: Lup-13-08-03-MinesiteArea-B.mxd

Prepared By: PW

Date Revised: 15 Apr 2013

Project: **Lupin Gold Mine**

Location: Kitikmeot Region, Nunavut, Canada

Lupin Mines Incorporated

ELGIN MINING INC.

Figure: 3
Rev: 130415

Appendix B – Applicable Guidelines

Environmental Guideline for the Burning and Incineration of Solid Waste



Department of Environment
Government of Nunavut

GUIDELINE: BURNING AND INCINERATION OF SOLID WASTE

Original: October 2010

Revised: January 2012

This Guideline has been prepared by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment under the authority of Section 2.2 of the *Environmental Protection Act*.

This Guideline is not an official statement of the law and is provided for guidance only. Its intent is to increase the awareness and understanding of the risks, hazards and best management practices associated with the burning and incineration of solid waste. This Guideline does not replace the need for the owner or person in charge, management or control of a solid waste to comply with all applicable legislation and to consult with Nunavut's Department of Environment, other regulatory authorities and qualified persons with expertise in the management of solid waste.

Copies of this Guideline are available upon request from:

Department of Environment

Government of Nunavut

P.O. Box 1000, Station 1360, Iqaluit, NU, X0A 0H0

Electronic version of the Guideline is available at <http://env.gov.nu.ca/programareas/environmentprotection>

Cover Photos: Nunavut Department of Environment (left and bottom right), Aboriginal Affairs and Northern Development Canada (top right)

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Introduction

People living and working in Nunavut often have limited options available for cost effective and environmentally sound management of household and other solid waste. The widespread presence of permafrost, lack of adequate cover material and remote locations make open burning and incineration a common and widespread practice to reduce the volume of solid waste and make it less of an attractant to wildlife. A wide variety of combustion methods are used ranging from open burning on the ground to high temperature dual-chamber commercial incinerators. Generally, high temperature incinerators are more expensive to purchase and operate and cause less pollution than do the less expensive and lower temperature methods. However, high temperature incinerators can safely dispose of a wider variety of waste than can the lower temperature open burning methods.

The Guideline for the Burning and Incineration of Solid Waste (the Guideline) is not intended to promote or endorse the burning and incineration of solid waste. It is intended to be a resource for traditional, field and commercial camp operators, communities and others considering burning and incineration as an element of their solid waste management program. It examines waste burning and incineration methods that are used in Nunavut, their hazards and risks and outlines best management practices that can reduce impacts on the environment, reduce human-wildlife interactions and ensure worker and public health and safety. This Guideline does not address incineration of biomedical waste, hazardous waste and sewage sludge. The management of these wastes requires specific equipment, operational controls and training that are beyond the scope of the current document.

The *Environmental Protection Act* enables the Government of Nunavut to implement measures to preserve, protect and enhance the quality of the environment. Section 2.2 of the *Act* provides the Minister with authority to develop, coordinate, and administer the Guideline.

The Guideline is not an official statement of the law. For further information and guidance, the owner or person in charge, management or control of a solid waste is encouraged to review all applicable legislation and consult the Department of Environment, other regulatory agencies or qualified persons with expertise in the management of solid waste.

1.1 Definitions

<i>Biomedical Waste</i>	Any solid or liquid waste which may present a threat of infection to humans including non-liquid tissue, body parts, blood or blood products and body fluids, laboratory and veterinary waste which contains human disease-causing agents, and discarded sharps (i.e. syringes, needles, scalpel blades).
<i>Bottom Ash</i>	The coarse non-combustible and unburned material which remains at the burn site after burning is complete. This includes materials remaining in the burn chamber, exhaust piping and pollution control devices where such devices are used.
<i>Burn Box</i>	A large metal box used to burn solid waste. Combustion air is usually supplied passively through vents or holes cut above the bottom of the box. An exhaust pipe or stack may or may not be attached.

<i>Commercial Camp</i>	A temporary, seasonal or multi-year facility with a capacity greater than 15 people and which has been established for research, commercial or industrial purposes. A commercial camp does not include a traditional camp or field camp.
<i>Commissioner's Land</i>	Lands that have been transferred by Order-in-Council to the Government of Nunavut. This includes roadways and land subject to block land transfers. Most Commissioner's Land is located within municipalities.
<i>Contaminant</i>	Any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment, (a) endangers the health, safety or welfare of persons, (b) interferes or is likely to interfere with the normal enjoyment of life or property, (c) endangers the health of animal life, or (d) causes or is likely to cause damage to plant life or to property.
<i>Determined Effort</i>	The ongoing review of opportunities for reductions and the implementation of changes or emission control upgrades that are technically and economically feasible and which result in on-going reductions in emissions. Determined efforts include the development and implementation of waste management planning which is focussed on pollution prevention.
<i>De Novo Synthesis</i>	The creation of complex molecules from simple molecules.
<i>Environment</i>	The components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c) above.
<i>Field Camp</i>	A temporary, seasonal or multi-year facility consisting of tents or other similar temporary structures with a capacity of 15 people or less and which has been established for research, commercial or industrial purposes. A field camp does not include a traditional camp or commercial camp.
<i>Fly Ash</i>	Unburned material that is emitted into the air in the form of smoke or fine particulate matter during the burning process.
<i>Hazardous Waste</i>	A contaminant that is a dangerous good and is no longer wanted or is unusable for its original intended purpose and is intended for storage, recycling, treatment or disposal.
<i>Incineration</i>	A treatment technology involving the destruction of waste by controlled burning at high temperatures.

<i>Incinerator</i>	A device or structure intended primarily to incinerate waste for the purpose of reducing its volume, destroying a hazardous substance in the waste or destroying an infectious substance in the waste. An incinerator has means to control the burning and ventilation processes.
<i>Inspector</i>	A person appointed under subsection 3(2) of the <i>Environmental Protection Act</i> and includes the Chief Environmental Protection Officer.
<i>Modified Burn Barrel</i>	A metal drum used to burn waste that has been affixed with devices or features which provide limited increased heat generation, heat retention and holding time.
<i>Open Burning</i>	Burning of waste with limited or no control of the burn process. For clarity, open burning includes burning on the open ground or using a burn box or unmodified or modified burn barrel.
<i>Qualified Person</i>	A person who has an appropriate level of knowledge and experience in all relevant aspects of waste management.
<i>Responsible Party</i>	The owner or person in charge, management or control of the waste.
<i>Smoke</i>	The gases, particulate matter and all other products of combustion emitted into the atmosphere when a substance or material is burned including dust, sparks, ash, soot, cinders and fumes.
<i>Solid Waste</i>	Unwanted solid materials discarded from a household (i.e. single or multiple residential dwellings, other similar permanent or temporary dwellings), institutional (i.e. schools, government facilities, hospitals and health centres), commercial (i.e. stores, restaurants) or industrial (i.e. mineral, oil and gas exploration and development) facility. For clarity, solid waste does not include biomedical waste, hazardous waste or sewage sludge.
<i>Traditional Camp</i>	A temporary or seasonal camp used primarily for camping, hunting, fishing or other traditional or cultural activities. A traditional camp does not include a field camp or commercial camp.
<i>Unmodified Burn Barrel</i>	A metal drum used to burn waste that has not been affixed with devices or features which provide for enhanced heat generation, heat retention and holding time.
<i>Untreated Wood</i>	Wood that has not been chemically impregnated, painted or similarly modified to improve resistance to insects or weathering.
<i>Waste Audit</i>	An inventory or study of the amount and type of waste that is produced at a location.

1.2 Roles and Responsibilities

1.2.1 Department of Environment

The Environmental Protection Division is the key environmental agency responsible for ensuring the proper management and disposal of solid waste and other contaminants on Commissioner's Land. Authority is derived from the *Environmental Protection Act*, which prohibits the discharge of contaminants to the environment and enables the Minister to undertake actions to ensure appropriate management measures are in place. Although programs and services are applied primarily to activities taking place on Commissioner's and municipal lands and to Government of Nunavut undertakings, the *Environmental Protection Act* may be applied to the whole of the territory where other controlling legislation, standards and guidelines do not exist. A complete listing of relevant legislation and guidelines can be obtained by contacting the Department of Environment or by visiting the web site at:

<http://env.gov.nu.ca/programareas/environmentprotection>.

The Wildlife Management Division is responsible for managing wildlife in Nunavut. Section 90 of the *Wildlife Act* prohibits the intentional feeding of wildlife and the placement of any food or garbage where there is a reasonable likelihood that it would attract wildlife. Once wildlife has been 'conditioned' to obtaining food associated with human activities, it can become dangerous and often will have to be destroyed. Further information on ways to reduce contact between wildlife and humans can be obtained by contacting the local Conservation Officer or by visiting the web site at:

<http://env.gov.nu.ca/programareas/wildlife>.

The Department of Environment will provide advice and guidance on the burning and incineration of solid waste. However, it remains the responsibility of the owner or person in charge, management or control of the solid waste to ensure continued compliance with all applicable statutes, regulations, standards, guidelines and local by-laws.

1.2.2 Generators of Solid Waste

The generator, or responsible party, is the owner or person in charge, management or control of the solid waste at the time it is produced or of the facility that produces the waste. The responsible party must ensure the waste is properly and safely managed from the time it is generated to its final disposal. This is referred to as managing the waste from cradle-to-grave.

Contractors may manage solid waste on behalf of the responsible party. However, the responsible party remains liable for ensuring the method of management complies with all applicable statutes, regulations, standards, guidelines and local by-laws. If the contractor does not comply with the requirements of the *Environmental Protection Act* or *Wildlife Act* and is charged with a violation while managing the waste, the responsible party may also be charged.

1.2.3 Other Regulatory Agencies

Other regulatory agencies may have to be consulted regarding the burning and incineration of solid waste as there may be other environmental or public and worker health and safety issues to consider.

Workers' Safety and Compensation Commission

The Workers' Safety and Compensation Commission is responsible for promoting and regulating worker and workplace health and safety in Nunavut. The Commission derives its authority from the *Workers' Compensation Act* and *Safety Act* which require an employer to maintain a safe workplace and ensure the safety and well being of workers.

Department of Community and Government Services

The Department of Community and Government Services is responsible under the *Commissioners' Lands Act* for the issuance of land leases, reserves, licenses and permits on Commissioner's Lands. The Department, in cooperation with communities, is also responsible for the planning and funding of municipal solid waste and sewage disposal facilities in most Nunavut communities.

The Office of the Fire Marshal is responsible for delivering fire and life safety programs including reviewing plans to ensure incinerators and other heating devices comply with all legislation, codes and standards. The Office of the Fire Marshal derives its authority from the *Fire Prevention Act*, *National Fire Code* and *National Building Code*.

Department of Health and Social Services

Activities related to the burning and incineration of solid waste may have an impact on public health. The Office of the Chief Medical Officer of Health and Regional Environmental Health Officers should be consulted regarding legislated requirements under the *Public Health Act*.

Environment Canada

Environment Canada is responsible for administering the *Canadian Environmental Protection Act* (CEPA) and Canada's Toxic Substances Management Policy. Many pollutants that are released into the atmosphere from the incomplete combustion of unsegregated, or mixed, solid waste are listed as Toxic Substances in Schedule I of CEPA, or are targeted for phase-out through the Toxic Substances Management Policy. Environment Canada is also responsible for administering the pollution prevention provisions of the federal *Fisheries Act* and for regulating the international and interprovincial movement of solid and liquid hazardous waste under the *Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.

The Air Quality Research Division of Environment Canada is responsible for conducting research into atmospheric releases of chemicals in commercial use in Canada, measuring exhaust emissions from stationary and mobile sources and undertaking ambient air quality monitoring in partnership with provinces and territories.

Aboriginal Affairs and Northern Development Canada

Aboriginal Affairs and Northern Development Canada is responsible under the *Territorial Lands Act* and *Nunavut Waters and Nunavut Surface Rights Tribunal Act* for the management of federal lands and waters, including the impact solid waste may have on the quality of these lands and waters.

Local Municipal Governments

The role of municipal governments is important in the proper local management of solid waste. Under the Nunavut Land Claims Agreement, municipalities are entitled to control their own municipal disposal sites. Local environmental and safety standards are determined, in part, by how the land is designated under municipal government development plans (i.e. land use zoning). Solid waste may be deposited into municipal landfill sites only with the consent of the local government. The local fire department may also be called upon if a fire or other public safety issue is identified.

Co-management Boards and Agencies

Co-management boards and agencies established under the Nunavut Land Claims Agreement have broad authority for land use planning, environmental impact assessment and the administration of land and water. Activities involving the burning and incineration of solid waste may be controlled through the setting of terms and conditions in plans, permits and licenses issued by the Nunavut Water Board and other co-management boards and agencies.

