

# **LANDFILL CRITERIA FOR MUNICIPAL SOLID WASTE**

**Draft Interim Second Edition**

**BRITISH COLUMBIA**

**BC Ministry of Environment**

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## LIST OF ACRONYMS AND ABBREVIATIONS

DOCP	DESIGN, OPERATIONS AND CLOSURE PLAN
GCL	GEO-SYNTHETIC CLAY LINER
GHG	GREENHOUSE GAS
HDPE	HIGH DENSITY POLYETHYLENE
LEL	LOWER EXPLOSIVE LIMIT
LFG	LANDFILL GAS
MSW	MUNICIPAL SOLID WASTE
OC	OPERATIONAL CERTIFICATE
QA/QC	QUALITY ASSURANCE/QUALITY CONTROL
QP	QUALIFIED PROFESSIONAL
SWMP	SOLID WASTE MANAGEMENT PLAN

## FOREWORD

In 1993 the Ministry of Environment released the first edition of the Landfill Criteria for Municipal Solid Waste which outlined how landfills were to be constructed, operated and monitored to ensure that the environment would be protected.

This interim second edition of the Landfill Criteria for Municipal Solid Waste builds on the original. It incorporates new standards and operating practices that have been developed over the years to enhance environmental protection and incorporate current regulations for Landfill Gas Management and Contaminated Sites.

The document was developed by a group of experts with extensive knowledge of landfill science and technology from the Ministry of Environment and industry. The Criteria provide guidance on environmentally sound landfilling practices and procedures that are consistent with regulatory requirements and desirable environmental outcomes. They become legal requirements when incorporated into solid waste management plans, operational certificates and permits, issued under the *Environmental Management Act* and associated regulations.

## 1.0 DEFINITIONS

For the purposes of this document:

"Active Face" means the working surface of a landfill upon which MSW is deposited before placement of daily cover.

"Active landfill phase" means the portion of the landfill footprint that has received or is receiving MSW for disposal, where final cover has not been placed. The DOCP provides for the phased landfill development regarding design, construction, operation and closure of each landfill phase.

"Approved" means authorized in writing or specified in writing, with or without conditions or requirements by the Minister of Environment, the Director, or the Director's delegate.

"Buffer Zone" means the area between the landfill footprint and the landfill site boundary.

"Cell" means that portion of compacted MSW in a landfill which is enclosed by cover after a designated period.

"Clean wood" means solely wood and:

- does not include composite wood products including plywood, particle board, fibreboard, hardboard, oriented strandboard, laminated lumber, laminated wood, veneer, laminate flooring, or engineered wood products; and,
- must not be contaminated with, or have been treated or coated with, antiseptics, preservative, fire retardant, glue, adhesive, laminate, bonding agents, resin, paint, stain, varnish or a substance harmful to humans, animals, plants or the environment.

"Compaction" means the mechanical process of reducing the volume of MSW placed at the active face.

"Composting" means composting as defined in the Organic Matter Recycling Regulation.

"Contaminating Lifespan" means the period of time during which the landfilled waste has the potential to produce effluent or air contaminants (as defined in the *Environmental Management Act*), including at least 25 years after installation of final cover over the entire landfill footprint.

"Controlled waste" means waste that requires special handling including:

- Slaughter and poultry processing industry waste, fish hatchery and farming wastes, cannery wastes and by-products.
- Animal carcasses including road kill, domestic pets, etc.
- Bulk liquids and semi-solid sludges which contain free liquid, including septage, black water, sewage treatment sludge, etc.

"Cover" means clean soil or approved alternate material used in covering compacted MSW. Cover material may serve as daily, intermediate, or final cover:

- "Daily Cover" means cover placed on compacted MSW on the active face.
- "Intermediate Cover" means cover placed where the active face will not be located for 30 days or more.
- "Final Cover" means cover placed on intermediate cover on the final contours of the landfill footprint. The top of the final cover is the permanently exposed final surface of the landfill.

"Design Capacity" is the volume of airspace available for waste within the landfill footprint.

