LANDFARM OPERATIONS & MAINTENANCE MANUAL

For

Boston Camp Landfarm Treatment Area

&

Windy Lake Camp Landfarm Treatment Area

NWB Water License

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1.0 INTRODUCTION

1.1 Overview

This Landfarm Operations and Maintenance Manual (Manual) provides information on how contaminated soil and snow is to be handled in a safe and environmentally sound manner at the Miramar Hope Bay Ltd. (MHBL) Boston Advanced Exploration Project (Boston) and at the Hope Bay Regional Exploration Project (Windy Lake) in Nunavut.

Landfarming is a form of bioremediation that uses naturally occurring micro-organisms contained in the soil (yeast, fungi or bacteria) to metabolize or break down petroleum hydrocarbons. Natural processes include volatilization, aeration, biodegradation and photolysis. End products are micro-organism protein, carbon dioxide and water. Stimulation of microbial growth and activity for hydrocarbon removal is accomplished primarily through the addition of air and nutrients (metabolism of hydrocarbons is mediated predominantly through aerobic microbes).

1.2 Purpose and Scope of the Landfarm Operations and Maintenance Manual

The purpose of this document is to provide a consolidated summary of information on the operation and maintenance of the landfarm treatment areas located at both the Boston and Windy exploration camps to treat hydrocarbon contaminated soil and snow generated by MHBL's exploration activities. These procedures will be periodically reviewed and updated.

This operations and maintenance manual is a component of the Miramar Environmental Management System and will be reviewed annually during the first quarter of each calendar year by the site's environmental staff and updated as needed to reflect changes in operating and maintenance procedures. The revised Landfarm Operations and Maintenance Manual will be made available to the appropriate exploration staff with appropriate refresher training and sent to the Nunavut Water Board for inclusion in the public registry.

The Landfarm Operations and Maintenance Manual is intended to provide the mine's operating staff with a summary of the handling and management procedures for the treatment of hydrocarbon contaminated snow and soil materials. It similarly provides a summary of the same to the regulatory agencies and to the land owner who have regulatory interest over the exploration camp facilities.

This Manual is not intended to be a design document for the landfarm treatment facilities at the Boston or Windy Lake camps. The reader is referred to the following sources for design information:

- Appendix A - Windy Camp, Nunavut Diesel Fuel Spill Assessment and Remediation, prepared for Miramar Hope Bay Limited by EBA Engineering Consultants Ltd dated July 2004;
    - Section 4.3 Removal of Impacted Soil and Landfarm Construction; and
    - Figures 3 and 4

- Appendix B - Hydrocarbon Spill Assessment and Remediation Boston Camp, Nunavut; 67^0 39.41' North, 106^0 23.04' West, prepared for Miramar Mining Corporation by EBA Engineering Consultants, dated February 2004;

- Land Treatment Area Construction on Page 18;
- Figures 8 and 9.

1.3 Responsibility

- Exploration Manager – The Exploration Manager has overall responsibility for this management plan and will be the party to provide the resources to operate and maintain the two landfarm facilities.
- Exploration Site Superintendent – The Exploration Site Superintendent will have site responsibility at both the Boston and Windy Lake camps for the implementation of this operations and maintenance manual and will provide the on-site resources to operate, manage and maintain the landfarm facilities in accordance with the manual; conduct regular inspections of the two landfarm facilities; and provide input on modifications in design and operational procedures to improve operational performance of these two facilities. The Exploration Site Superintendent, through his foremen, will provide daily supervision to site operational personnel on the operation of these two landfarm facilities including but not limited to: turning of soil within the landfarm, treatment and removal of water and snow accumulations within the landfarm as needed, and the removal of treated soil into the natural environment once cleared by the site's Environmental Coordinator.
- Environmental Coordinator – The site Environmental Coordinator has responsibility to: keep this Landfarm Operations and Maintenance Manual updated; provide technical expertise to the site operational personnel on the operation and maintenance of both landfarms; sampling of the contaminated soil and assessment of whether remediation has met applicable regulatory standards; provide operational personnel with direction as to when and where remediated soil should be moved; conduct annual audits of the two facilities; and provide an audit report to the Exploration Site Superintendent and Exploration Manager.

2.0 APPLICABLE LEGISLATION

Both federal and territorial legislation regulates the management of hazardous materials in Nunavut. Copies of relevant legal documents will be kept on file at the Windy Lake exploration camp site. Management and safety personnel will provide an overview of the applicable regulations to all employees as part of their orientation training and through ongoing training.

The Environmental Protection Service of the Nunavut Department of Sustainable Development has published an "Environmental Guideline for Soil Remediation" that provides guidance as to acceptable levels for the remediation of hydrocarbon contaminated soils in Nunavut. These guidelines are derived from the CCME 1991 Interim Criteria and the CCME 1997 Recommended Soil Quality Guidelines. MHBL will use the industrial remediation guideline as set out in Table 1 to determine when soil has been remediated to a level acceptable for removal from the landfarm facility for use in site remediation.