Waste Burning and Incineration

2.1 The Combustion Process

The combustion, or burning, of solid waste proceeds through a series of stages. Water is first driven from the unburned waste by heat produced from material burning nearby or from an auxiliary burner. As the waste heats up, carbon and other substances are released and converted into burnable gases. This is referred to as gasification. These gases are then able to mix with oxygen. If the temperature inside the burn chamber is high enough and maintained for a long enough period of time, the hot gases are completely converted into water vapour and carbon dioxide, which is then released into the air. If the temperature inside the burn chamber is not high enough and the burn time is too short, complete conversion of the burnable gases does not occur and visible smoke is released into the air. Another result of burning at low temperatures is the creation of pollutants that were not originally present in the waste. This process is known as *de novo* synthesis. Dioxins, furans and other complex chemical pollutants can be formed through this process.

Ash produced from combustion takes the form of either fly ash or bottom ash. Fly ash is the fine particles carried away in the form of smoke while bottom ash is the coarse non-combustible and unburned material that remains after the burn is complete. The type and amount of pollutants in the fly and bottom ash depend upon what waste is burned and completeness of the combustion process.

The completeness of combustion is determined by all of the following factors:

Temperature

The temperature generated is a function of the heating value of the waste and auxiliary fuel, incinerator or burn unit design, air supply and combustion control. Complete combustion requires high temperatures. Generally, temperatures that exceed 650°C with a holding time of 1-2 seconds will cause complete combustion of most food and other common household waste. Segregation of waste is required when using methods that don't routinely achieve these temperatures. Dual chamber incinerators, which are designed to burn complex mixtures of waste, hazardous waste and biomedical waste, must provide a temperature higher than 1000°C and a holding time of at least one second to ensure complete combustion and minimize dioxin and furan emissions. When these high temperatures and holding times are achieved, waste will be completely burned and ash, smoke and pollutant concentrations will be minimized.

Because exhaust gas temperatures vary from ambient to greater than 1000°C each time a batch waste incinerator is used, optional air pollution control systems with evaporative cooling towers and scrubbers are seldom recommended. However, it may be necessary to employ these systems with large continuous feed incinerators if additional cleaning of exhaust gas is required by regulatory authorities.

Holding Time

Complete combustion takes time. Holding time, otherwise known as retention or residence time, is the length of time available to ensure the complete mixing of air and fuel, and thus the complete burning of waste. Low temperatures, low heating values of the waste and reduced turbulence require that the holding time be increased to complete the combustion process.

Turbulence

The turbulent mixing of burnable gases with sufficient oxygen is needed to promote good contact between the burning waste and incoming air. This will help in achieving the high temperatures at which waste can be completely burned. The amount of mixing is influenced by the shape and size of the burn chamber and how the air is injected. Passive under-fire ventilation achieved during open burning does not result in sufficient turbulence for the burning of a wide variety of waste. Also, it is important not to overfill the burn chamber as airflow may be blocked and the amount of turbulence further reduced. The more advanced incineration designs provide effective turbulence through the forced introduction of air directly into hot zones.

Composition of the Waste

The heating value, wetness and chemical properties of the waste affect the combustion process and the pollutants that are contained in the resulting smoke and ash. The higher the burn temperature, holding time and turbulence that are achieved, the less effect the composition of the waste has on completeness of the burn.

2.2 Pollutants of Concern

Extreme care must be exercised when burning or incinerating solid waste. Open burning and the improper incineration of solid waste can result in environmental, health and safety hazards from the pollutants found in smoke and exhaust gases and in the bottom ash. These pollutants may either be found in the original waste itself, or may be created through *de novo* synthesis if sufficient temperature, holding time and turbulence is not achieved in the burn chamber.

Many different types of pollutants can be released during burning and incineration. A few of these pollutants include acid gases, trace metals, fine particulates, volatile organic compounds and semi-volatile organic compounds. Acid gases such as hydrogen chloride and sulphur oxides result from burning waste that has high levels of chlorine and sulphur (i.e. plastics). Mercury, lead and cadmium are examples of trace metals found in both fly and bottom ash when batteries, used lubricating oil and other metal-containing wastes are burned. Fine particulates are the very small particles found in smoke created by incomplete combustion and can cause respiratory irritation in humans and wildlife.

Dioxins and furans are pollutants that have drawn much attention in recent years because they have been linked to certain types of cancers, liver problems, impairment of the immune, endocrine and reproductive systems and effects on the fetal nervous system. These pollutants persist in the environment for long periods of time, bioaccumulate in plants and animals, result predominantly from human activity and have been identified for 'virtual elimination' in Canada under the federal Toxic Substances Management Policy. The incineration of solid waste accounts for almost 25% of the dioxin and furan emissions in Canada each year. They are formed in trace amounts by *de novo* synthesis during the low temperature burning of waste containing organic compounds and chlorine (i.e. chlorinated plastic, PVC pipe, marine driftwood).

The most effective way to reduce or minimize the release of pollutants is to segregate the waste before burning and achieve sufficiently high temperature, holding time and turbulence in the burn chamber. Open burning produces more smoke and pollutants, including dioxins and furans, than does an incinerator capable of achieving complete combustion.

2.3 Burning and Incineration Methods

The burning and incineration method used is a major factor in determining what type of waste can be safely and effectively disposed of. The methods commonly used in Nunavut include open burning on the ground, unmodified burn barrels and various mechanical incineration systems. Other useful methods include the use of burn boxes and modified burn barrels. Each method is discussed separately in the following sections.

2.3.1 Open Burning

Open burning means the burning of waste where limited or no control of the combustion process can be exercised by the operator. This method includes burning solid waste directly on the open ground or in burn boxes or burn barrels and often does not achieve the temperatures or holding time needed for complete combustion of the waste to occur. This results in the formation of potentially hazardous pollutants and ash, which are likely to impact nearby land and water. Food waste that is not completely burned through open burning can also be a powerful attractant for animals.

The various open burning methods can also present a risk of uncontrolled vegetation and tundra fires through the release of hot sparks or embers. The level of fire risk depends upon the type of open burning used, its location, the skill of the operator and the environmental conditions that exist at the time (i.e. dryness of the surrounding vegetation, wind).

The open burning of solid waste remains a common practice in Nunavut. It is the policy of the Department of Environment to eliminate or minimize open burning of mixed solid waste to the extent practicable and to encourage more acceptable methods of disposal and incineration.

Open Burning on the Ground

Open burning on the ground involves burning solid waste that has been piled directly on the surface of the ground or placed in a small open pit. Many large and small communities and camp operators in Nunavut continue to practice open burning on the ground as a means of reducing the volume of solid waste that must ultimately be disposed of. In general, open burning on the ground results in the incomplete combustion of waste and the release of various harmful pollutants to the air, can cause vegetation or tundra fires through the uncontrolled release of hot sparks and embers, and is actively discouraged by the Nunavut Department of Environment as a method for disposing of unsegregated or mixed solid waste.



Figure 1 – Open Burning on the Ground
Photo courtesy of Aboriginal Affairs and Northern Development Canada

Burn Boxes

There are two basic types of burn boxes. The *enclosed burn box* is constructed using heavy sheets of steel or other metal while the *open burn box* is constructed using expanded metal grating. The latter type is commonly referred to as a *burn cage*. These devices are not commercially-available in Nunavut, but can be constructed using locally available materials. For example, the enclosed metal burn box shown in Figure 2 is made from a dump truck bed and steel plating.



Figure 2 – Enclosed Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

Burn boxes are considered a modification of open burning. Combustion air is provided passively using a natural draft making electricity unnecessary. Burn boxes are single chambered units. Waste is raised off the bottom of the box by placing it on grates inside the unit. Unburned bottom ash falls through the grate during burning making removal easier once a sufficient amount has accumulated. Combustion air in enclosed burn boxes is typically provided by cutting holes near the bottom of the box allowing for better mixing with the burning waste.

Open burn boxes, or burn cages, are an improvement over enclosed burn boxes as the waste is exposed to natural drafts through the metal grating on all surfaces including the bottom. This enables air to better mix with burning waste and promotes more efficient combustion throughout the burning period. Both types of burn boxes are constructed with hinged tops to enable easier loading and cleaning.

Unlike open burning on the ground, burn boxes help to contain the burning waste within a specific location reducing the risk of fire spreading to other disposal areas or surrounding tundra, while still enabling moderate amounts of solid waste to be burned.

Burn Barrels

There are two basic types of burn barrels – the unmodified burn barrel and modified burn barrel.



Figure 3 – Open Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

The *unmodified burn barrel* is normally a 45 gallon, or 205 litre, metal fuel or oil drum with the top removed. These devices typically operate at a low temperature resulting in incomplete combustion of the waste and production of large volumes of smoke and fly ash.

A *modified burn barrel* is a 45 gallon metal fuel or oil drum that has been affixed with devices or features which result in higher burn temperatures, better mixing of the air and a longer holding time. These modifications include a 'metal mesh basket' insert or grate designed to suspend the burning waste. Evenly spaced vents or holes cut above the bottom of the barrel supply combustion air. These features provide for enhanced passive under-fire ventilation and promote better contact between the waste being burned and incoming air. The basket insert is topped with a hinged lid and a chimney port for attachment of an exhaust pipe or stack. The lid helps to increase heat retention and holding time inside the barrel while also allowing for easier loading and mixing of the waste. The removable mesh basket enables access to the unburned bottom ash.

Modified burn barrels can be built using commonly available materials. They can either be pre-built locally or transported to the site for assembly. Detailed construction plans are provided in Appendix 2.

Although modified burn barrels are designed to create an advantage over open burning on the ground, burn boxes and unmodified burn barrels through achieving higher burn temperatures and increased turbulence and holding time, incomplete combustion of waste and the release of pollutants to the atmosphere are still likely. In fact, emissions testing by Environment Canada on a modified burn barrel in April 2011 suggest that these devices do not provide any improvement over open burning on the ground in terms of emissions quality, particularly if wet food waste is added to the waste mixture. Other common problems include easily overfilling the unit and loading waste that should not be burned (refer to section 3.2). Wet or frozen masses of waste are particularly difficult to burn and the resulting partly burned food waste may still attract animals. The proper operation of modified burn barrels is critical to achieving the most efficient burn possible. Basic operating instructions are provided in section 4.1.

Burn barrels are capable of burning only small volumes of solid waste. Like burn boxes, they reduce the risk of fire spreading to vegetation and tundra by containing the burning waste to a specific location.

2.3.2 Incineration

Solid waste incinerators are engineered systems that are capable of routinely achieving burn temperatures in excess of 1000°C and a holding time of at least one second. Properly designed and operated incinerators are able to effectively and safely destroy a wide range of waste. Only incinerators designed for burning mixed municipal solid waste are discussed in the guideline. The incineration of



Figure 4 – Modified Burn Barrel

hazardous and biomedical waste and sewage sludge requires specific equipment, operational controls and training that are beyond the scope of the current document.

There are four basic types of incinerators. They vary based upon the number of burn chambers they have, the amount of air provided to each chamber and how waste is fed into the primary burn chamber.

<i>Dual-Chamber Starved Air System</i>	The primary burn chamber receives less air than is needed to achieve full combustion. Gases from this incomplete combustion then pass into a second burn chamber where sufficient air is injected and complete combustion is achieved.
<i>Single Chamber Excess Air System</i>	More than a sufficient amount of air (as much as 50% more than the amount of air needed) is injected into the single burn chamber to achieve complete combustion of the waste.
<i>Continuous Feed Incinerator</i>	An incineration process that is in a continuous burn cycle. A continuous feed incinerator operates without interruption throughout the operating hours of the facility by having waste continually added to the primary burn chamber.
<i>Batch Feed Incinerator</i>	An incineration process that is not in a continuous or mass burning cycle. A batch feed incinerator is charged with a discrete quantity or single load of waste at the beginning of the burn cycle.

Batch feed dual-chamber controlled air incinerators currently operate at several remote industrial locations in northern Canada and Alaska. Although they are generally considered to have the highest qualities of all the incinerators and open burning methods mentioned, they must be designed for the type and quantity of waste to be burned. Too little heat and holding time will not allow waste to burn properly; too much heat will damage the incinerator.

Figure 5 illustrates the design of a typical batch feed dual-chamber controlled air incinerator. The main features of this type of incinerator are:

- Batch operation allows greater control of temperature and air throughout the burn process.
- Air turbulence can be reduced in the primary chamber so fewer particulates are released into the air from the stack.
- Although a wide range of wastes can be destroyed, waste may have to be segregated and remixed in order to achieve a uniform heating value close to the design point of the incinerator.
- Externally supplied fuel and electricity are needed for the burners and forced air ventilation.
- A properly operating dual-chamber controlled air system will reduce problems with animal attraction as the production of bottom and fly ash and smoke is minimized.