"Designated Flood" means a flood, which may occur in any given year, of such magnitude as to equal a flood having a 200 year recurrence interval, based on a frequency analysis of unregulated historic flood records or by regional analysis where there is inadequate stream flow data available. Where the flow of a large watercourse is controlled by a major dam, the designated flood shall be set on a site-specific basis.

"Floodplain" means a lowland area, whether diked, flood-proofed or not, which, by reasons of land elevation, is susceptible to flooding from an adjoining watercourse, ocean, lake or other body of water and for administration purposes is taken to be that area submerged by the designated flood plus freeboard.

"Groundwater" means water below the ground surface in a zone of saturation.

"Land use" means the modification of land and water by humans for their use including for residential, commercial, transportation, utility, recreational, agricultural, or industrial purposes. Land use is codified in public land use planning documents such as growth management plans, official community plans and zoning by-laws.

"Landfill Criteria" or "Criteria" mean the requirements and criteria stipulated within this document.

"Landfill Criteria Upgrading Plan" means an action plan and schedule to upgrade a landfill to meet these Criteria, including justification of any proposed exemptions from the Criteria.

"Landfill Footprint" means the area of the landfill site where MSW is approved to be deposited.

"Landfill Gas" (LFG) means a mixture of gases generated by the decomposition of MSW, as defined in the Landfill Gas Management Regulation.

"Landfill Site" means the landfill footprint and buffer zone.

"Landfill Site Boundary" means the perimeter boundary of the landfill site.

"Lateral Expansion" means an increase in the landfill footprint.

"Leachate" means any liquid and suspended materials which it contains, that has percolated through or drained from waste.

"Landfill Base Liner" means a continuous layer of primary geosynthetic membrane and secondary compacted clay or GCL, installed beneath and/or on the sides of a landfill footprint which acts as a barrier to vertical and lateral leachate and landfill gas movement.

"Municipal Solid Waste" (MSW) means municipal solid waste as defined in the *Environmental Management Act*.

"Nuisance" means an activity or action or result of such activity or action, which:

- (a) Interferes with the reasonable use and enjoyment of property surrounding a landfill.
- (b) Is a source of irritation to the public.
- (c) Is annoying, unpleasant or obnoxious to the public.

"Open Burning" means the combustion of solid waste without control of combustion air, without control of the combustion reaction and without control of the emission of the combustion products.

"Plans and reports" means assessments, designs, drawings, plans, reports, specifications, etc.

"Post-Closure Period" means that period of time from installation of final cover over the entire landfill footprint to the end of the contaminating lifespan.

"Qualified Professional" means a person who:

- (a) Is an engineer, scientist or technologist specializing in a particular applied science or technology,
- (b) Is registered in British Columbia with a professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization, and
- (c) Through suitable education, experience, accreditation and knowledge respecting solid waste management and related engineering disciplines for the management of leachate, surface water, storm water, and landfill gas and other specialist disciplines, may reasonably be relied upon to provide advice within his or her area of expertise and to carry out duties or functions in those areas.

"Scavenging" means unauthorized and/or uncontrolled removal of MSW or recyclable material.

"Septage" means the pumped contents of a domestic septic tank.

"Service Life" means the period of time during which an engineered system will perform in accordance with its intended design.

"Solid Waste Management Plan" (SWMP) means waste management plan for municipal solid waste and recyclable material, as defined in the *Environmental Management Act*.

"Surface Water" means lakes, bays, sounds, ponds, impounding reservoirs, perennial or ephemeral streams and springs, rivers, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of British Columbia, and all other perennial or ephemeral bodies of water, natural or artificial, inland or coastal, fresh or salt, public or private, but excludes groundwater or leachate collection channels or works.

"Vector" means a carrier that is capable of transmitting a pathogen from one organism to another and includes, but is not limited to, flies and other insects, birds and rodents.

"Vertical Expansion" means an increase in the design capacity without an increase in the landfill footprint.

"Wetland" includes any land such as a tidal flat, marsh, swamp, bog, pocosin, or fen which is frequently inundated and for that reason has developed an organic soil and occurs in an area which is lower lying than its surroundings.

"Yard waste" means non-food vegetative matter from gardening, landscaping, and land clearing.