Table 2.1: Nunavut Environmental Guidelines for Soil Remediation

Remediation Guidelines for Soil				
	Agricultural	Residential/ Parkland	Commercial	Industrial
Benzene	0.05	0.5	5	5
Toluene	0.1	0.8	0.8	0.8
Ethylbenzene	0.1	1.2	20	20
Xylene	0.1	1	17	20
Total Petroleum Hydrocarbons (TPH)*	-	500**	2500**	2500**
Lead	70	140	260	400
Polychlorinated biphenyl	0.5***	5***	50***	50***

Note: All values are in µg/g or parts per million (ppm). These are the more commonly required parameters. The type of contamination at the site may require analysis for additional CCME parameters.

* Total petroleum hydrocarbons (includes total purgeable and total extractable hydrocarbons).
** The TPH guidelines were developed by the Government of the Northwest Territories (GNWT)
*** CCME 1991 Interim Criteria (note: 1998 PCB Soil Quality Guidelines are currently under development).

Other acts, regulations, guidelines and general guidance pertinent to the landfarm treatment of contaminated soil materials are as follows:

Federal

- Canadian Council of Ministers for the Environment (CCME) 2003 Guidelines for Contaminated Soils – Industrial Sites (attached in Appendix C).

- Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils. SAIC Canada (Science Applications International Corporation), December 2005;

- Bioremediation of Petroleum Hydrocarbons in Soil and Groundwater Under Cold Climate Conditions: A Review, Implications for Applications in Canada, Dale Van Stempvoort and Pamela Grande, National Research Institute in Burlington, December 2005;

- Cold Climate Bioremediation: A Review of Field Case Histories. Pamela Rogers, Research Assistant, Department of Civil & Environmental Engineering, University of Alberta, July 2005;

- Canadian Council of Ministers of the Environment (CCME) Canada Wide Standard for Petroleum Hydrocarbons in Soil (CWS-PHC) (CCME, 2001);

- Canadian Standards Association (CSA) Environmental Site Assessment Standards Z768-01 (2001) and Z769-00 (2000), for Phase 1 and Phase 2; and

- Subsurface Assessment Handbook for Contaminated Sites (CCME, 1994).

Nunavut

- Consolidation of Environmental Protection Act (RSNWT 1988c E.7)
- Consolidation of the Environmental Rights Act RSNWT 1988 c83 2nd Supp)
- Fire Prevention Act and Regulations
- Environmental Guideline for General Management of Hazardous Waste

3.0 LOCATION AND CONSTRUCTION OF FACILITIES

Landfarm treatment facilities were constructed at both the Boston and Windy Lake exploration camps as remediation measures for diesel fuel spill events at both locations. In both cases the facilities were designed and constructed under the supervision of EBA Engineering Consultants Ltd. As built drawings were prepared by EBA for both facilities.

3.1 BOSTON CAMP LANDFARM FACILITY

A landfarm treatment facility was constructed at the Boston Advanced Exploration site in the summer of 2003 in response to three separate spills of diesel fuel that occurred at this site in 2003. The facility was designed and constructed under the supervision of EBA Engineering Consultants Ltd. The dimensions of the land treatment area (LTA) are approximately 30 meters by 20 meters wide with a minimum wall height of 0.75 meters. The facility was constructed using HDPE liner underlain by Bentomax matting for protection and was constructed on a layer of crushed waste rock obtained from the underground exploration decline that was placed on top of the native esker gravel pad that makes up the Boston exploration camp.

The location of the Boston LTA is shown in Figure 8 of the EBA document entitled Hydrocarbon Spill Assessment and Remediation Boston Camp, Nunavut; 67^0 39.41' North, 106^0 23.04' West, prepared for Miramar Mining Corporation by EBA Engineering Consultants, dated February 2004 (attached as Appendix A). The "As Built" drawing of the LTA is included as Figure 9 in the same document. Photographs of the construction of this LTA are contained in Appendix A of the EBA report noted above, specifically Photo 12, 13, 14 and 18.

Approximately 100 cubic meters of native soil, native sand gravel and crushed waste rock were excavated in response to the 2003 spill incidents, placed in drums and then transferred into the LTA once construction was complete. As of October 2007 all of this soil remains within the Boston LTA.

3.2 WINDY LAKE CAMP LANDFARM FACILITY

In the summer of 2004 Miramar Hope Bay Ltd. (MHBL) constructed a landfarm facility at the Windy Camp as part of a long-term remediation strategy to address clean up of a ~19,000 litre spill of diesel fuel (Nunavut Spill Number 04-388 – June 16, 2004). This facility was constructed on an urgent time basis to accommodate the immediate and longer term remediation of soil that was contaminated with diesel fuel by the June 2004 spill. This facility was constructed following consultation with the Kitikmeot Inuit Association (KIA) (June 23, 2004) and in accordance with a design provided by EBA Engineering Consultants Ltd (EBA).

The facility was designed and constructed under the supervision of EBA Engineering Consultants Ltd. Site selection for the land treatment facility was primarily determined by the location of the June 2004 fuel spill. The facility was sited immediately down slope of the fuel tank from where the spill occurred; and on top of the area where the contaminated organic layer and topsoil were removed. This site was chosen to minimize the overall

footprint of the Windy Camp and to utilize the area that had to be excavated to recover the organics and top soil that was contaminated.