Section 2.3.2 is intended to provide the reader with a brief introduction to incinerators. It is not intended to provide information suitable for the design, selection or operation of an incineration system. Any person considering the purchase of an incineration system should first consult the system's manufacturer or other qualified persons with expertise in the incineration of solid waste.

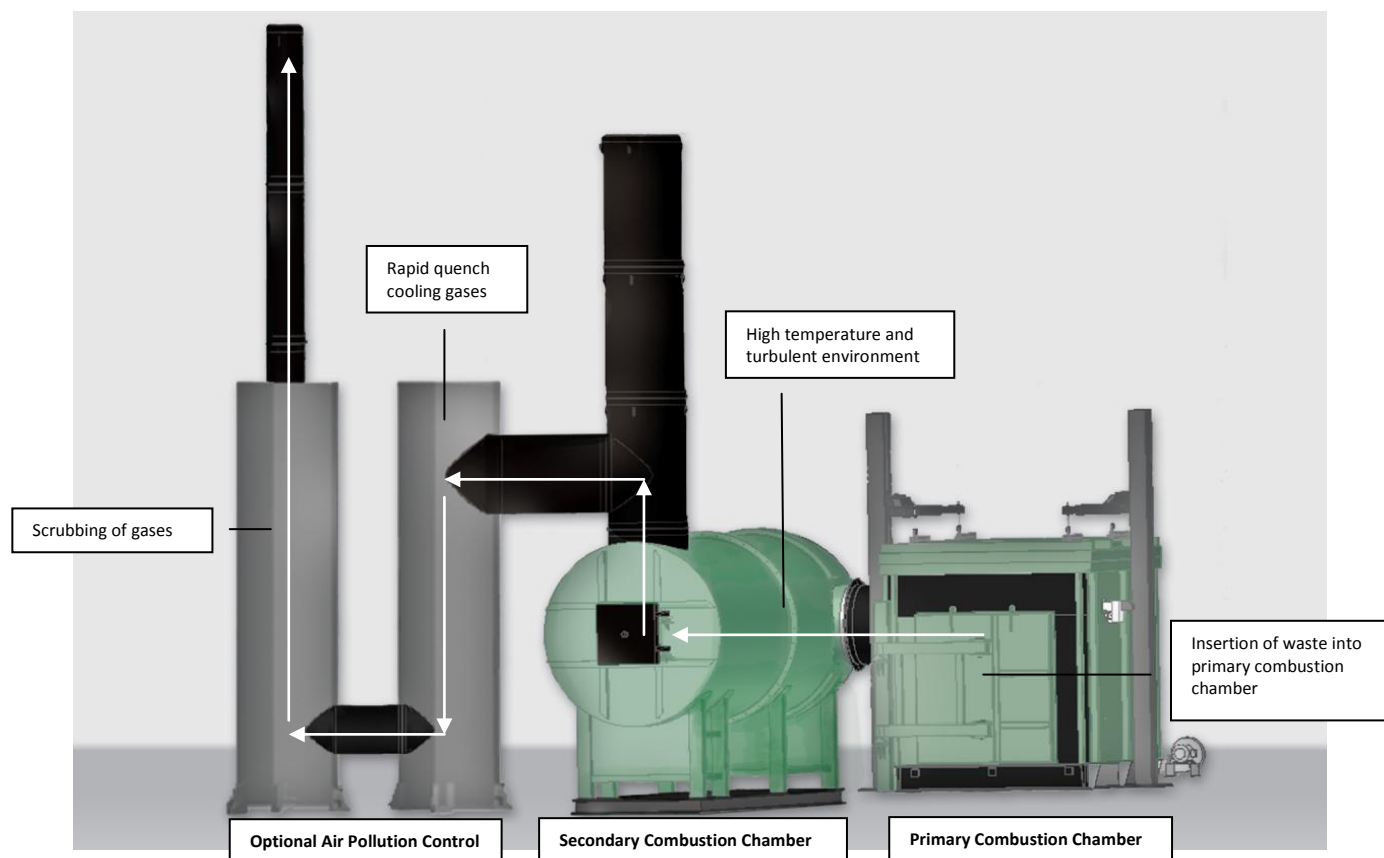


Figure 5 – Typical Batch Feed Dual-Chamber Controlled Air Incinerator with Optional Air Pollution Controls
Illustration courtesy of Eco Waste Solutions

2.4 Environmental Standards

2.4.1 Air Emissions

Air emission standards establish limits on the amount of contaminants that can be released into the atmosphere. These standards are expressed as a concentration in the exhaust gases leaving the stack and are capable of being achieved using generally available incineration technology and waste diversion practices. The following emission standards¹ apply to existing, new or expanding solid waste incinerators operating in Nunavut and have been adopted from the Canadian Council of Ministers of the Environment (CCME) Canada-Wide Standards for Dioxins and Furans and Mercury Emissions, respectively. Similar standards for the open burning of solid waste have not been established.

¹ Stack concentrations are always corrected to 11% oxygen content for reporting purposes.

Table 1. Air Emission Standards for Solid Waste Incinerators

Parameter	Numeric Standard	Explanation
Dioxins and Furans	80 pg I-TEQ/cubic metre	Unit of measure is picograms of International Toxicity Equivalents per cubic metre of air
Mercury	20 µg/Rcubic metre	Unit of measure is micrograms per Reference cubic metre (the volume of gas adjusted to 25°C and 101.3 kilopascals)

Opacity is the degree to which the exhaust gases reduce the transmission of light and obscure the view of any object in the background. It is expressed as a percentage representing the extent to which an object viewed through the gases is obscured. Although not an emission standard, opacity provides an indication of the general performance of the incinerator during normal operation². Opacity in the incinerator stack should not exceed 5%. While it is not anticipated that opacity levels would exceed 1% to 2% under normal operation, values greater than 5% indicate the incinerator is not performing properly and additional performance evaluation and adjustment is required.

**Figure 6 - Examples of Smoke Opacity Ratings**

The opacity ratings are estimates and are provided for illustrative purposes only

Centre and right photos courtesy of GNWT Department of Environment and Natural Resources

2.4.2 Bottom Ash

The *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* establishes criteria for determining whether process residuals³ are suitable for disposal in landfill sites in Nunavut. For the purpose of this Guideline, process residuals include bottom ash from industrial and commercial incinerators. The Toxicity Characteristic Leaching Procedure Test method 1311 (US EPA) is the preferred method to analyze the residuals as this test is designed to simulate the processes a material would be subjected to if placed in a landfill.

Refer to the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* for additional information on the management of process residuals.

² The time during which optimum designed temperature is maintained in the burn chamber, and excludes 'startup' and 'cool down' operations.

³ Process residuals are the solid, semi-solid or sludge waste resulting from industrial operations.

Best Management Practices

Best management practices are methods and techniques that have been shown to be effective in preventing or reducing pollution. They include policies, prohibitions of practices, maintenance and monitoring procedures and other practices adopted by the responsible party. Implementing best management practices together with using best available technology is an effective means of reducing costs, reducing pollution and reducing a parties' legal liabilities.

3.1 Waste Management Planning

The generator of a waste is responsible for its safe management from cradle-to-grave. Using raw materials efficiently and reducing the amount of waste generated is the most important step in waste management planning. For example, through improved waste management planning, it may be possible to reduce or eliminate the need to burn or incinerate waste altogether. Undertaking a waste audit will help to identify the type and amount of waste being generated, the costs of current management options and examine opportunities for better managing the waste. This information will also enable the generator to implement a waste management regime that is tailored to its own unique needs, location and circumstances.

Even with improved waste reduction measures in place there will be waste generated. Waste by its nature is usually a mixture of different unwanted materials. The segregation and diversion of different types of waste is an effective way to reduce the amount of waste requiring costly handling, storage, treatment and disposal. Segregation also enables the reuse of certain types of waste for a different purpose. Reuse activities may be undertaken either on-site or off-site.

Treatment and disposal is the last step in effective waste management and should be undertaken only after all other practical reduction and reuse options have been examined. A wide variety of treatment and disposal options exist and each must be examined before deciding on a final method, regardless of whether waste is to be treated and disposed of on-site or off-site. If burning and incineration is the method of choice, equipment must be designed and sized accordingly to accommodate the type and quantity of waste being produced. As described in the following section, open burning is capable of safely destroying a limited number of types of waste. While incinerators are capable of safely destroying a wider range of waste, many types of waste must still be diverted. Because of this, on-site segregation remains a critical component of any waste management plan.

Overall, the following principles should be used to guide responsible solid waste management planning:

- Know your waste by conducting a waste audit.
- Reduce the amount of solid waste produced by implementing strategic purchasing policies that focus on the substitution or reduction of purchased products as well as product design, composition and durability.
- Reuse waste where different purposes can be identified.
- Segregate and divert mixed waste streams enabling waste to be reused or recycled, thereby reducing the amount of waste to be disposed of.
- All practical disposal methods should be examined. Burning and incineration of waste should be considered only where other practical methods do not exist.

- If burning and incineration is used, the equipment chosen should be designed and sized to accommodate the waste produced, minimize fire hazard and result in the complete combustion of the waste.

3.2 Wastes That Can be Burned or Incinerated

Complete combustion converts waste into inert bottom ash with minimal creation of smoke, fly ash and hazardous gases. Several factors influence this process including the heating value, wetness and chemical composition of the waste itself, operating conditions in the burn chamber (i.e. temperature, holding time and turbulence) and operator skill.

The method used is important in determining what can safely be burned. Certain wastes can only be incinerated using equipment that has been specifically designed and equipped with sufficient air pollution controls and that achieve specific air emission standards. For example, waste containing chlorinated compounds (i.e. chlorinated solvents and plastics, PVC piping, wood treated with pentachlorophenol or PCB-amended paint, marine driftwood) must be separated from other waste as their burning will result in the *de novo* creation and emission of various dioxin and furan compounds. Waste containing mercury (i.e. batteries, thermostats and fluorescent light bulbs) and other heavy metals (i.e. lead acid batteries, wood treated with lead paint) should not be burned as the mercury and heavy metals will not be destroyed. Other waste that should not be burned unless using specially designed incinerators include used lubricating oil, hydrocarbon contaminated soil, biomedical waste, sewage sludge or any other waste specifically prohibited by the Department of Environment.

Table 2 provides a listing of common wastes that can be burned and those that require special consideration and treatment. Note that open burning and incineration are identified as separate columns in the table and that different restrictions apply depending upon which method is used. In general, more restrictions apply to the various methods of open burning because of the incomplete combustion achieved. Fewer restrictions apply to incineration because of the operator's ability to control the combustion process.

Non-combustible materials such as metal and glass do not burn and will rob heat away from waste that can be destroyed by burning. Combustible waste should always be separated from non-combustible waste before being loaded into the burn chamber.

3.3 Keeping Waste Dry

Typical mixed garbage has a moisture content of less than 20% while the moisture content of food wastes can range up to 80%. Anything that can be done to reduce the moisture of waste burned will decrease the amount of smoke produced and increase the completeness of combustion. Waste should be covered or stored inside sheds or other secure buildings to keep rain and snow out of the waste. This will also lessen the opportunity for wildlife to access the waste. If wet waste must be burned, the wet waste should be mixed or layered with dry waste to reduce the overall moisture content of the waste burned. Mixing or layering waste in this manner is particularly important when loading wet solid waste into a burn box or modified burn barrel.

Table 2. Waste That Can be Burned or Incinerated

Waste Type	Method	
	Open Burning ⁴	Dual-Chamber Incinerator
Paper products	✓	✓
Paperboard packing including boxboard and cardboard	✓	✓
Untreated wood including lumber and plywood	✓	✓
Food waste		✓
Food packaging		✓
Natural fiber textiles	✓	✓
Plastic and Styrofoam except plastic containing chlorine ⁵		✓
Painted wood except wood painted with lead or PCB-amended paint		✓
Wood treated with creosote or tar oil		✓
Hydrocarbon spill absorbents		✓
Animal carcasses except those affected by disease-causing agents		✓

The following waste requires special consideration. It is not to be burned or incinerated unless the equipment used has sufficient air pollution controls, meets specific air emission standards and has been specifically designed to safely incinerate the waste product.

Hydrocarbon contaminated soil
 Radioactive waste including smoke detectors
 Organic compounds containing chlorine including plastics, solvents, PVC piping and marine driftwood
 Pesticides
 Items containing mercury, lead or other heavy metals including paint, computer equipment and fluorescent bulbs
 Batteries
 Explosives
 Pressurized cans, cylinders or other containers that may explode when heated
 Synthetic fiber textiles
 Biomedical waste and animal carcasses affected by disease-causing agents
 Wood treated with pentachlorophenol, inorganic preservatives, lead paint or PCB-amended paint
 Sewage sludge
 Rubber tires
 Used lubricating oil
 Waste fuel except limited quantities used solely as a starting fuel
 Construction and demolition waste including roofing materials, electrical wire and insulation

3.4 Locating the Facility

Distance from sensitive areas (i.e. camp, work site, drinking water supply) and prevailing wind direction are important factors to consider when locating any facility that burns waste. The facility should be kept

⁴ Includes open burning on the ground and the use of burn boxes, unmodified burn barrels and modified burn barrels.