## **2.0 APPLICABILITY**

These "Landfill Criteria for Municipal Solid Waste" are effective from the date of issuance and apply to all landfills in British Columbia including public and private landfills on public and private land, that receive municipal solid waste (MSW) after the date of issuance of these Criteria, including:

- New landfills.
- Lateral and/or vertical expansions of existing landfills.
- New active landfill phases.
- Existing landfills.

The conformance status of all existing landfills shall be evaluated and a Landfill Criteria Upgrading Plan shall be prepared by the authorization holder for non-conforming landfill sites. The evaluations and Landfill Criteria Upgrading Plan shall be submitted to the director during the next SWMP review or within 5 years of the date of issuance of these Criteria, whichever time period is shorter.

## **2.1 EXEMPTIONS**

These Criteria apply to all MSW landfills. However, in special cases, mainly for existing landfills and vertical expansion of existing landfills, the Director may consider exemptions from specific Criteria (e.g. Siting Criteria, etc.). Requests for exemption from specific Criteria must be submitted to the Ministry of Environment in writing. The requests shall include sufficient technical justification to demonstrate that proposed exemptions provide an equivalent or better level of environmental protection.

## **2.2 LEGAL REQUIREMENTS**

This "Landfill Criteria for Municipal Solid Waste" is a guidance document for MSW landfills provided by the Ministry of Environment and is to be considered during the setting of legal standards specified within SWMPs, operational certificates and permits. The director may require additional information and/or specify legal standards that are more or less stringent than these Criteria. Information regarding the waste discharge authorization process is available on the ministry website. Compliance with the Landfill Criteria does not relieve the owner/operator from the requirements of any other Acts, Regulations, including regulations under the *Environmental Management Act*, or By-Laws.

### **3.0 SITING CRITERIA**

Proper siting of a landfill site is one of the most important aspects of environmental protection. Siting must consider the physical conditions of a site, the remoteness of the area, the existing and planned land uses in proximity, the sensitivity of the receiving environment and the size of the landfill site.

From an environmental perspective, the principal objective of site selection is to identify a suitable location for a landfill to safeguard public health, have minimal impact on the environment, and provide for long term isolation of MSW deposited in the landfill site. Distance requirements stated in the following sections are Ministry criteria, unless noted otherwise.

#### **3.1 LAND USE**

The landfill footprint must not be located within 500 m of an existing or planned sensitive land use. A planned sensitive land use is one that has been identified as an allowed use in a regional growth management plan, official community plan or zoning by-law but has not yet been built/established.

Sensitive land uses include, but are not limited to: schools, residences, hotels, restaurants, cemeteries, food processing facilities, churches, and municipal parks. Land uses such as heavy industry, forestry operations, aggregate extraction/mining, railways/rail yards, etc. are not considered sensitive land uses.

#### **3.2 HERITAGE AND ARCHEOLOGICAL SITES**

The landfill footprint shall not be located within 100 m of a heritage or archaeological site.

Landfill siting is also subject to the requirements of the BC *Heritage Conservation Act* administered by the Archaeology Branch of the British Columbia Ministry of Forests, Lands and Natural Resource Operations. The Branch and website should be consulted for requirements.

### **3.3 AIRPORTS**

Transport Canada policies generally require that a landfill footprint be located no closer than 8 km from airports. This is due to the propensity for landfills to attract birds, thereby creating potential hazards to aircraft, especially during take-off and landing. That minimum separation distance may be reduced to 3 km if bird control measures acceptable to Transport Canada are implemented at the landfill site, and the reduction in the necessary buffer is approved by the airport authority. Where airport zoning regulations exist, the provisions of those regulations shall prevail.

### **3.4 BUFFER ZONE**

The buffer zone between the landfill footprint and the landfill site boundary shall be a minimum of 50 m, of which the 30 m closest to the landfill site boundary shall be reserved for natural or landscaped screening (berms and/or vegetative screens). Only the 20 m buffer closest to the landfill footprint shall be used for access roads, surface water management works, leachate management, landfill gas management and monitoring works, firebreaks, and other ancillary works as required.