The dimensions of the land treatment area (LTA) are approximately 33 meters by 14 meters wide with a minimum wall height of 0.25 meters. The facility was constructed using a 60 mil HDPE liner underlain by native soil consisting of silty sand. The location of the Windy Lake LTA is shown in Figure 3 of the EBA document entitled Windy Camp, Nunavut Diesel Fuel Spill Assessment and Remediation, prepared for Miramar Hope Bay Limited by EBA Engineering Consultants Ltd dated July 2004 (attached as Appendix B). The “As Built” drawing of the LTA is included as Figure 4 in the same document. Photographs of the construction of this LTA are contained in the EBA report noted above, specifically Photo 14, 15, and 16.

Approximately 100 cubic meters of native soil was excavated in response to the 2004 spill incident and then transferred into the LTA once construction was complete. As of October 2007 all of this soil remains within the Windy Lake LTA.

It is acknowledged that due to the circumstances of the 2004 spill, the Windy LTA is not ideally sited and is too close to Windy Lake to continue operating over the long term. Consequently the short term plan is to continue the operation and maintenance of the Windy Lake LTA until the landfarm facility at the Doris North Project is constructed and commissioned (summer of 2008). At that time the remaining contaminated soil at the Windy Lake LTA will be transferred to the Doris North LTA (winter of 2008/2009). The Windy LTA will then be decommissioned and removed so that remediation under Nunavut Spill Number 04-388 can be completed and the file closed (following approval by the Inspector).

4.0 LANDFARM OPERATION

4.1 What Materials Will Be Treated at the Landfarm Facility

The Boston and Windy Lake landfarm facilities will only receive hydrocarbon contaminated snow and soil materials generated through MHBL's ongoing exploration activity on the Hope Bay Belt. No material from other sites will be accepted at this facility without the approval of the Kitikmeot Inuit Association (KIA) and the Nunavut Water Board (NWB).

At both the Boston Advanced Exploration Project and at the Hope Bay Regional Exploration Project, MHBL's use of hydrocarbons is limited by need to the following products:

- Diesel fuel for generators and for diesel fuelled mobile equipment (vehicles);
- Aviation fuel for helicopters and small aircraft (Jet B);
- Hydraulic oils; and
- Gasoline.

In the event of all spills, MHBL's on-site Environmental Coordinator will be contacted and consulted by the operations personnel and their contractors on clean up and remediation protocols. The Environmental Coordinator will, based on investigation and understanding of the spill, make a decision on how each spill is to be cleaned up and the affected area remediated. In the event where soil or snow is contaminated by spilled hydrocarbons, the Environmental Coordinator will give direction to the clean up personnel on whether this contaminated soil and/or snow is to be taken to the Doris North landfarm facility and where within the facility it is to be placed. The Environmental Coordinator will ensure that only hydrocarbon contaminated soil and/or snow is taken to the landfarm and that other contaminants such as heavy metals, glycol or heavy oils that are not bio-remedial using the landfarm procedures are not mixed with soils/snow taken to the landfarm. This action is to preserve the remedial performance of the landfarm and prevent generation of large volumes of contaminated soil that cannot be successfully bio-remediated. Alternative methods will be used to address these types of contaminants, up to and including off-site disposal through appropriate remediation/disposal facilities or by placing them underground in stopes to be subsequently backfilled where they will be isolated from surface water by permafrost.

The characterization of the contaminants and contaminant levels in the soil determined during the environmental site assessment may be used to determine landfarming applicability. An evaluation of the type and degree of contamination helps to exclude soil material that might be toxic to certain species of micro-organisms and also helps to determine if landfarming would be the appropriate remediation technology to be employed for the contaminants of concern. Although landfarming is recommended for petroleum hydrocarbon contaminated soils only, it is understood that other contaminants may also be present. Table 2 indicates, through shaded selections, the type of analyses recommended for contaminated soil characterization.

Table 4.1: Recommended Analyses Based on Suspected Soil Contamination

Contaminant Source	Parameters Analyzed								
	CWS - PHC fractions	BTEX	TPH	Lead	Total Heavy Metals	Chromium/Cadmium	PCBs	Phenols	PAHs
Unleaded gasoline	■	■	■		■				
Leaded gasoline, aviation gasoline	■	■	■	■	■				
Fuel oil, diesel, kerosene, jet fuel, mineral oil/spirits, motor oil	■	■	■		■				■
Petroleum solvents	■		■				■		
Crude oils, hydraulic fluids	■		■	■	■				■
Waste petroleum products	■	■	■	■	■	■	■	■	■

Please note that if any of the levels detected exceed the following maximums, the contaminated soil should be considered hazardous waste and handled accordingly (packaged and shipped off-site to a licensed disposal facility). Landfarming is not recommended for such contaminated soils.

- Total petroleum hydrocarbon (TPH) or total extractable hydrocarbons (TEH) < 3% (Yukon, 2004a and 2004b);
- total heavy metal concentrations < 2500 mg/L (USEPA, 1994);
- electrical conductivity (EC) < 4 dS/m; and
- sodium adsorption ratio (SAR) < 6 (Alberta EUB, 1996).

Prior to placing any contaminated soil into either LTA, an evaluation of the soil characteristics provided in Table 3 will ensure that the contaminated soil is well-suited to landfarming.