⁵ Chlorinated plastic materials are identified by the number "3" associated with the mobius loop symbol.



at least 100 metres from any surface water body. Although the objective is to minimize pollutants being released to the air, the site should be selected so that any resulting emissions are adequately dispersed. This includes locating the structure or facility away from areas or features that may trap smoke close to the ground (i.e. located in a valley). Avoid burning waste if people will be living or working within the plume of smoke. The facility should be located on stable and level ground. A gravel, rocky outcrop or other area free of combustible materials and vegetation should be chosen to avoid accidentally starting a vegetation or tundra fire.

3.5 Maximizing Combustion Efficiency

More smoke and other pollutants are released into the air during the 'start-up' and 'cool down' phases of the burn cycle than during the 'full burn phase' when high temperatures are maintained. Low temperature smoldering fires should be avoided. Burn only dry feedstock and periodically add additional waste to the fire in order to maintain high burn temperatures until all waste has been destroyed. If waste is to be open burned on the ground, the use of deep or steep-walled 'pits' should be avoided as this will prevent the necessary turbulent mixing of oxygen with the burnable gases.

Desired operating temperature should be achieved as quickly as possible when operating any burning or incineration device. A rapid 'start-up' can be achieved by first loosely loading dry paper, paperboard packing and untreated wood into the bottom of the device. Dry, loosely loaded material will ignite more quickly and burn more evenly than a wet, tightly packed load. Wet waste should only be added after the fire is actively burning. Overfilling the burn chamber will prevent the turbulent mixing of burnable gases and oxygen, and should be avoided.

Modern batch feed incinerators are designed with primary and auxiliary burners to achieve and maintain the necessary high burn temperatures. Additional waste should only be added to these incinerators once the 'cool down' phase has been completed and it is safe to do so.

3.6 Ash Management

The management of bottom ash and other unburned residue is an integral part of sound waste management and the ash will need to be disposed of. Extreme care must be exercised when handling ash because of its physical (i.e. glass, nails) and chemical hazards. Use closed or covered containers when moving or transporting bottom ash from the burning device or incinerator to the approved disposal site. This will minimize physical contact with the ash and the release of fine ash particles to the environment.

Avoid handling bottom ash until it is completely cool. Hot ash and embers can cause painful skin burns and should never be buried or landfilled as they could cause unburned waste in the disposal area to catch fire.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill. Because incinerators can be used to destroy a wide variety of waste and the subsequent ash may contain a wide variety of toxic residues, bottom ash from an incinerator is suitable for burial only where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities*. Waste originating from outside a municipality and meeting the criteria may be deposited in municipal landfills only with the consent of the local government. Any bottom ash

not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste. This ash is not suitable for landfilling and its management must comply with the *Environmental Guideline for the General Management of Hazardous Waste*.

3.7 Monitoring and Record Keeping

Burn boxes, burn barrels and incinerators should be inspected for signs of damage, corrosion or other physical defects before each burn cycle. Repairs must be completed before the equipment is used again to ensure the health and safety of the operator, nearby people and the environment.

The various open burning methods tend to produce large quantities of smoke. Burning dry waste, high burn temperatures and sufficient air mixing with the burnable gases will reduce, but not eliminate, the amount of smoke and other pollutants that are generated. Large quantities of dark smoke indicate problems and inefficiencies with the combustion process and the generation of pollutants. Keep records of when, how much and what waste was burned, how the waste was loaded into the burning device or incinerator, the amount of smoke and bottom ash generated, how the fire was started and any other information that would help remind the operator of what worked well, and what didn't. These records would also assist the operator, Department of Environment and other regulatory agencies if complaints of nuisance smoke were to be received.

The operation of incinerators should be monitored using on-line instruments capable of continuously measuring the combustion process and stack emissions. The most basic measurement associated with the combustion process is temperature in both the primary and secondary burn chambers. Temperature readings outside of the normal range can warn the operator that the system is not working properly. In-stack monitoring provides the operator with additional information on the combustion process and on pollutants that may be released to the environment. A continuous opacity or particulate monitor should be installed in the incinerator stack to monitor emissions quantity. Additional combustion chamber and in-stack sampling and monitoring may be required depending upon the type and quantity of waste being incinerated. Each process and in-stack monitor should be equipped with visible and audible alarms to warn operators of poor incinerator operation. Refer to section 4.2 for additional information on incinerator monitoring requirements.

Written records should be kept by incinerator operators of what waste is burned, when and how much. Other record keeping requirements for incinerators may include:

- Operating data including readings from the process and emissions monitoring instruments.
- Weather conditions (i.e. air temperature and wind speed) at the time the incinerator is being operated.
- Repairs and maintenance performed on the incinerator and monitoring instruments.
- Major changes in operation.
- Quantity, condition and disposal location of the collected bottom ash.
- Operator training.

Records should be maintained on-site throughout the operational life of the facility and be made available to Inspectors and other regulatory officials upon request.

3.8 Operator Training

The cornerstone of ensuring proper and safe operation of any equipment is adequate operator training. Facility owners must ensure qualified operators are available and have been properly trained to operate the equipment under both normal and emergency conditions. This will help to ensure the continued operation and maintenance of the equipment and facility, protection of the environment and the continued health and safety of the operator and nearby people. In particular, operators of incinerators should be trained in the following areas:

- Physical and mechanical features of the equipment and facility.
- Operation and trouble-shooting procedures.
- Environmental and safety concerns related to operation of the facility.
- Spill and fire emergency response procedures.
- Emergency and accident reporting procedures including use of the NWT/Nunavut 24-Hour Spill Report Line at (867) 920-8130.

Every incinerator manufacturer has its own approach to designing and building incinerators. Operators should be qualified and trained to safely operate the specific make and model of incinerator they are expected to operate.

The Application of Open Burning and Incineration

The Department of Environment does not promote or endorse the burning and incineration of solid waste. This method of waste management should be implemented only after the owner or operator has made all reasonable and determined efforts to implement sound waste management planning and practices. Opportunities to reduce or eliminate the need for burning and incineration through changes in purchasing practices, reuse, recycling, segregation and diversion, and other changes or emission control upgrades that would result in emission reductions, must be reviewed periodically and implemented where practical. Refer to section 3 for additional information on best management practices.

This section provides guidance on the application of open burning and incineration of solid waste. In addition to the guidance and direction provided through the Guideline, the burning and incineration of solid waste may also be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

4.1 Open Burning

Open burning is the burning of solid waste where limited or no control over the combustion process can be exercised by the operator. For the purposes of the Guideline, open burning includes burning waste that has been piled on the surface of the ground or placed in small open pits, or the use of a burn box, unmodified burn barrel or modified burn barrel. Open burning does not include the destruction of waste using a commercial or manufactured incinerator.

The open burning of unsegregated, or mixed, solid waste must not occur under any circumstances. Today's household, institutional, commercial and industrial garbage contains many materials which, when burned at low temperature, can result in the release of high levels of particulates, acid gases, heavy metals, carbon monoxide, dioxins, furans and other chemicals, some of which may cause cancer. The only solid wastes that may be disposed of through open burning are paper products, paperboard packing, untreated wood waste and natural fiber textiles (i.e. cotton, wool). Refer to section 3.2 for further information on what waste can and cannot be burned.

The open burning of solid waste remains a hazardous practice from a fire prevention and environmental management perspective. **Open burning on the ground** should not take place within a municipality without first obtaining authority to do so from the local community government. It should never occur at a municipal or industrial landfill because of the proximity of other combustible wastes within the working landfill. Where permission has been obtained and paper, paperboard packing, untreated wood waste and natural fiber textiles are open burned on the ground or in a small open pit, the activity must be attended and carefully monitored by a responsible adult at all times.

The preferred alternative to open burning on the ground is the use of an **enclosed burn box or burn cage**. These devices should be used when burning a moderate to large quantity of paper, paperboard packing, untreated wood waste and natural fiber textiles. They are designed to contain the waste while it is burning and reduce the likelihood of sparks or burning embers igniting adjacent vegetation and other combustible materials. When using a burn box or cage at a municipal or industrial landfill, extreme caution must be taken to ensure other areas of the working landfill are not ignited. Their

proper operation includes loading the device with dry waste to about half its capacity before igniting the fire. Additional or wet waste can be added in small batches so as not to dampen the fire once the fire has developed into a good flame and it is safe to do so.

The following general conditions should be met whenever open burning on the ground or burning using an enclosed burn box or burn cage takes place:

- Only paper, paperboard packing, untreated wood waste and natural fiber textiles are burned.
- The waste is burned in a controlled manner and at a site which is separate from combustible vegetation and other materials.
- Burning takes place only on days when winds are light and blowing away from people.
- Waste is burned in manageable volumes so the fire does not get out of control.
- The fire is started, attended and monitored at all times by authorized and qualified personnel.
- The waste is kept dry or covered to the extent practicable prior to burning.
- Where applicable, authority is first obtained from the municipality or other regulatory agencies.

Modified or unmodified burn barrels should only be used to burn small quantities of paper, paperboard packing, untreated wood waste and natural fiber textiles at remote locations such as traditional camps and field camps. Food and food packaging waste, which make up a significant portion of kitchen garbage produced at these camps, should not be burned. These wastes should be segregated daily and stored in wildlife-proof containers for frequent removal to an approved disposal site.

It is important that burn barrels are properly constructed and operated to ensure safety of the operator and the environment. Appendix 2 provides detailed construction drawings for a modified burn barrel. The Department of Environment will consider other designs if they provide an equivalent level of environmental protection.

Below are some easy-to-do actions to ensure unmodified and modified burn barrels are operated safely and waste is burned to the greatest extent possible⁶.

When locating and constructing a burn barrel:

- Locate the burn barrel in a place predominantly downwind of the camp site or burn only on days when the wind is light and blowing away from the camp.
- Ensure the burn barrel is located on gravel, rocky outcrop or other area free of combustible materials and vegetation to avoid accidentally starting a tundra fire.
- Ensure the detailed plans provided in Appendix 2 are carefully followed when constructing a modified burn barrel. The 'exhaust gas to combustion air' ratio is particularly important to achieving the maximum burn rate. A 2:1 ratio of exhaust stack to air intake area consisting of a 6-inch exhaust port and three 2-inch air intake holes positioned equidistantly around the bottom of the barrel a few inches up from the base is preferred.

⁶ Testing of a modified burn barrel was performed by Environment Canada's Air Quality Research Division in April 2011 at the request of Nunavut's Department of Environment. Ten trial burns were completed prior to emissions testing in order to optimize and standardize barrel design and operational procedures. Following the trial burns, four test runs were performed and air emission samples collected for analysis. Results of the emission testing program will be available from Nunavut's Department of Environment. This list of recommended practices reflects the operational observations and measurements made during the testing program.

When operating a burn barrel:

- Inspect the barrel for any signs of leakage, corrosion or other physical defects before each burn cycle. Any necessary repairs must be completed before the equipment is used.
- Burn only dry waste. If wet waste must be burned, mix or batch the waste with other waste that has a low moisture content and high heating value (i.e. dry wood). This will help ensure the slow-burning wet waste is completely burned.
- Burn only paper, paperboard packing, untreated wood waste and natural fiber textiles. Food and food packaging waste should not be burned. Burning non-combustible waste (i.e. metal and glass) will rob the fire of valuable heat and should also be avoided. Food and food packaging, non-combustible and other waste that cannot be burned should be segregated and removed from the site for disposal on a regular basis.
- Do not overfill or densely pack waste into the burn barrel as air will be prevented from properly mixing with the waste. This will result in a smouldering, low temperature burn and smoke.
- Layering wet or slow burning waste with dry fast burning waste will help ensure more complete combustion of all waste.
- The burn barrel should not be used unless a responsible adult is available to monitor and watch over it until the fire has completely cooled.
- When using a modified burn barrel, the exhaust port on the 'metal basket insert' should be aligned between two of the 2-inch air intake holes in order to avoid short-circuiting of the combustion air directly through to the stack. Also, the spark arrest screen should be cleaned following each burn to ensure the stack does not become blocked with soot and other debris. If the barrel lid begins to 'puff' during a burn, inspect the screen to ensure it is not obstructing the flow of exhaust gases.

Care must be taken by the operator at all times to avoid skin contact with hot surfaces and avoid breathing smoke and other exhaust gases.