### **3.5 WATER SUPPLY SOURCES**

The landfill footprint shall be a minimum distance of 300 m from a water supply well or water supply intake and a minimum 500 m from municipal or other high capacity water supply wells.

### **3.6 GULLIES AND DEPRESSIONS**

The landfill footprint shall not be located in a gully or depression that acts as a point of water collection during rainfall events unless acceptable diversion works are provided such as interception ditching or other diversion measures are undertaken. Diversion of water through culverts beneath the landfill footprint is not allowed.

### **3.7 FAULTS AND UNSTABLE AREAS**

The landfill footprint shall not be located within 100 m of a geologically unstable area. A geologically unstable area is defined as a location where natural or man-made features

pose a substantial risk to the integrity of the landfill environmental control systems or global stability of the fill. Specifically, the landfill footprint must not be located within 100 m of:

- A Holocene fault.
- A known active or historic landslide.
- Areas underlain by weak or collapsible soils, karst limestone, frozen mineral soil or muskeg with an active layer, or underground mine workings.
- Areas prone to debris movement (landslide paths, avalanche paths, alluvial fans).
- A location at risk of tsunamis.

### 3.8 ENVIRONMENTALLY SENSITIVE AREAS

The landfill footprint must not be located within 100 m of an environmentally sensitive area such as:

- A national, provincial, regional or municipal park.
- A wildlife management area as designated under Section 4 of the provincial *Wildlife Act*.
- A critical wildlife area or wildlife sanctuary designated under Section 5 of the provincial *Wildlife Act*.
- A land acquired and administered under Section 3 of the provincial *Wildlife Act*.
- An ecological reserve designated under the provincial *Ecological Reserve Act*.
- A bird sanctuary designated under the regulations pursuant to the federal *Migratory Birds Convention Act*.
- A wildlife area designated under the federal *Wildlife Act*.
- A marine sanctuary.
- A wetland.
- The habitat of rare, threatened or endangered species under federal and/ or provincial Species at Risk legislation.

### 3.9 SURFACE WATER

A landfill footprint shall not be located within 100 m of surface water.

**3.10**      **FLOODPLAINS**

A landfill footprint shall not be located in a floodplain.

**3.11**      **SHORELINES**

A landfill footprint shall not be located within 100 m of the sea level maximum high tide or seasonal high watermark of an inland lake shoreline.

**3.12**      **DEPTH TO WATER TABLE**

The landfill base shall be a minimum 1.5 m above "groundwater" at all times.

## 4.0 PERFORMANCE CRITERIA

Performance criteria in this guidance document ensure adequate protection of human health and environment. All assessments, designs, reports and plans, developed under this guidance document must demonstrate how they will satisfy performance criteria. All the documents must be prepared under the supervision of, and certified by, a Qualified Professional.

### 4.1 GROUNDWATER AND SURFACE WATER QUALITY

Existing and potential future uses of groundwater and surface water must be identified within 1 km of the landfill footprint. After considering existing and potential future uses of groundwater and surface water, a Qualified Professional must recommend the appropriate water quality criteria, compliance locations, and provide related rationale and justification.

Water quality criteria to be considered include:

- The Contaminated Sites Regulation Schedule 6 Generic Numerical Water Standards and Schedule 10, Generic Numerical Soil and Water Standards, Column V Drinking Water (DW) Water Standard.
- The Canadian Drinking Water Quality Guidelines.
- The BC Approved and Working Water Quality Guidelines.
- BC Water Quality objectives.
- Other water quality criteria for parameters not addressed by the preceding water quality criteria.

The appropriate water quality criteria and compliance monitoring locations are subject to the approval of the Director in writing.

As a minimum, the appropriate water quality criteria must be satisfied at and beyond the landfill site boundary, or 150 m from the landfill footprint, whichever is closer. More stringent requirements may be set by the director. Any surface water in the buffer zone must also satisfy appropriate water quality criteria. Any discharges to surface water considered as potential fish habitat must also comply with the requirements of the federal *Fisheries Act*.

## **4.2            LANDFILL GAS MANAGEMENT**

Soil gas concentrations at the landfill site boundary must not exceed the lower explosive limit of methane (5 percent by volume).