***Table 4.2*: Optimal Soil Characteristics for Landfarming**

Landfarming Parameter	Optimal Characteristics
Microbial population density:	For landfarming to be effective, the minimum heterotrophic plate count should be 10^3 CFU/g (colony forming units/gram). Below this minimum, landfarming may still be effective provided the existing bacteria are stimulated using nutrients or the soil is amended to increase the bacteria population (USEPA. 1994) In the latter case adding non-indigenous bacteria to a site has had limited success in enhancing degradation of petroleum hydrocarbons. There are also regulatory restrictions associated with the addition of bacteria to sites.
Soil pH:	To support bacterial growth, soil pH should be between 6 and 8. Outside this range, landfarming may still be effective through soil amendments.
Moisture content:	Bacterial growth requires moisture, optimally between 40-85% of field capacity[2] (USEPA, 1994) Periodically, moisture may be added to land farmed soil to maintain this moisture level. Excess moisture due to periods of high precipitation, during spring thaw or due to poor site drainage may need to be addressed. Site drainage may be improved through landfarm design, but uncontrollable influx of moisture may simply mean that longer operating times will be required for the landfarm.
Nutrient concentration:	For proper growth, micro-organisms require inorganic nutrients that may be naturally-occurring in the soil. Nitrogen and phosphorous may be added in the form of commercial fertilizer. For effective biodegradation, carbon:nitrogen:phosphorus ratios need to be between 100:10:1 and 100:1:0.5 (USEPA. 1994). This ratio may be calculated from the soil bulk density and the total hydrocarbon concentration.
Soil Type:	Clayey soils hamper biodegradation because of difficulties in aeration and the distribution of nutrients and moisture. Soil amendments such as gypsum and bulking agents such as sawdust, may be required. Clumpy soils may also require pre-treatment in the form of shredding, in order for landfarming to be effective. Very coarse soils are not suitable to landfarming as they do not retain moisture and nutrients (University of Saskatchewan, 2002). Volatile compounds will also volatilize more readily from course-grain soils than from fine grain soils. Typically, large diameter soil particles have a low contamination concentration due to their low surface area. As such, these particles can be screened out prior to placing soils in the landfarm.

2 The most reliable measure of moisture content is expressed as a percent of field capacity (also referred to as "soil capacity"). Field capacity itself is the maximum %-weight of moisture the unconfined, gravity-drained soil can retain. An example would be a sandy soil with a field capacity of 25%, meaning a maximum of 250 grams of water retained in 1,000 grams (dry wt.) of unconfined soil. Typically the target moisture content is expressed as a percent of the field capacity; for example, 50% of field capacity for the above sandy soil would be 125 grams water per 1,000 grams dry soil.

4.2 Water Balance for the Landfarm Facility

A precipitation and temperature profile for the area is taken from the baseline meteorology data compiled for the Doris North Project[1]. The average monthly air temperature is typically above 0°C between June and September with the peak in July, and below freezing between October and May with the coldest temperatures usually occurring in February. The mean annual precipitation adjusted for under-catch is approximately 207 mm with 41% occurring as rain between May and October and 59% as snow through the remainder of the year.

Both the Boston and Windy Lake landfarm treatment facilities have a footprint of approximately 600 m^2 (including the berm footprint) providing a total precipitation collection area of 600 m^2 from which water must be collected and treated. Mean precipitation ranges from 94 mm to 207 mm, with only about 41% falling as rain. Annual lake evaporation (typically occurring between June and September) is about 220 mm. Consequently the mean annual volume of precipitation runoff expected to be collected within each landfarm is as follows:

Landfarm (600 m^2) 56 m^3 to 124 m^3 (600 m^2 x (mean precipitation in mm/1,000))

While it is understood that a lot of this runoff will be lost through wind movement of snow, sublimation and evaporation, for the purposes of estimating the maximum potential volume of water to be treated through the oil adsorption system, these losses have not been considered. Offsetting sublimation and evaporation losses from within the liner of the tank farm and landfarm treatment facilities will be contaminated snow brought to the landfarm treatment facility for remediation (estimated at approximately 3 m^3 per year). Consequently the total estimated volume of water to be treated through the landfarm oil-water adsorption system is between 59 m^3 to 127 m^3 (59,000 to 127,000 liters per year).

All precipitation runoff and snowmelt collected each of the two landfarm facilities will be collected and treated through an F1 "Flow and Plug" Oil Adsorption System (Model F11-C-180-TM-Cx2 as supplied by Terry Ruddy Sales of Edmonton Alberta). A photo and a copy of the operations/maintenance manual for this system are attached as Appendix D). This system consists of a self priming electric pump, a particulate filter, a drum containing TM-100 oil adsorbing media and two activated carbon media containers connected in series. The unit operates at 5 to 7 gpm (19 to 26 lpm). Consequently the maximum discharge time required to treat and release all of the expected water collected within each of the two landfarm facilities will be ~111 operating hours (5 operating days). This system will be operated (i.e. the frequency of pumping) to keep the sump level down so that the soil undergoing remediation does not become saturated with the precipitation and snowmelt

1 AMEC, 2003. Meteorology And Hydrology Baseline, Doris North Project, Nunavut, Canada, prepared for Miramar Hope Bay Ltd. November 2003, p.D-iii.

water collected within the landfarm (remediation is not effective when the soil is saturated as aeration is prevented).