Written records of open burning should be kept by the operator. These record what was burned, when and how much, how waste was loaded into the device, how the fire was started, its location, weather conditions at the time and any other information that may help remind the operator of what worked well, and what didn't. These records are to be made available for review upon request by an Inspector.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill site. Consent to use a municipal landfill should first be obtained from the local government. Bottom ash must be completely cooled before it can be safely handled and disposed of. Refer to section 3.6 for further information.

4.2 Incineration

Incinerators differ from the simpler methods of open burning as the operator has a higher degree of control over the burning process. The resulting higher temperatures, longer holding times and greater turbulence lead to more complete combustion of the waste. Although a wider range of wastes can be destroyed using high temperature single or dual-chambered incinerators, determined efforts should still be taken to reduce the quantity and type of waste generated and to implement other changes which would result in reductions in air emissions. Refer to section 3 for further information proper waste management practices and a listing of what waste can and cannot be incinerated.

The incinerator manufacturer's operating instructions must be followed at all times to ensure designed temperature, holding time and turbulence conditions are achieved and to avoid damage to the facility. When operating during winter months, additional care must be taken because cold air introduced into the primary and secondary chambers may make it difficult for normal operating temperatures to be achieved. Operators must be properly trained and qualified to operate the equipment under both normal and emergency conditions. Owners are strongly encouraged to consult system manufacturers or other qualified persons with expertise before purchasing an incinerator. Additional guidance on the selection of incinerator technologies and their operational requirements can be obtained by referring to Environment Canada's *Technical Document for Batch Waste Incineration*.

The installation and operation of monitoring and control systems is critical for the proper and safe operation of any incinerator. The design, installation, certification and operation of continuous emissions monitoring systems (CEMS) should comply with the principles described in Environment Canada's *Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation*. While the document is written for power generation facilities, the principles apply equally well to other types of facilities and continuous emissions monitoring systems. For incinerators operating in Nunavut, key operational parameters must be monitored at all times using on-line instruments capable of continuously measuring the combustion process and stack emissions quality. These instruments should be equipped with visible and audible alarms and be on-line whenever the incinerator is in operation, including 'start-up' and 'cool down' phases. Table 3 lists the monitoring and control system requirements.

Table 3. Incinerator Monitoring and Control System Requirements

System Description	Quantity of Waste to be Burned ⁷	
	Less than 26 Tonnes per Year	Greater than 26 Tonnes per Year
Weight and composition of feedstock waste on a batch basis	✓	✓
Temperature in the primary and secondary combustion chambers	✓	✓
Opacity in the stack ⁸	✓	✓
Initial Certificate of Operation ⁹		✓

While not a specific requirement of the Guideline, additional one-time or continuous emissions monitoring may be required depending upon the type and quantity of waste to be incinerated. Examples include monitoring oxygen and carbon monoxide in the undiluted gases exiting the combustion chamber, such as a secondary chamber of a conventional dual-stage incinerator. Annual or periodic stack sampling for hydrogen chloride, dioxins and furans may also be required where the feedstock includes a significant quantity of organic materials that contain chlorine (i.e. chlorinated solvents and plastics, PVC piping, marine driftwood). The reader is encouraged to contact Nunavut's Department of Environment for guidance on additional emissions monitoring requirements.

⁷ The CCME Canada-Wide Standard for Dioxins and Furans Emissions from Waste Incinerators and Coastal Pulp and Paper Boilers (2001) established a criterion of 26 tonnes per year to distinguish between a 'small facility' and 'large facility' incinerator.

⁸ An acceptable alternative to monitoring opacity is to continuously monitor particulate matter in the stack.

⁹ An initial Certificate of Operation includes satisfactory confirmation based on manufacturers' or third-party testing and certification that the unit is capable of complying with the requirements contained in the Guideline when operated in accordance with the manufacturer's recommendations and with minimal requirement for operator attention. The Certificate is to be provided to the Nunavut Department of Environment before the incinerator is placed into routine operational service.

Monitoring and control data should be recorded each time a burn cycle is completed. Records are to be maintained for the operational life of the incinerator and made available for review upon request by an Inspector. Refer to section 3.7 for additional information on monitoring and record keeping.

Bottom ash and other solid residue collected from the incinerator is suitable for burial where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* or in accordance with land use permits and water licenses issued by Nunavut's co-management boards and Aboriginal Affairs and Northern Development Canada. Where bottom ash meets the criteria and is to be disposed of into a municipal landfill, the quantity transported off-site must be recorded and the consent of the local municipal government first be obtained. Bottom ash not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste and must be managed in accordance with the *Environmental Guideline for the General Management of Hazardous Waste*.

Conclusion

This is a general introduction to the practice of burning and incinerating solid waste. It is not intended to promote or endorse the practice but to provide the reader with information on the risks, hazards and best management practices associated with this activity. It also provides specific guidance on the application of burning and incinerating solid waste should this practice be undertaken by municipalities and operators of traditional, field and commercial camps.

Familiarity with the Guideline does not replace the need for the owner or person in charge, management or control of the solid waste to comply with all applicable federal and territorial legislation and municipal by-laws. The burning and incineration of solid waste may be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

For additional information on the management of solid waste, or to obtain a complete listing of available guidelines, contact the Department of Environment at:

Environmental Protection Division
Department of Environment
Government of Nunavut
Inuksugait Plaza, Box 1000, Station 1360
Iqaluit, Nunavut, X0A 0H0

Phone: (867) 975-7729

Fax: (867) 975-7739

Email: EnvironmentalProtection@gov.nu.ca

Website: <http://env.gov.nu.ca/programareas/environmentprotection>

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<http://env.gov.nu.ca/node/82#Guideline Documents>

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<http://env.gov.nu.ca/node/82#Guideline Documents>

APPENDICES

APPENDIX 1 - ENVIRONMENTAL PROTECTION ACT

The following are excerpts from the *Environmental Protection Act*

1. "Contaminant" means any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment,
 - (a) endangers the health, safety or welfare of persons,
 - (b) interferes or is likely to interfere with normal enjoyment of life or property,
 - (c) endangers the health of animal life, or
 - (d) causes or is likely to cause damage to plant life or to property;

"Discharge" includes, but not so as to limit the meaning, any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping;

"Environment" means the components of the Earth and includes

- (a) air, land and water,
- (b) all layers of the atmosphere,
- (c) all organic and inorganic matter and living organisms, and
- (d) the interacting natural systems that include components referred to in paragraphs (a) to (c).

"Inspector" means a person appointed under subsection 3(2) and includes the Chief Environmental Protection Officer.

- 2.2 The Minister may
 - (a) establish, operate and maintain stations to monitor the quality of the environment in the Territories;
 - (b) conduct research studies, conferences and training programs relating to contaminants and to the preservation, protection or enhancement of the environment;
 - (c) develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment;
 - (d) collect, publish and distribute information relating to contaminants and to the preservation, protection or enhancement of the environment:
3.
 - (1) The Minister shall appoint a Chief Environmental Protection Officer who shall administer and enforce this Act and the regulations.
 - (2) The Chief Environmental Protection Officer may appoint inspectors and shall specify in the appointment the powers that may be exercised and the duties that may be performed by the inspector under this Act and regulations.
5.
 - (1) Subject to subsection (3), no person shall discharge or permit the discharge of a contaminant into the environment.
 - (3) Subsection (1) does not apply where the person who discharged the contaminant or permitted the discharge of the contaminant establishes that
 - (a) the discharge is authorized by this Act or the regulations or by an order issued under this Act or the regulations;
 - (b) the contaminant has been used solely for domestic purposes and was discharged from within a dwelling house;
 - (c) the contaminant was discharged from the exhaust system of a vehicle;

- (d) the discharge of the contaminant resulted from the burning of leaves, foliage, wood, crops or stubble for domestic or agricultural purposes;
- (e) the discharge of the contaminant resulted from burning for land clearing or land grading;
- (f) the discharge of the contaminant resulted from a fire set by a public official for habitat management of silviculture purposes;
- (g) the contaminant was discharged for the purposes of combating a forest fire;
- (h) the contaminant is a soil particle or grit discharged in the course of agriculture or horticulture; or
- (i) the contaminant is a pesticide classified and labelled as "domestic" under the *Pest Control Products Regulations* (Canada).

(4) The exceptions set out in subsection (3) do not apply where a person discharges a contaminant that the inspector has reasonable grounds to believe is not usually associated with a discharge from the excepted activity.

- 5.1. Where a discharge of a contaminant into the environment in contravention of this Act or the regulations or the provisions of a permit or license issued under this Act or the regulations occurs or a reasonable likelihood of such a discharge exists, every person causing or contributing to the discharge or increasing the likelihood of such a discharge, and the owner or the person in charge, management or control of the contaminant before its discharge or likely discharge, shall immediately:
- (a) subject to any regulations, report the discharge or likely discharge to the person or office designated by the regulations;
 - (b) take all reasonable measures consistent with public safety to stop the discharge, repair any damage caused by the discharge and prevent or eliminate any danger to life, health, property or the environment that results or may be reasonably expected to result from the discharge or likely discharge; and
 - (c) make a reasonable effort to notify every member of the public who may be adversely affected by the discharge or likely discharge.
6. (1) Where an inspector believes on reasonable grounds that a discharge of a contaminant in contravention of this Act or the regulations or a provision of a permit or license issued under this Act or the regulations has occurred or is occurring, the inspector may issue an order requiring any person causing or contributing to the discharge or the owner or the person in charge, management or control of the contaminant to stop the discharge by the date named in the order.
7. (1) Notwithstanding section 6, where a person discharges or permits the discharge of a contaminant into the environment, an inspector may order that person to repair or remedy any injury or damage to the environment that results from the discharge.
- (2) Where a person fails or neglects to repair or remedy any injury or damage to the environment in accordance with an order made under subsection (1) or where immediate remedial measures are required to protect the environment, the Chief Environmental Protection Officer may cause to be carried out the measures that he or she considers necessary to repair or remedy an injury or damage to the environment that results from any discharge.

APPENDIX 2 – MODIFIED BURN BARREL DESIGN AND SPECIFICATIONS

A modified burn barrel is typically constructed from a 45 gallon metal fuel or oil drum. The modifications result in greater heat generation and retention, better mixing of the waste with incoming air and longer holding time inside the barrel. Together, these modifications result in more complete combustion of the solid waste than does open burning on the ground or in a pit.

Placing a metal screen over the top of the exhaust pipe may be required to prevent sparks and hot ash from escaping. Care should be taken to ensure the screen does not become blocked with soot.



A stove pipe attached to the top of the barrel allows smoke to escape and creates an effective draft.

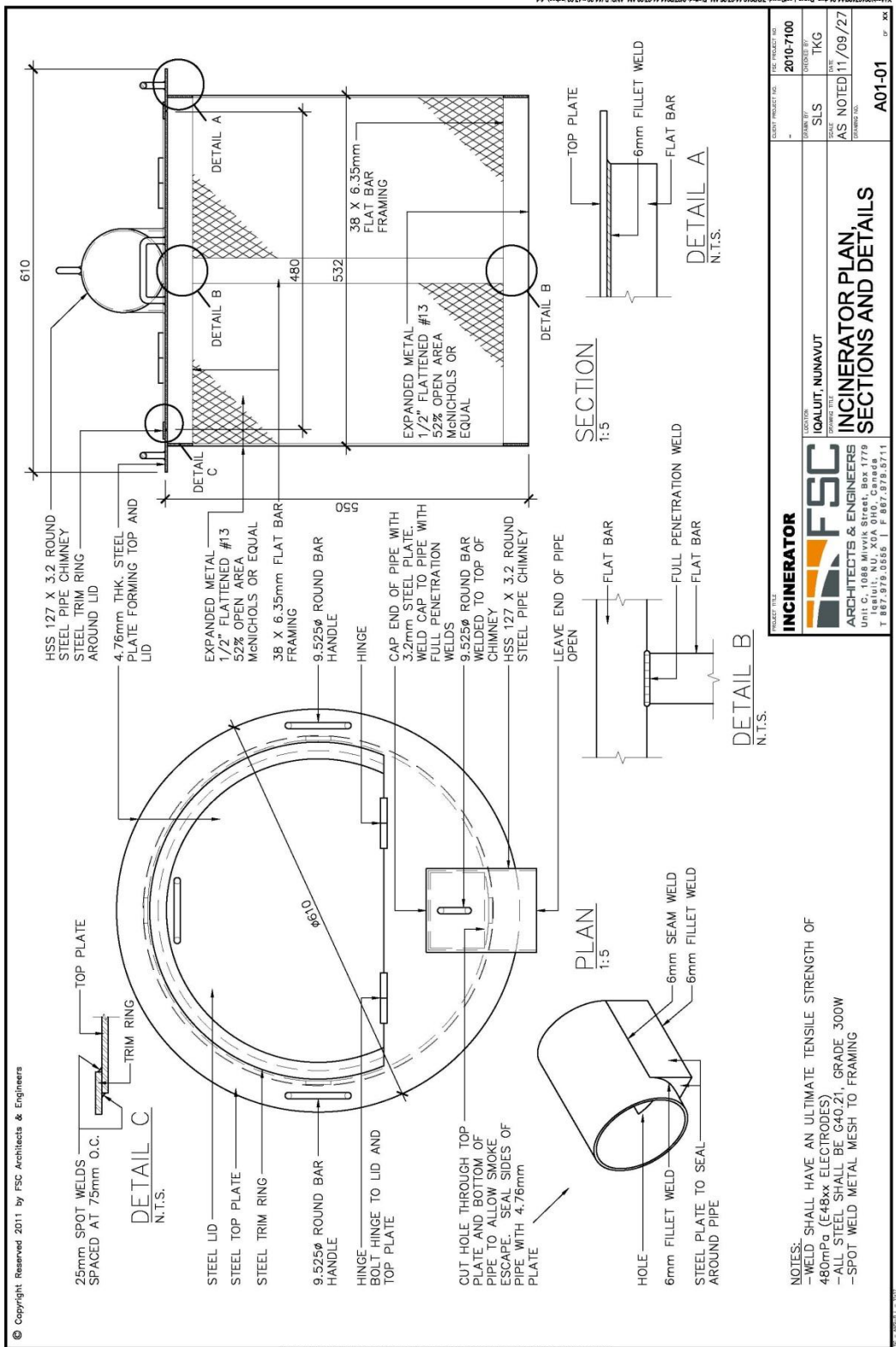
Evenly spaced vents or holes cut above the bottom of the barrel enable fresh air to mix with waste inside the metal basket.