Combustible gas concentrations measured in on-site buildings must not exceed 20 percent of the lower explosive limit of methane (1 percent by volume) at any time.

Landfill Gas (LFG) must also be managed in accordance with all migration and health and safety requirements. Resources include Worksafe BC and the Landfill Gas Management Facilities Design Guidelines (Section 8.0 LFG Migration Assessment and Control; Section 9.0 Health and Safety).

LFG emissions must be managed such that all federal, provincial, and local ambient air quality objectives and standards are not exceeded.

LFG management is also regulated under the BC Landfill Gas Management Regulation. This regulation requires that all landfills having more than 100,000 tonnes of waste in place, or receiving more than 10,000 tonnes of waste per year, are to submit a Landfill Gas Generation Assessment Report. Landfills determined to be generating more than 1,000 tonnes of methane per year are required to prepare a Landfill Gas Management Facilities Design Plan and to have a LFG management system in place four years after the Facilities Design Plan submission. LFG management systems are to be designed to maintain 75 percent collection efficiency.

## **4.3            NUISANCE**

A landfill must not create a "nuisance" including but not limited to dust, noise, litter, odour, vectors and/or wildlife attraction.

## 5.0 DESIGN CRITERIA

This section of the Criteria presents the design objectives and minimum requirements for a landfill site and the environmental control systems to be implemented on the site.

Landfills must be designed to protect the environment and satisfy all criteria set out in this document. The performance of the site-specific design must be assessed within the plans and reports described in Section 10.

### 5.1 SERVICE LIFE AND CONTAMINATING LIFESPAN

A landfill site must be designed such that the service life of the facilities exceeds the contaminating lifespan.

### 5.2 SITE LAYOUT

The site layout must be designed to satisfy all criteria including the siting criteria, and minimise environmental impacts.

Figure 5.1 provides an illustration of landfill buffer zones. The buffer zone between the landfill footprint and the landfill site boundary shall be a minimum of 50 m of which the 30 m closest to the landfill site boundary shall be reserved for natural or landscaped screening. A vegetative screen serves to reduce the visual impact of the landfill on adjacent properties. The 20 m buffer closest to the landfill footprint shall be used for access roads, firebreaks, leachate and landfill gas management and monitoring works, as required.

The site layout must provide for site entrance, gatehouse, material recovery/recycling area, structures, access roads, landfill footprint, surface water ditching and management ponds and leachate and gas management infrastructure. The site layout should minimize the potential for leachate and landfill gas impacts offsite taking into consideration groundwater flow direction and surface water infiltration and discharge points.