4.3 How Will Contaminated Soil Be Tested

Early in each summer the soils placed within the landfarm facility will be sampled and analyzed for CWS-PHC fractions (F1 through F4), Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Total Petroleum Hydrocarbons (TPH), and an ICP-MS 30 element trace metal scan to determine the nature and amount of contamination to be addressed (see Table 2 for guidance for contamination other than diesel fuel).

Soils with light hydrocarbon fraction products (diesel fuel and Jet B) are expected to be most easily landfarmed and will thus be kept in a separate pile within the landfarm for remediation. Soils contaminated with heavy fraction hydrocarbons, such as hydraulic oils, will be more difficult to remediate and thus these materials will be segregated and treated within a separate pile within the same landfarm facility. Hydrocarbon contaminated snow will be placed within one designated area of the landfarm facility in a location where the snowmelt can be collected in the early summer at the low point within the berm and the resultant contaminated water pumped to an oil water treatment system (an F1 “Flow and Plug” Oil Adsorption System (Model F11-C-180-TM-Cx2 as supplied by Terry Ruddy Sales of Edmonton Alberta).

Additional information on environmental performance sampling (sampling procedures, analytical parameters, frequency and target performance criteria) around this landfarm facility is provided in Section 4.7

4.4 Landfarm Operational and Maintenance Procedures

Placement of Soil in Landfarm

A contaminated soil depth less than 0.5 m within cell(s) or in windrows is recommended. However, the type of equipment available for tilling, as well as the landfarm space availability, will dictate soil depth. Typically, landfarming is practiced with soil depths between 0.30 and 0.45 m. Contaminated soil should not be applied on a continuous layer of snow or ice or when the existing soil base is saturated with moisture.

A soil depth of between 0.30 and 0.45 m and a maximum soil thickness of 0.5 m is recommended. Therefore, a single plot or multiple plots may be required.

Recording Where and When Soil is Placed

A record will be kept by MHBL’s on-site Environmental Coordinator of the amount of contaminated soil and snow placed in the landfarm and the location of each batch of contaminated soil within the landfarm by contaminant type and length of remediation. The landfarm will be monitored weekly during summer months by the Environmental Coordinator to ensure proper operating conditions of soil moisture and aeration, i.e., moisture content between 15 and 30%, uncompacted soil.

Moisture Content Monitoring

The amount of moisture in the landfarm soil impacts biodegradation and, therefore, should be monitored and adjusted if possible and necessary. If moisture levels are too high, the movement of air through the soil is restricted thereby reducing oxygen availability. Effective moisture levels are 40 - 85 % of water-holding capacity in the soil, but 20 – 85 % will support microbes. Water spraying is often needed during summer months, particularly prior to tilling, in order to reduce wind erosion. Soil may be amended with organic matter to increase moisture retention. A rule of thumb is the soil should be moist, not dry and dusty or dripping wet.

Soil will be watered as required to prevent dust generation; saturation will be avoided. The source of this water will be from the low point or “sump” located within the landfarm facility and applied using a pump and hose with a spray nozzle or spray bar. Moisture determinations will be made on site using the procedure outlined in ASTM D2216-05 standard test method for determination of water content in soil and rock.

pH Maintenance

The optimal pH for landfarming operations is between 6 and 8. The soil pH may be increased with the addition of lime and decreased with the addition of elemental sulphur.

Microbial Population Density Monitoring

If microbial amendments are being considered, the user should be aware that products containing microorganisms, biochemicals (such as enzymes) or biopolymers, are "biotechnology products" and may be subject to the New Substances Notification (NSN) Regulations, pursuant to the Canadian Environmental Protection Act, 1999. (Contact the New Substances Division of Environment Canada and http://www.ec.gc.ca/substances/nsb/eng/index e.htm for more information.)

Although a few petroleum hydrocarbon-degradable micro-organisms have been found to be active at temperatures below 0^{o}C, most biodegradation occurs above freezing. Research has shown appreciable biodegradation may occur after one summer season, additional biodegradation over a second season is usually required. Therefore, it is recommended that the landfarm should operate for a minimum between 6 months to 2 years. This operation period assumes optimal conditions are maintained (i.e. regular tilling; moisture control; nutrient amendment, if required). Please note that soil sampling and analyses are required to confirm remediation progress and completion.

Nutrient Amendment Requirements

Biodegradation requires that micro-organisms are meeting nutritional requirements. The optimal range of carbon:nitrogen:phosporus (C:N:P) is 100:10:1 to 100:1:0.5. If the available nutrients are not sufficient, soil amendment in the form of commercial fertilizers, is required. Note that the addition of nitrogen may inadvertently lower the pH. Nutrients can be supplied to the soil in either liquid or solid form. Solid nutrients can be added directly to the soil when the soil is mixed prior to placement in the landfarm or during tilling events once the landfarm is operational. Liquid nutrient can be added to watering or irrigation systems. The frequency of nutrient addition can be reduced by using slow release nutrients.

Tilling, with a rototiller or turning over the soil with a backhoe or other similar equipment, is a means of aerating the soil. This provides oxygen for the micro-organisms as well as distributes nutrients and moisture in the soil, thereby aiding biodegradation. Tilling is recommended once per month during the operating season of the landfarm, provided the soil is uniformly moist but not saturated. Tilling when soil is excessively wet is unproductive, whereas tilling while the soil is excessively dry may erode the soil and cause wind-blown dust problems. Tilling must be carefully carried-out by an experienced operator, since it is possible to disturb or damage the liner placed under the contaminated soil.