A hinged top helps to capture heat and enables easy loading and mixing of waste.



A metal basket or grate suspends the burning waste and enables mixing with the incoming air. The removable basket also enables access to any unburned ash that may collect in the bottom of the barrel.

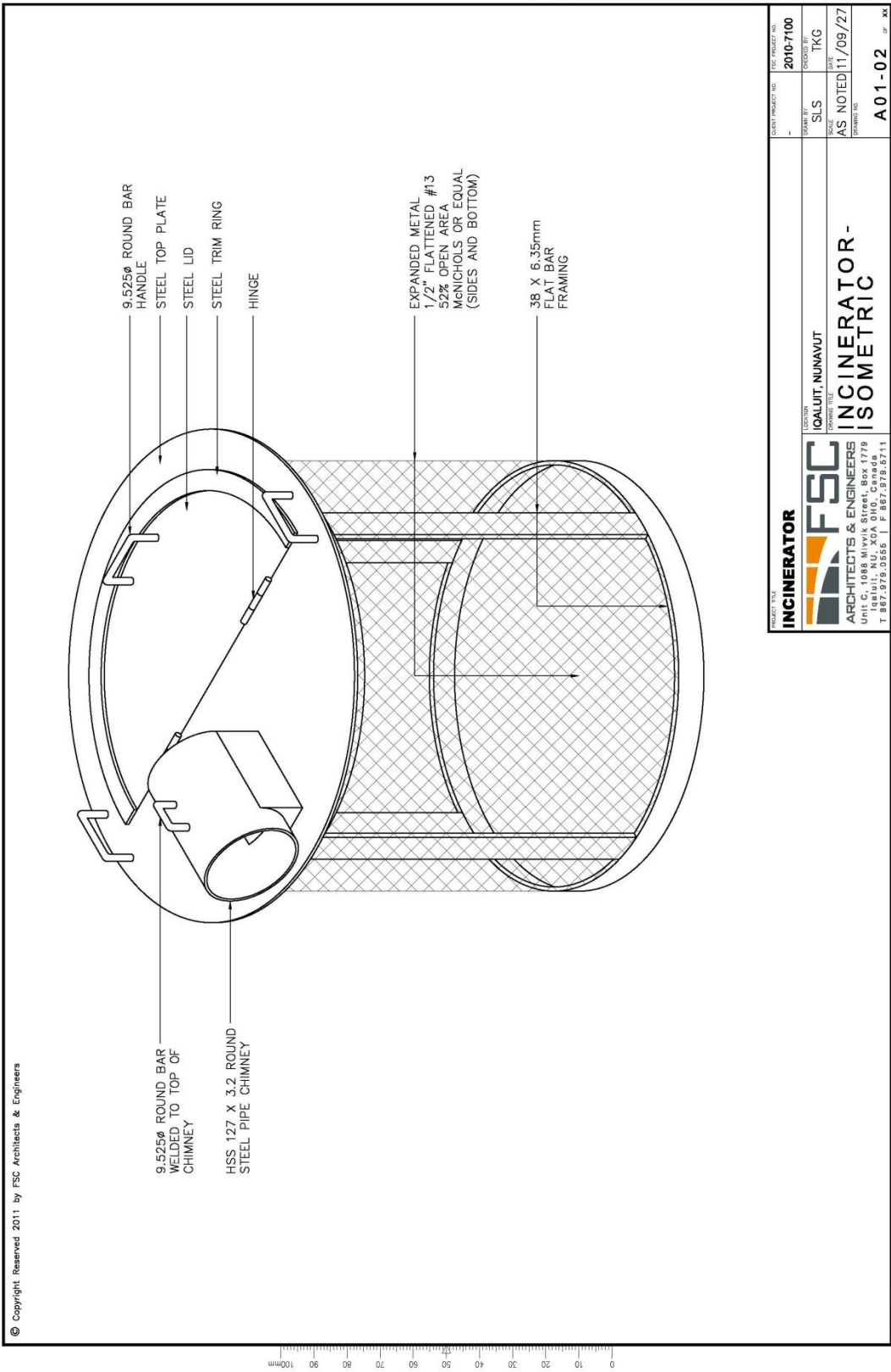


NOTES:
- WELD SHALL HAVE AN ULTIMATE TENSILE STRENGTH OF 480MPa (E48xx ELECTRODES)
- ALL STEEL SHALL BE Q40.21, GRADE 300W
- SPOT WELD METAL MESH TO FRAMING

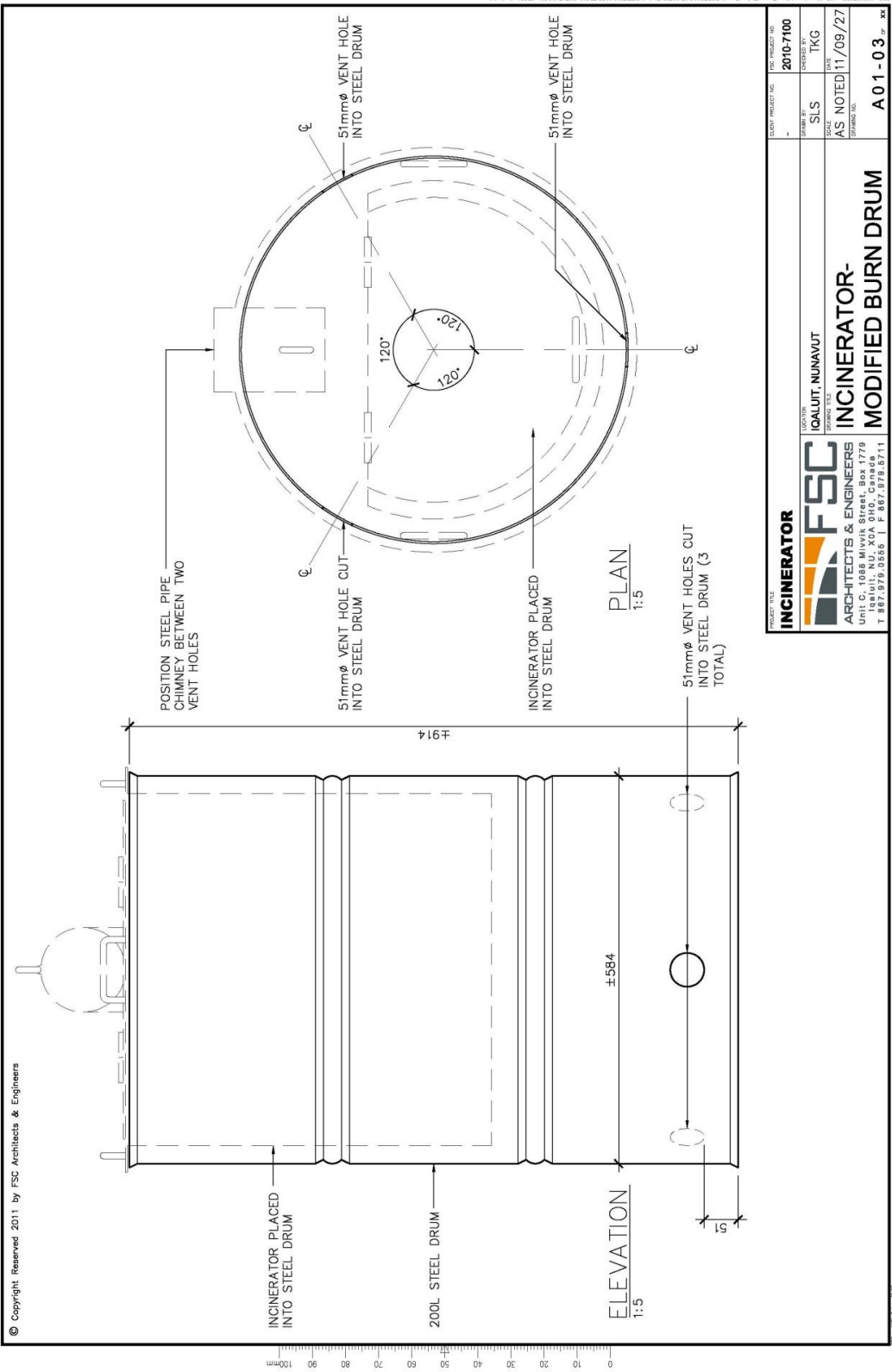
PROJECT TITLE	INCINERATOR	LOCATION	IGALUIT, NUNAVUT
CLIENT PROJECT NO.	2010-7100	DESIGNED BY	SLS
		CHECKED BY	TKG
		DATE	11/09/27
		SCALE	AS NOTED
		REVISION NO.	
			A01-01

INCINERATOR PLAN, SECTIONS AND DETAILS

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Appendix 3 Landfarm Management Plan

Lupin Mines Incorporated

A wholly owned subsidiary of Mandalay Resources Corporation

Lupin Mine

Nunavut, Canada

Landfarm Management Plan

(Care and Maintenance)

March 2016

Lupin Mines Incorporated
Mandalay Resources Corporation
76 Richmond Street East, Suite 330
Toronto, Ontario M5C 1P1

Document Control

Revision No	Date	Details	Author	Approver
1.0	05/12/14	Initial Plan created	SRK	K. Lewis
2.0	25/03/16	Updated to reflect new water licence Updated contact and general information Corrected typographical errors Added link to the Liquid Waste Management Plan	SRK	K. Lewis

Executive Summary

This Landfarm Management Plan has been prepared by Lupin Mines Incorporated (LMI), a wholly owned subsidiary of Mandalay Resources Corporation for the Lupin Gold Mine to support the Water Licence 2AM-LUP1520 (Licence). The Project site is located in the Kitikmeot Region, Nunavut, 400 km north of Yellowknife, Northwest Territories and 285 km southeast of Kugluktuk, Nunavut. The site is on the western shore of Contwoyto Lake, approximately 60 km south of the Arctic Circle. The site has been in a state of care and maintenance since 2006. LMI continues to evaluate the feasibility of returning to operations.

The Landfarm Management Plan has been developed to provide the operating guidance for the landfarm, which will be put in place on an existing pad to treat select hydrocarbon impacted soils. The Landfarm Management Plan details the landfarm layout, materials that are suitable for landfarming, safety considerations, operating procedures and sampling approach.

Executive Summary Inuktitut

Awaiting translation – to be provided as soon as possible

Executive Summary Inuinnaqtun

Awaiting translation – to be provided as soon as possible

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1. Introduction

Lupin Mines Incorporated (LMI), a wholly owned subsidiary of Mandalay Resources Corporation (Mandalay), has prepared this Landfarm Management Plan for the Lupin Mine (Mine) to provide operational guidance for a landfarm which forms part of the on-going progressive reclamation at the minesite.

The Mine is located in the Kitikmeot Region, Nunavut, 400 km north of Yellowknife, Northwest Territories and 285 km southeast of Kugluktuk, Nunavut. The airport serving this Site is at 65° 46'00" N and 111° 14'41" W. The Site is on the western shore of Contwoyto Lake (Appendix A).