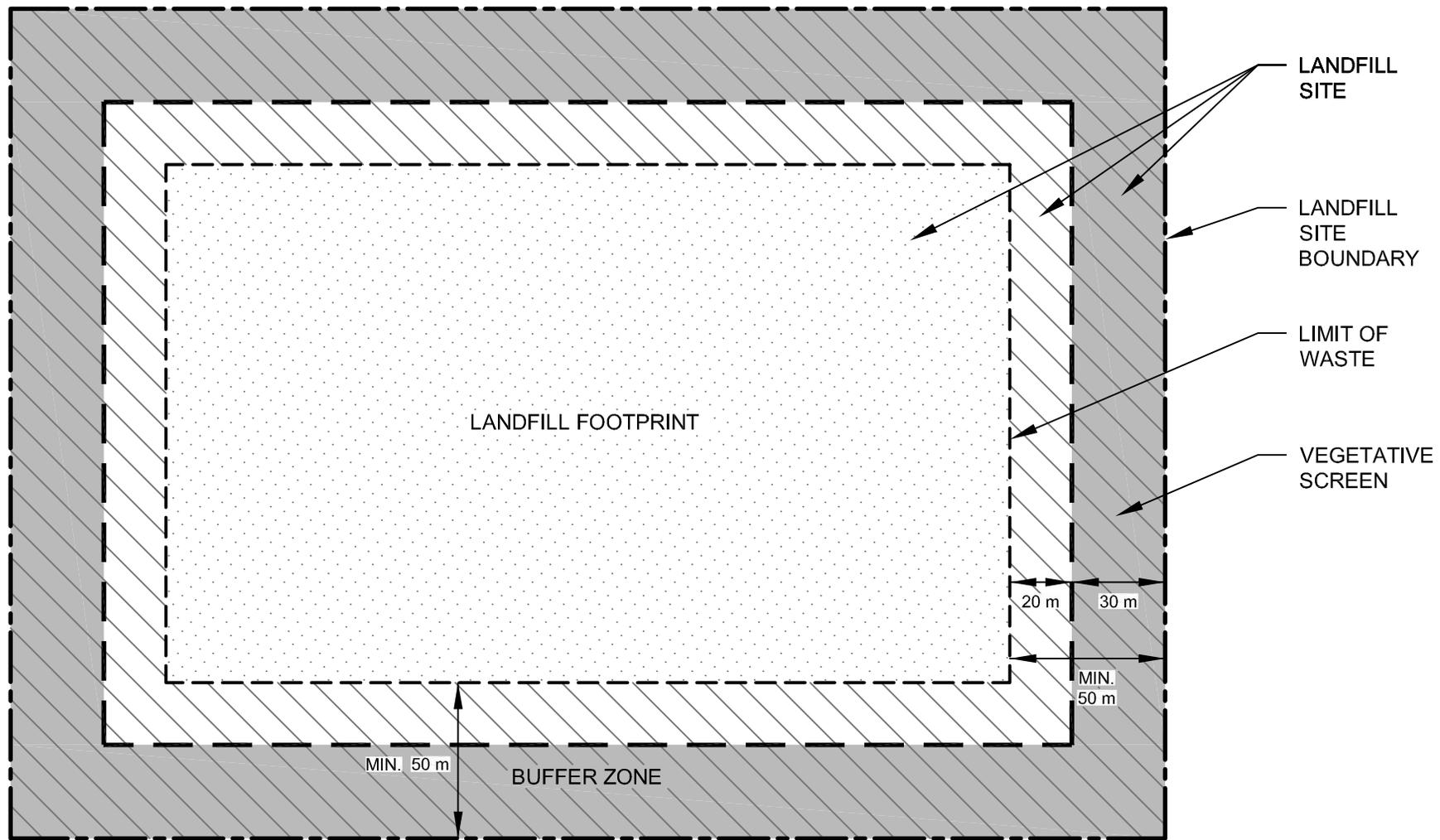


figure 5.1  
ILLUSTRATION OF BUFFER ZONES

### **5.3 LANDFILL BASE DESIGN**

The landfill base provides the foundation for construction of the landfill base liner and leachate collection system. The landfill base shall be graded to provide a minimum 2 percent grade for the primary drainage path and minimum 0.5 percent for the secondary drainage path that results in a maximum drainage path of 50 m.

The landfill base shall be placed in stable soils or rock, with a minimum distance of 1.5 m above groundwater at all times, as presented in Figure 5.2. The landfill base soils shall not be subject to consolidation that could result in differential settlement under the applied waste and cover soil loading.

Geologic inspection of the landfill base by a QP is required to be completed to confirm the geology beneath the landfill footprint and confirm the geologic assumptions used in the landfill design prior to placement and construction of the landfill base liner system. Any geologic features that pose a risk to the landfill design performing as intended, including unstable soils or unstable bedrock or groundwater conditions, discovered during site construction are to be identified and addressed prior to construction of the landfill base liner system.

### **5.4 LANDFILL BASE LINER**

The landfill base liner (illustrated on Figure 5.3) shall be comprised of a primary HDPE geomembrane liner and a secondary compacted clay liner or Geosynthetic Clay Liner (GCL). Continuous QA/QC inspection by a QP during membrane installation and subsequent membrane coverage is required to limit occurrence of undetected defects. Each seam should be individually tested using non-destructive methods.

The minimum specifications for the primary HDPE geomembrane liner are:

- HDPE membrane thickness of 1.5 mm (60 mil).
- Service life of 100 years.
- High quality seams.
- Consideration is to be given to the requirement for texturing and asperity size of the primary geomembrane to ensure stability of the fill in all circumstances, including earthquake loading.