System Maintenance

Maintenance of the landfarm is essential in ensuring its effectiveness. At some appropriate point during landfarm construction, inspection of the synthetic liner(s) should be conducted to ensure that the seams and joints are tight, and that there is an absence of punctures, blisters or tears. Imperfections (e.g. lenses, cracks, channels) can occur in soil and clay liners. Weekly, during landfarm operations, and immediately after a major storm or catastrophic event, inspections should be conducted on the:

(i) drainage control systems for evidence of deterioration, malfunction, leaks or improper operation, and
(ii) leachate collection systems to ensure proper functioning and to determine if leachate is being generated or is accumulating.

If any defects or malfunctioning works are detected, immediate repair is required to maintain the integrity of all works.

The drainage control system should be inspected as necessary/required during periods of precipitation or spring thaw to ensure control measures are taken if the system is approaching its capacity.

All water collected in the landfarm sump will be pumped to a portable head tank and then treated through an F1 “Flow and Plug” Oil Adsorption System (Model F11-C-180-TM-Cx2 as supplied by Terry Ruddy Sales of Edmonton Alberta). This is a portable unit set up on standard pallets so that they can be moved to the landfarm facility as and when needed. The system consists of a self priming electric positive displacement pump, a particulate filter, a drum containing TM-100 oil adsorbing media and two activated carbon media containers connected in series. The unit operates at 5 to 7 gpm. The unit is designed so that the TM-100 oil adsorbing media will blind off when it reaches its absorbent capacity. The unit will be moved into location soon after the spring snowmelt so that the landfarm can be drained of standing water to prevent saturation of the contained soil undergoing remediation. The unit will then be moved back into the landfarm whenever the sump fills to keep the soils unsaturated.

No allowance has been made to remove uncontaminated snow from the landfarm. It has been designed on the assumption that all snow collected in the landfarm will melt and have to be treated through the oil-water adsorption system. In reality, MHBL will attempt to remove uncontaminated snow from this facility, specifically in areas of drift in the late winter ahead of the spring thaw. A combination of hand shovelling and a small bobcat front end

loader will be used to clear this snow where practical. This activity will be directed by the on-site Environmental Coordinator.

All precipitation runoff collected within the landfarm facility is pumped from the internal landfarm low point to the portable head (feed) tank and then pumped through the Oil Adsorption System with the treated water then directed onto the nearby tundra to be land applied in a method that prevents erosion at the point of application. The discharge from the Oil Adsorption System is sampled and analyzed on a once per day basis whenever the system is in operation (see Section 4.7).

Equipment used in the landfarming operation for aeration, etc. will be cleaned off within the landfarm area prior to exiting to ensure that contaminated soil is not transferred away from the landfarm on the wheels and other parts of this equipment.

4.5 Soil Sampling, Applicable Remediation Guidelines, Inspections and Repairs

The Environmental Protection Service of the Nunavut Department of Sustainable Development has a published an "Environmental Guideline for Soil Remediation" that provides guidance as to acceptable levels for the remediation of hydrocarbon contaminated soils in Nunavut. These guidelines are derived from the CCME 1991 Interim Criteria and the CCME 1997 Recommended Soil Quality Guidelines.

MHBL will use the industrial remediation guideline as set out in Table 1 (in Section 2 above) to determine when soil has been remediated to a level acceptable for removal from the landfarm facility for use in site remediation.

A record will be kept by MHBL's on-site Environmental Coordinator of the amount of contaminated soil and snow placed in the landfarm and the location of each batch of contaminated soil within the landfarm by contaminant type and length of remediation. The landfarm will be monitored weekly during summer months by the Environmental Coordinator to ensure proper operating conditions of soil moisture and aeration.

A sampling plan should include sampling methods (grid, composite) and frequency (number of samples per surface area). Since the landfarmed material is relatively thinly applied and homogenized through tilling, only one depth of sample collection is required. The samples should then be analyzed for the contaminants of interest and compared with the remediation guidelines. These protocols are recommended for the landfarm soils to determine at which point the soils have been remediated and the landfarm can be closed. Monitoring of contaminant levels in the leachate is only required prior to discharge to the environment; during recirculation, testing may be done for purposes of tracking remediation progress.

Soil samples will be collected at least twice per year by MHBL and tested for CWS-PHC fractions (Fraction F1 thru F4), Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Total Petroleum Hydrocarbons (TPH) and total metals using a 36 element ICP-MS scan (see Table 2 for further guidance when dealing with contamination other than diesel fuel). Soil hydrocarbon concentrations will be monitored to ascertain the point where soils are no longer considered contaminated. There are no CCME guidelines for density of soil sampling in landfarms, consequently MHBL proposes that each separate pile within the landfarm be divided into quadrants, and sampled with a target density of one composite of ten samples per 25 m^3 to adequately characterize the soil's hydrocarbon levels. The soil sampling

records will be kept by the Environmental Coordinator and reported to the KIA and the NWB as required (at a minimum as part of the annual reporting). More frequent sampling may be conducted by the Environmental Coordinator especially when soil is nearing the successful remediation levels to verify when soil can be moved out of the landfarm and used in site reclamation.