Landfarming is an *ex situ* contaminated soil bioremediation technique that involves excavating and spreading impacted soil material either in beds consisting of a thin uniform layer, or in windrows. Remediation occurs by manipulating the soil conditions to stimulate microbial activity. Nutrients and water may be applied to the soil to stimulate microbial activity. Landfarms are an effective method to remediate petroleum hydrocarbon contaminated soils, particularly in remote regions of Canada due to the simplicity of the operational requirements.

The landfarm is required to reduce the volume of contaminated soil at the Mine prior to final closure and reclamation. The landfarm will be built on an existing concrete pad. Once hydrocarbon concentrations in the soil have been remediated to an acceptable level, it will be removed and re-used as clean fill material.

An annual review of the Landfarm Management Plan will take place and revisions will be submitted as necessary with the Annual Report to the Nunavut Water Board (NWB). The Landfarm Management Plan, dated December 2014 was approved by the NWB under Part E(22) of Type A water licence 2AM-LUP1520 (Water Licence).

2. Background

Mandalay is a Canadian based company focused on producing assets in Australia, Chile and Sweden, a development project in Chile and the exploration and development of the past-producing Lupin Gold Mine and the Ulu gold project, both located in Nunavut, Canada.

Mandalay purchased Elgin Mining Inc., which owns LMI and the Lupin Mine, in September 2014. Lupin was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004. The mine resumed production in March 2004 until February 2005. Since 2005, the Site has remained in Care and Maintenance.

General site maintenance and facilities upgrades are underway at the Lupin Mine to assess operational requirements. The activities underway were screened by the Nunavut Impact Review Board under file 99WR053 and approved by the Nunavut Water Board under Water Licence 2AM-LUP1520. Surface exploration is conducted under Water Licence 2BE-LEP1217. All camp infrastructure required for the surface exploration program currently exists at the Lupin Mine

Company:	LMI
Project:	Lupin Mine, Nunavut
Company Address:	Suite 330, 76 Richmond Street East, Toronto, ON M5C 1P1
Telephone:	778-386-7340
Email:	klewis@elginmining.com
Attention:	Karyn Lewis, General Administration

Effective Date: March 18, 2016

Distribution List:

Karyn Lewis	General Administration
Discovery Mining Services	Site Contractor
Golder Associates	Site Consultant
SRK Consulting	Site Consultant

Additional copies of this Plan are available from General Administration. This Plan will be posted in key locations at the site, and all employees and contractors will be made aware of its contents.

3. Environmental and Sustainable Development Policy

Lupin Mine Incorporated (LMI) is committed to maintaining a safe, clean, compliant and respectful work environment. LMI looks to our employees, contractors and managers to adopt and grow a culture of social responsibility and environmental excellence. Together we achieve this by:

- Promoting environmental stewardship in all tasks. Nothing is too important that it cannot be done in a clean and responsible manner. We strive towards maintaining a zero-incident work place.
- Recognizing that we have a shared responsibility as stewards of the environment in which we operate. We will not walk away from a non-compliant act.
- Identifying, managing and mitigating environmental, business and social risks in an open, honest and transparent manner.
- Planning our work so it is done in the cleanest possible manner and executing work according to plan.
- Continually improving environmental and operational performance by setting and reviewing achievable targets.
- Providing appropriate and necessary resources in the form of training, personnel and capital, including that required for closure planning and reclamation.
- Managing our materials and waste streams, maintaining a high degree of emergency response preparedness and minimizing our operational footprint to maintain environmental protection at all stages of project development.
- Procuring goods and services locally, where available, and favouring suppliers with environmentally and socially responsible business practices.
- Seeking to understand, learn from and mitigate the root causes of environmental incidents and near misses when they do occur.
- Employing systems and technology to achieve compliance, increase efficiency and promote industry best practices in development, operations and environmental stewardship.
- Working with stakeholders to identify and pursue opportunities for sustainable social and economic development and capacity building.
- Conducting early and ongoing stakeholder engagement relevant to the stage of project and mine development and operation.
- Recognizing diversity in the workplace and building meaningful relationships with all stakeholders in a timely, collaborative and transparent manner.

Through implementation of this policy, LMI seeks to earn the public's trust and be recognized as a respectful and conscientious employer, neighbor and environmental steward.

4. Landfarm Siting

The landfarm is to be located within the foundation of the former paste backfill building, as shown on Photograph 1 and Appendix A. The overall foundation is 90 m by 30 m. A bund wall of approximately 1.0 m high surrounds most of the foundation. For this stage of landfarming it is proposed to utilize the southern 17 m by 30 m section which is a raised concrete slab that is in good condition. Subsurface site drainage patterns were documented in the *Phase 1 and 2 Environmental Site Assessment* (Morrow 2005). Figure 2 is taken from that report and it shows that subsurface drainage from the landfarm reports to the Lower Sewage Lake. The footprint of the facility and surrounding development rock has elevated metal concentrations (Morrow 2005) and remedial measure to address the contamination will be required during final closure of the mine site.



Figure 1: Foundation of former paste backfill building

Climate in this region is classified as semi-arid subarctic, with an average annual precipitation of about 300 mm and a mean daily temperature of -11°C . Average temperature for the months of May through September is 4.6°C (Canadian Climate Normals 1981 to 2010). Total precipitation at Lupin is 298.5 mm distributed about equally between rain (160.5 mm) and snow (138 mm) (Environment Canada, 2014). An extreme daily rainfall event of 41.8 mm was recorded on 9 July 1983.

The fuel handling facilities at Lupin include a main tank farm, a satellite tank farm and various other storage and day tanks containing diesel, gasoline, Jet A fuel, waste oil and glycol. The petroleum hydrocarbon and glycol handling systems are described in detail in the Fuel Containment Management Strategy (LMI 2012). Many of the day tanks described were removed from service or replaced with double walled tanks in 2012. The landfarm will initially be used to remediate petroleum hydrocarbon contaminated soil adjacent to the satellite tank farm. Additional areas of petroleum hydrocarbon impacted soil and development rock are known to be present at the site (Morrow 2005), however most of these areas will not be accessible until final closure when infrastructure has been removed.

The active layer is at least 1.5 m. Test pits excavated immediately adjacent to the landfill site indicate that native fine grained, silty sand is overlain by sand and gravel fill which is capped with a layer of development rock (Morrow 2005). No hydrocarbon contamination was detected in the test pit downgradient of the landfill site (Morrow 2005).



Figure 2: Inferred groundwater contours

5. Landfarm Design

The area of the foundation to be utilized for landfarming will initially be the southern 17 m by 30 m section of the foundation which is a raised concrete pad in good condition. Any cracks and holes in the concrete pad will be backfilled and sealed with concrete. The raised slab will be sloped 0.5% to allow for contact water to drain to a 5 m by 30 m by 0.5 m catchment sump located immediately adjacent to the north of the raised slab (see attached Figure 3: Drawing LMI-LF-001 and 002 attached for details). Normal catchment will be retained within this sump area and pumped back onto the soil undergoing treatment or it will be pumped to an oil water separator for treatment if necessary (See Section 6-Moisture Management for further details.)

In general if there are any openings in the surrounding 1.0 m wall, a new section of bund wall will be cast in place or an earthen berm will be established that will be lined with Reinforced Linear Low Density Polyethylene (RLLDPE) geomembrane liner. Drawings LMI-LF-001 and 002 show both a plan view and cross sectional view of the conceptual design. As required under Part G(4) of the water licence, sixty (60) days prior to the construction of the landfarm facility, the construction design drawings and specifications prepared by a qualified Engineer will be submitted to the NWB.

The conditions applying to construction under the Water Licence (Part G) will be followed during construction. Final as-built construction drawings and a construction summary report will be prepared by a qualified Engineer and submitted within ninety (90) days following the completion of the landfarm as required under Part G(3) of the Water Licence.

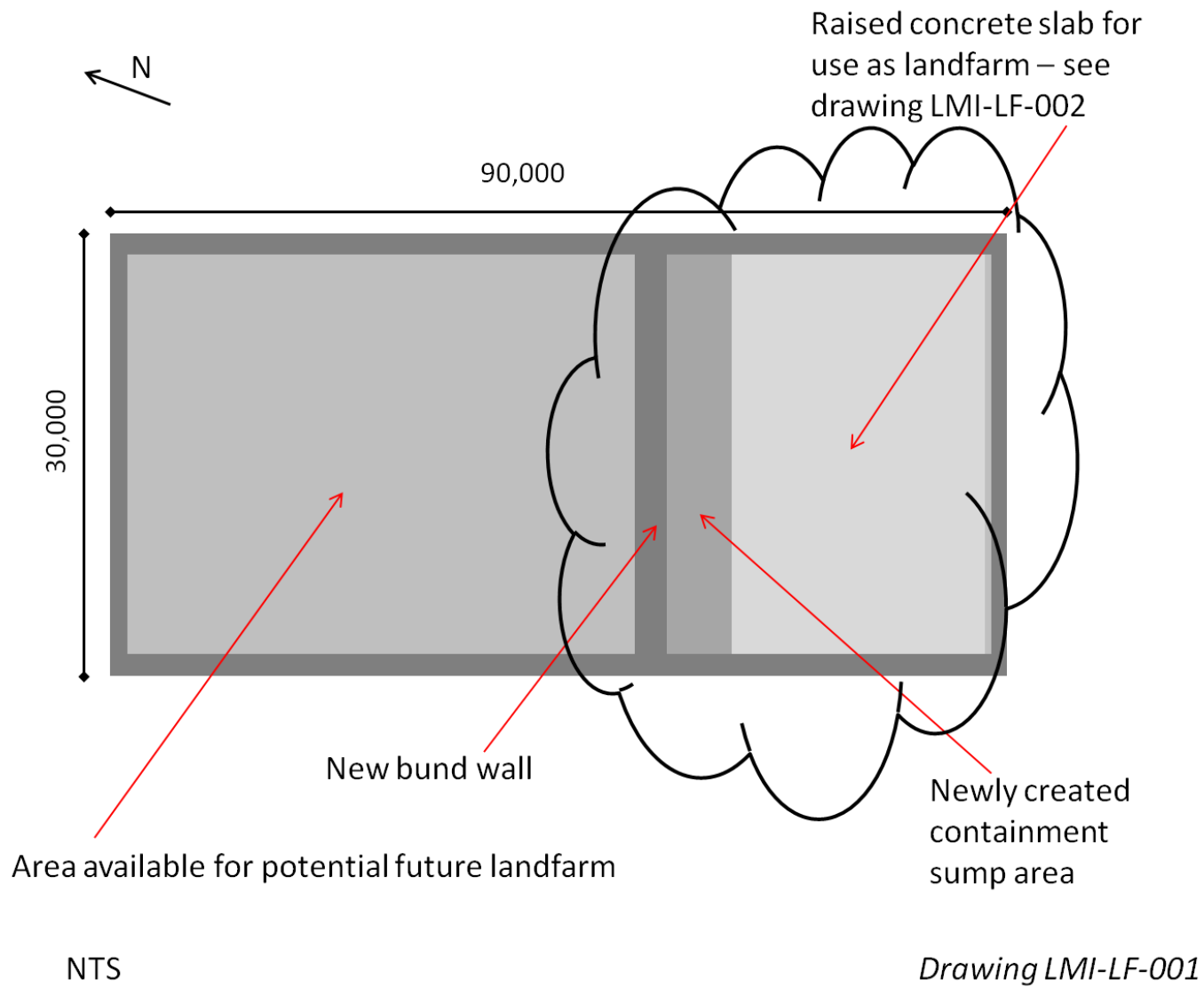
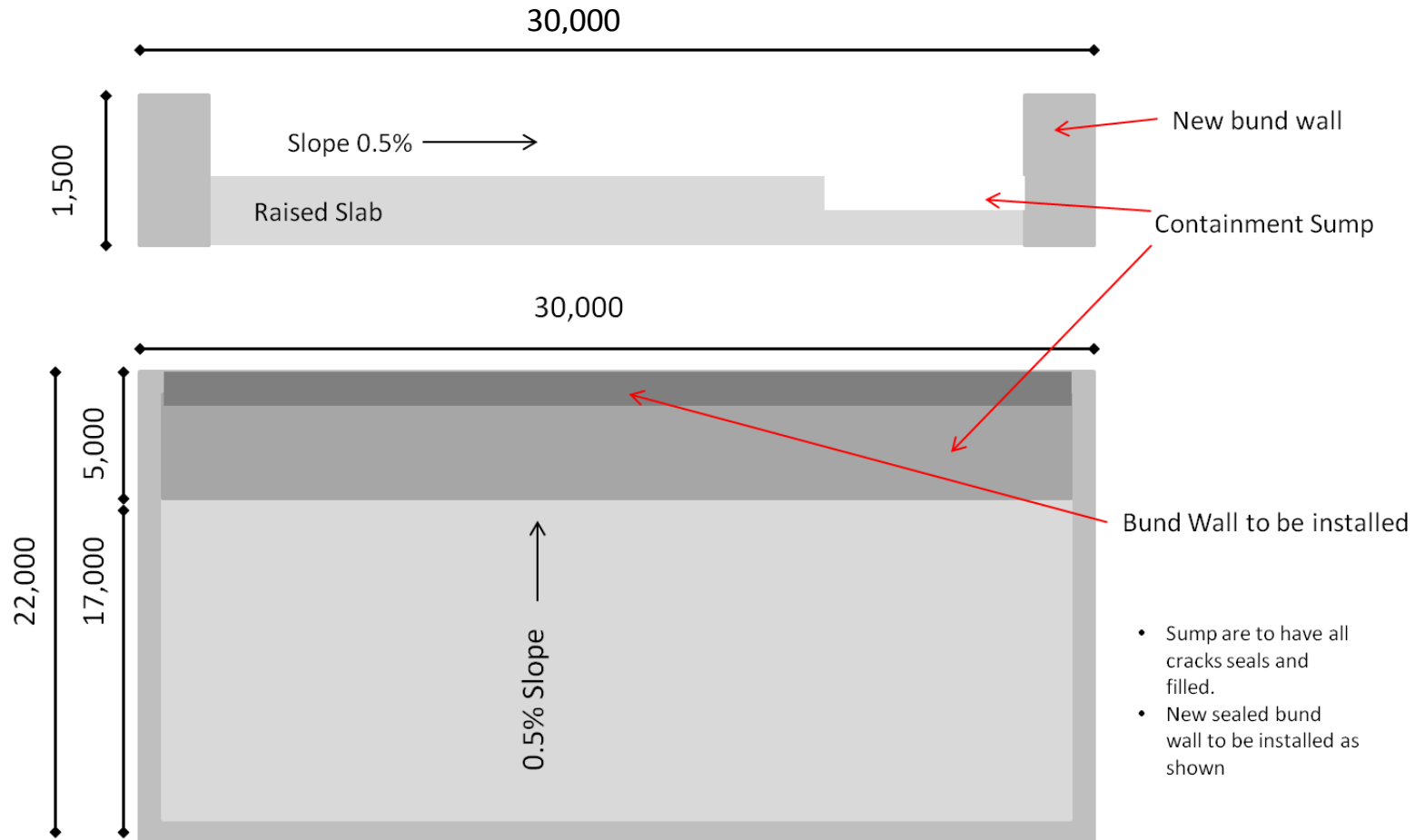


Figure 3: Drawing LMI-LF-001



1. All dimensions shown in mm
2. Surface to be examined and all cracks and holes sealed with lean concrete
3. Any openings in cast bund wall to be filled and sealed to existing bund height
4. Concrete area to be water tested prior to use as landfarm to ensure proper sealed and drained area
5. Drain installed along south wall as shown covered with suitable safety grating
6. Sump to be cast in place with spiral or soli piping
7. All areas to be inspected and approved prior to use as landfarm

NTS

Drawing LMI-LF-002

Figure 4: Drawing LMI-LF-002

6. Landfarm Operating Procedures

Hydrocarbon impacted soil, that has resulted from gasoline and diesel fuel spills will be placed in the Landfarm area and treated one batch at a time. The soil will be aerated and additional measures will be taken to stimulate microbial activity based on test results. The Landfarm treatment season is generally from June to September.

Soil Preparation

Excavated petroleum hydrocarbon impacted soil will be transferred directly to the landfarm or stockpiled on an area known to be contaminated with hydrocarbons (i.e. between the Waste Oil Tank Farm and the Satellite Tank Farm). The stockpiled soil may be screened to remove rocks greater than 10 cm. The reject would then be screened a second time during dry weather to remove residual soils adhering to the rock.

Soil samples will be collected to test for levels of petroleum hydrocarbons, pH, total Kjeldahl nitrogen, total phosphorous and microorganisms that target petroleum hydrocarbons (i.e. hydrocarbonoclastes) in the untreated soil.

Soil Mixing

The depth of soil to be treated will typically be 1.5 m. To optimize remedial performance the soil is to be aerated/mixed as needed during warm dry periods. The maximum soil height allowed within the soil treatment facility is 3.0 m measured from the base of the facility to the peak of the soil pile. During years where a discharge from the Tailings Containment Area is planned there will be sufficient activity at site to allow for regular turning of the soil within the landfarm. The soil is aerated/mixed in order to allow oxygen, nutrients and moisture to be blended with the soil. Mixing will also help minimize the occurrence of pockets of elevated hydrocarbons.

During periods of inactivity at the site the landfarm will be loaded to a depth of 0.3 m following the removal of the remediated soil. The thinner layer provides a larger surface contact with the air and maximizes the breakdown of hydrocarbons in the absence of biweekly aeration.

Soil may be mixed using handheld equipment or by using earth moving equipment taking care not to leave compacted soil within the landfarm.

Moisture Management

The landfarm soil should have between 5% and 35% moisture content to encourage bacterial growth. A handheld soil moisture meter will be used to monitor levels. In the absence of a soil moisture meter, there are some general principles for moisture management. After mixing the soil:

- Examine the soil for moisture content. The soil should be moist, but not wet.
- If the soil appears dry, add water as a spray overtop.
- If the soil is too moist, increase the mixing to promote evaporation.

Any excess water that accumulates in the landfarm is directed towards the sump. Contact water collected in the sump can be applied to the soil undergoing treatment during dry periods or it will be

transferred to an oil-water separator for treatment. The separated petroleum contaminated water will be stored in drums and subject to the handling conditions outlined in the *Waste Management Plan*.

The landfarm facility effluent discharge and groundwater monitoring procedures required under Part E of the Water Licence are described in the *Liquid Waste Management Plan*.

Soil Amendment

During treatment, nutrients in the form of a commercial fertilizer (urea, DAP) may be added to the soil layer to promote bacterial activity. The volume of nutrients to be added to the soil will be based on the volume of soil being treated, the petroleum hydrocarbon concentrations and an assessment of nutrients available in the soil. Nutrient application rates will be based on a C:N:P ratio between 100:10:1 to 100:1:0.5.

Fertilizer is applied directly on the soil within the landfarm manually, taking care to evenly distribute the fertilizer overtop of the soil. Excessive nutrient application may negatively impact the soil bacteria.

The pH of the soil will also be tested and amended with lime if necessary.

Soil Removal

Once soil sampling has confirmed that the concentrations of hydrocarbons in the soil have reached acceptable levels, the soil will be made available for re-use on-site. Samples results along with volumes of treated materials removed from the facility will be documented in the annual report.

Soil quality remediation objectives for the treatment of contaminated soil at Lupin are listed in **Error! Reference source not found..** The objectives were derived from generic commercial land use guidelines established in the Canadian Council of Ministers of the Environment (CCME) in Canadian Environmental Quality Guidelines (CCME 1999) and Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CCME 2008) in accordance with Part E(21) of the Water Licence.

Table 1: Soil quality remediation objectives for petroleum hydrocarbons

Parameter	Surface (mg/kg)	Soil
Benzene	110	
Toluene	250	
Ethylbenzene	300	
Xylenes	350	
PHC Fraction 1 (F1)	320	
PHC Fraction 2 (F2)	260	
PHC Fraction 3 (F3)	1,700	
PHC Fraction 4 (F4)	3,300	
PAH Anthracene	32	
PAH Benzo(a)pyrene	72	
PAH Fluoranthene	180	

7. Soil Sampling

Sample Plan

In accordance with the Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils (SAIC 2006, updated 2013) the sampling plan includes the methods (grid, composite) and frequency (number of samples per surface area).

Soil samples will be collected at the start of landfarm operations and at the end of each field season to characterize the material being treated. Confirmatory sampling will be undertaken to ensure that contaminated material is properly remediated prior to removing soil from the landfarm.

A composite sample to characterize the soil being treated is created by combining five contiguous discrete samples. Discrete grab samples will be collected following the turning (aeration) of soil or during the placement of soil into the landfarm. The volume of soil represented by each composite sample will typically range from 50 m³ to 150 m³, with no discrete sample representing more than 50 m³. Discrete samples will be analyzed by the laboratory as part of QA/QC measures.

Two composite sample areas (east half and west half) will be sampled during periods when the soil in the landfarm exceeds 0.3 m depth. Only one composite sample is required when the depth of soil in the landfarm is 0.3m.

Quality assurance and control (QA/QC) measures associated with the collection and analysis of the soil samples included the comparison of field screening results with laboratory data and laboratory analysis of blind duplicates and discrete QA/QC samples. Blind field duplicate samples monitor a combination of the precision of the laboratory analyses, sample preparation errors, sample collection errors and genuine short scale variations in soil geochemistry. Discrete samples monitor the homogeneity of composite sample areas.

The QA/QC sampling plan requires one duplicate and three discrete samples from one of the composite sample areas for every ten composite samples submitted for laboratory analysis.

Sampling Procedure

Clean disposable nitrile gloves should be used to transfer the soil into the sample container. Gloves should be disposed of between discrete sample locations. Sample containers will be provided by the analytical laboratory.

Samples for petroleum hydrocarbons will be submitted to an accredited chemical analysis laboratory. The petroleum hydrocarbon analyses include:

- benzene, toluene, ethyl benzene, xylenes (the BTEX compounds); and
- petroleum hydrocarbon (PHC) Fractions F1 through F4.

The chemical samples have a holding time of 7 days. Therefore, samples will be shipped to the laboratories as soon as possible after sample collection. The samples should be kept at a temperature between 0°C and 4°C. All soil samples are to be analyzed at a laboratory accredited by the Canadian Association for Environmental Analytical Laboratories.

8. Safety During Landfarm Operations

Operation of the landfarm can involve potential exposure to both physical and chemical hazards and noise. Site workers will be required to operate and work around equipment and collect soil samples. Physical hazards will include heavy lifting, working near heavy equipment, and walking over soft and uneven soil.

Chemical hazards include potential exposure to petroleum hydrocarbons through:

- dermal contact (getting soil on the skin or in the eyes);
- ingestion (getting contaminated soil in the mouth); and
- inhalation (breathing in hydrocarbon vapours or dust).)

Mitigation of dermal contact exposure to hydrocarbons will be achieved by providing Personal Protective Equipment (PPE) including protective coveralls, boots, gloves and safety glasses that are worn whenever the workers are on the landfarm. Workers will be advised of the location of the nearest safety shower and eyewash stations.

Potential exposure through ingestion can be mitigated by having the workers thoroughly clean hands and faces (with soap and water) and removing all PPE before meals and breaks (including cigarette breaks).

Mitigation of potential exposure through inhalation will be mitigated by avoiding working on the landfarm during times of high hydrocarbon volatilization (e.g. mid-day, high temperatures), managing moisture content in the soil to avoid dust, and provision of respiratory protective equipment.

Physical hazards will be mitigated by ensuring that there are adequate workers to lift and move heavy objects. It is important to remember that equipment operators have a limited field of vision. Always make eye contact with the operator of the equipment. The following precautions should also be taken:

- Never approach an operational piece of heavy equipment until the operator is aware of your presence, your desire to approach and signals the OK.
- Stand in a safe location well outside the maximum extended reach of the shovel or excavator arm, and out of the way of other mobile equipment. With an excavator, the optimum location is within the quadrant of the operator's visual coverage.

Adequate breaks will be provided to minimize continuous exertion. Care should be taken that adequate fluids (e.g., water) are consumed during periods of exertion to prevent dehydration.

Noise exposure will be mitigated with the use of hearing protection. Hearing protection must be worn at all times while operating heavy equipment.

The following PPE is required when working on the landfarm:

- Half mask respirator with cartridges to protect from organic vapours and dust;
- Disposable nitrile gloves;

- Leather over-gloves;
- Steel-toed rubber boots;
- Safety glasses;
- Hearing Protection;
- Coveralls; and
- Head Protection CSA-approved hard hats.

Prior to commencing work on the landfarm, all workers involved with the landfarm operations must have a safety orientation.

9. References

- Canadian Council of Ministers of the Environment (CCME), 1999 – Updated to September 2014. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg.
- Canadian Council of Ministers of the Environment (CCME), 2001, Revised 2008. Canada-Wide Standards for Petroleum Hydrocarbons in Soil: Technical Supplement. January 2008.
- Environment Canada, 2014. 1981 to 2010 Climatic Normals station data. http://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?stnID=1671&autofwd=1
- Morrow Environmental Consultants Inc., a member of the SNC-Lavalin Group; Phase 1 and 2 Environmental Site Assessment, Lupin Mine Site, Nunavut Territory; January 2006.
- SAIC Canada, 2006. Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils. Prepared for Environment Canada. March, 2006

Appendix A – Proposed Lupin Mine Site Landfarm Location