Soil will only be removed for use in remediation once approved by the Water License Inspector. Remediated soils will be used for reclamation purposes specifically on areas where the existing vegetative cover has been disturbed. The area where the remediated soil is to be used will be opportunistic in that the soil will be used in areas available for progressive reclamation when these soils meet the GN Remediation criteria.

Any required repairs to the landfarm facility will be noted during the weekly inspections conducted by the Environmental Coordinator and arrangements will be made to have the repairs effected promptly. The nature of the repairs required and when repairs were completed will be recorded in the landfarm log. Any unauthorized use of the facility noted on inspections will be reported to the Exploration Manager and Site Superintendent for corrective action and discussed at Health and Safety Committee meetings.

Accurate records should be maintained by the owner/operator that contain the following information:

- A detailed description of the size and location of the land treatment facility
- Quantitative and qualitative data on the soil treated at the site
- Monitoring data as set forth above
- The final destination of the treated soil and its intended use.

4.6 Performance and Environmental Monitoring Program

MHBL will implement a monitoring program around the landfarm facility. The objective is to measure both soil and water to verify that remediated soil removed from the landfarm and treated water from the landfarm meets the appropriate remediation criteria. The monitoring program proposed by MHBL is broken down as follows:

1. Contaminated soil within the landfarm will be sampled at the beginning and end of each summer treatment season to verify the nature and extent of contamination within the soils to be remediated. The soil samples will be collected by MHBL and tested for Extractable Hydrocarbons F1 thru F45, Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Total Petroleum Hydrocarbons (TPH) and total metals using a 36 element ICP-MS scan (see Table 2 for further guidance). MHBL proposes that each separate pile within the landfarm be divided into quadrants, and sampled with a target density of one composite of ten samples per 25 m^3 to adequately characterize the soil's hydrocarbon levels. The soil sampling records will be kept by the Environmental Coordinator and reported to the KIA and the NWB as required (at a minimum as part of the annual reporting).

2. A similar sampling program will be conducted by MHBL prior to any soil being removed from the landfarm for use in reclamation to demonstrate that the soil has

been remediated to the GN remediation standards (Industrial) as set out in Table 2.1. The soil samples will be collected by MHBL and tested for Extractable Hydrocarbons F1 thru F4, Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Total Petroleum Hydrocarbons (TPH) and total metals using a 36 element ICP-MS scan. MHBL proposes that each pile of remediated soil be divided into quadrants, and sampled with a target density of one composite of ten samples per 25 m^3 to adequately characterize the soil's hydrocarbon levels. The soil sampling records will be kept by the Environmental Coordinator and reported to the KIA and the NWB as required (at a minimum as part of the annual reporting). Similarly records will be kept and reported as above as to each location where remediated soil is placed along with an estimate of the volume placed in each location. Soil will only be removed from the landfarm for use in remediation once such activity has been approved by the Water License Inspector.

3. Samples of the precipitation runoff and snowmelt water collected within the landfarm facility liner will be conducted early each summer following the spring melt to determine water quality prior to the start up of the oil adsorption treatment system. The samples will be analyzed for pH, Total Suspended Solids, Total Oil and Grease, Benzene, Toluene, Ethyl benzene and Total Ammonia.

The discharge from the Oil Adsorption system will be sampled and analyzed on a once per day basis whenever the system is in operation. The sample will be taken from the discharge of the Oil Adsorption System prior to this water being land applied onto the tundra. The samples will be analyzed for: pH, Total Suspended Solids, Total Oil and Grease, Benzene, Toluene, Ethylbenzene and Lead. MHBL recommends that the standard that must be achieved for discharge be set as set out in Table 4:

Table 4.3: Discharge Standard for Water Discharged from the Landfarm Facilities

Parameter Being Monitored	Discharge Standard mg/L
Oil and Grease	**15.0 and no visible sheen**
Benzene	**0.37**
Toluene	**0.002**
Ethylbenzene	**0.09**
Lead	**0.001**[2]

At both Boston and Windy Lake the treated water released from the landfarm is co-disposed with the treated sewage water and land applied onto the tundra.

[2] License 2BE-HOP0712 and 2BB-BOS0712 requires that Lead meet a discharge standard of 1 ug/L (0.001 mg/L). This is being checked by MHBL as it is one order of magnitude less than the standard set in the Doris North water license (0.01 mg/L)

MHBL will apply the following QA/QC procedures during sampling:

- Use of field blanks: Field blanks are samples of pure water that are subjected to exactly the same procedures as routine samples, following which they are analyzed for the same parameters as the field samples. Any measurement of the parameter of interest, above method detection limits, will indicate any analytical error, impurities in the laboratory distilled water supply, contaminated sample preservatives, or contamination of the sample during the handling process. Combined with the results of other quality control procedures, analysis of field blanks can help identification of sources of contamination. New sample bottles will be used and prepared using distilled water from the normal laboratory water supply. This set will represent all of the parameters routinely analyzed. They will be preserved in the field and submitted to the laboratory identified as field blanks.

- Duplicate sampling – Replicate sampling (or sometimes referred to as duplicate sampling) is the collection of more than one sample for a given analysis at a given location. The replicate samples are collected, handled, and analyzed using the standard procedures applied to routine samples. Replicate sampling, combined with the results of other quality control procedures, can help indicate sources of error and are particularly useful in identifying problems with accuracy and sampling methods. Once per operating season, for each active Water License Surveillance Network Program stations (sampling stations prescribed in the Water License), a set of duplicate samples will be taken, representing as many of the routine analyses as possible. Where possible, this should be carried out in conjunction with audit sampling conducted by the designated inspector. Replicate sampling should alternate between the prescribed Water License Surveillance Network Program stations.

These results will be included in the reports provided to the NWB and KIA.

Samples will be delivered to the analytical laboratory as soon as possible after collection. All samples will be stored and transported at a temperature <10 degrees Celsius. Coolers and ice packs are provided for field transportation and samples will be refrigerated as soon as possible following arrival at the laboratory.

A chain of custody form will be completed for each sampling site respectively. The original will be sent to the external laboratory while a copy will be filed accordingly on-site. A follow-up call will be made to the external environmental laboratory ensuring that samples are received.

5.0 LANDFARM MANAGEMENT

5.1 General

The focus of management of the landfarm will be safety and environmental responsibility. Employees working in the landfarm will be trained prior to commencement of work so that they are aware of the health and safety risks associated with the landfarm.

5.2 Health and Safety

There are four primary exposure pathways to chemicals within the landfarm:

1. Inhalation;
2. Ingestion;
3. Skin contact; and
4. Eye contact.

Since the facility is outside and concentrations of contaminants will be generally relatively low, inhalation exposure is not likely to be problematic. In special circumstances where contamination is heavy, respirators can be worn to scrub the air of volatile organics. Ingestion, under normal circumstances is very unlikely.

Skin contact will be prevented by issuing suitable personal protective equipment to employees working in the landfarm. Personal protective equipment suitable for petroleum hydrocarbons is listed in the Material Safety Data Sheets for petroleum products that may be transferred to the landfarm in contaminated soil or snow and summarized in Table 5.

Eye contact is unlikely under normal circumstances. Where hand work is to be carried out in the landfarm with the risk of eye contact, protective goggles will be required.

Table 5.1: Guidelines for Safe Handling of Contaminated Soil and Snow

Personal Protection	
Ventilation	Use adequate ventilation (normally assured at the landfarm due to being outdoors).
Respiratory protection	Not generally required unless needed to prevent respiratory irritation. Use organic cartridge respirator per MSDS recommendations.
Eye protection	For splash protection, use chemical goggles and face shield
Skin protection	Use gloves resistant to the material being used, i.e., neoprene or nitrile rubber. Use protective garments to prevent excessive skin contact.
Health Hazard Data	
Acute effects of overexposure	Eye: May cause mild irritation, with stinging and redness of eyes.
	Skin: May cause severe irritation. Repeated or prolonged contact may cause defatting of the skin, resulting in dermatitis. Dermal LD50 for diesel fuel is >5 mg/kg (rabbit).
	Inhalation: May cause irritation to nose, throat or lungs. Headache, nausea, dizziness, unconsciousness may occur.
	Ingestion: Swallowing small amounts is not likely to produce harmful effects. Ingestion of larger amounts may produce abdominal pail, nausea and vomiting. Aspiration into lungs can produce severe lung damage and is a medical emergency.

First Aid and Emergency Procedures	
Eye	Flush eyes with running water for at least 15 minutes. If irritation or adverse symptoms develop, seek medical attention.
Skin	Immediately wash skin with soap and water for at least fifteen minutes. If irritation or adverse symptoms develop, seek medical attention.
Inhalation	Remove from exposure. If breathing is difficult, give oxygen. If breathing ceases, administer artificial respiration followed by oxygen. Seek immediate medical attention.
Ingestion	Do not induce vomiting. Seek immediate medical attention.
Fire	
Fire extinguishing media	Dry chemical, foam, or carbon dioxide.

5.3 Landfarm Closure

As stated earlier MHBL plans to decommission the Windy Lake LTA soon after the Doris North LTA is constructed and commissioned. The Boston LTA will be decommissioned when the Boston Advanced Exploration Project is closed, or some time period after closure, depending on requirements for its use during the reclamation period. Remediated soils that test clean (based on the Nunavut Environmental Guideline for Site Remediation – Industrial Standard) will be used for reclamation. Soils that remain contaminated and the underlying fine crushed rock from the landfarm will be relocated to the Doris North LTA at the time of landfarm decommissioning. The HDPE geomembrane will be cleaned, cut up and disposed of in the Doris North non-hazardous landfill. Bedding rockfill (below the geomembrane) will be tested for presence of petroleum hydrocarbons, and if clean, used for reclamation of the adjacent landfill but, if not, transferred to the Doris North LTA or placed underground at Doris North as backfill. A representative sampling grid will be used to characterize this underlying rockfill material using grid lines set at 10 m intervals with sampling of the rockfill at 50% of the grid intersection nodes.

The site will then be levelled consistent with other reclamation activities at the mine.

This report, “Landfarm Operations and Maintenance Manual, Boston Advanced Exploration Project and Hope Bay Regional Exploration Project, Nunavut, October 2007”, has been prepared by Miramar Hope Bay Ltd.

Prepared By

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