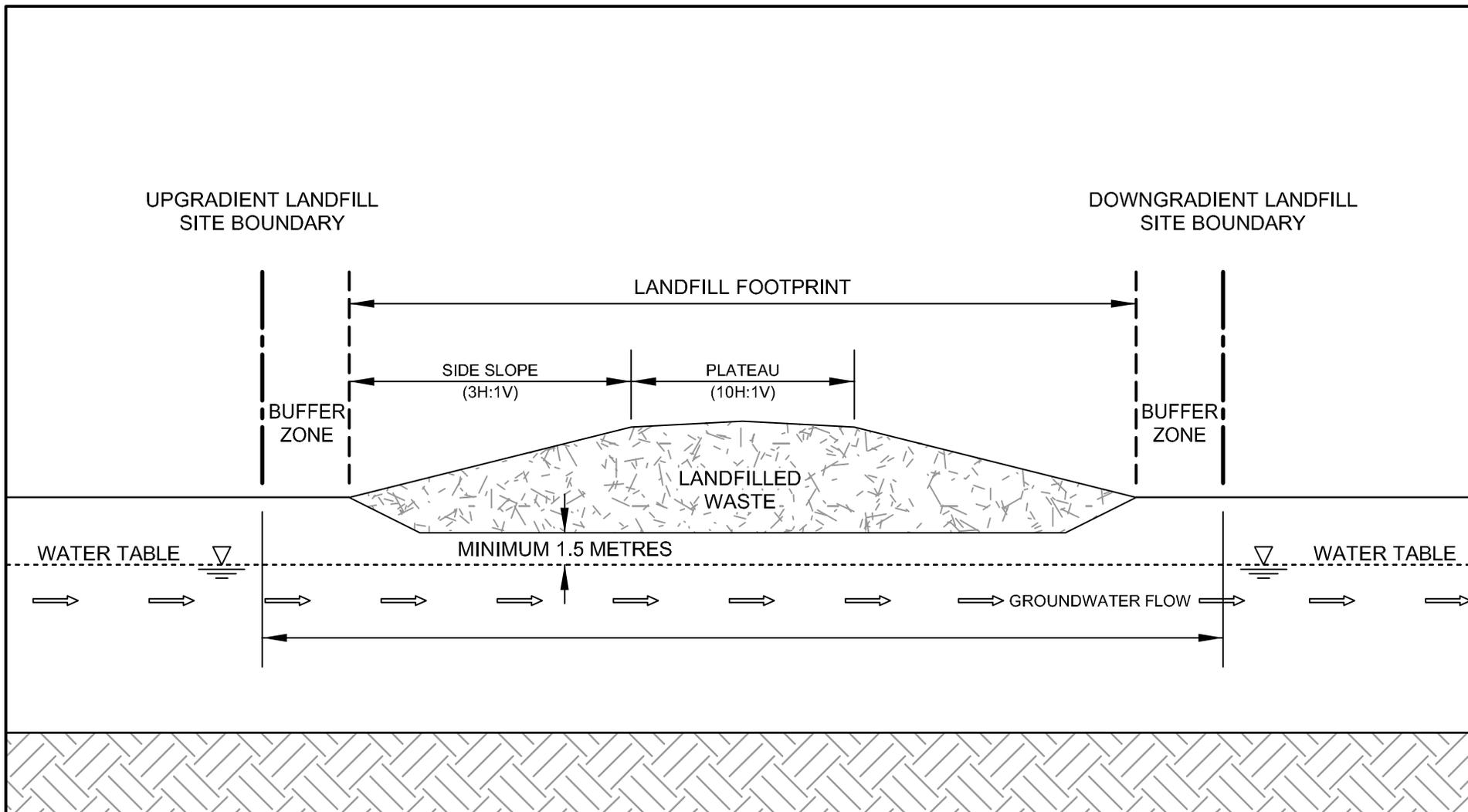
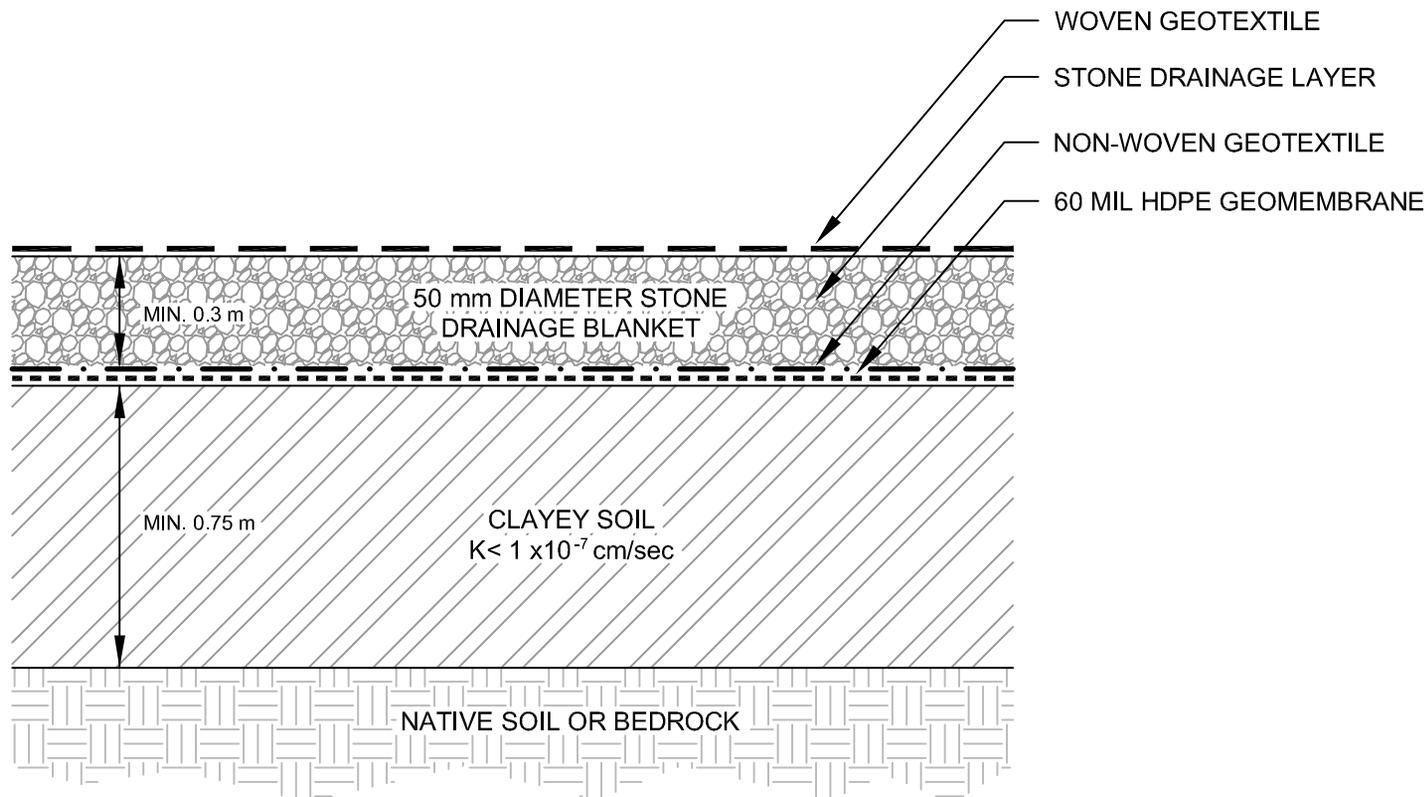


figure 5.2  
 LANDFILL CROSS-SECTION SCHEMATIC



LANDFILL BASE GRADES

- MINIMUM 2% GRADE PRIMARY DRAINAGE PATH
- MINIMUM 0.5% GRADE SECONDARY DRAINAGE PATH

NOTE

- GEOCOMPOSITE CLAY LINER CAN REPLACE CLAYEY SOIL LINER IF EQUIVALENT OF BETTER PERFORMANCE CAN BE ACHIEVED

figure 5.3

LANDFILL BASE LINER SYSTEM

The specifications for the secondary compacted clay liner are:

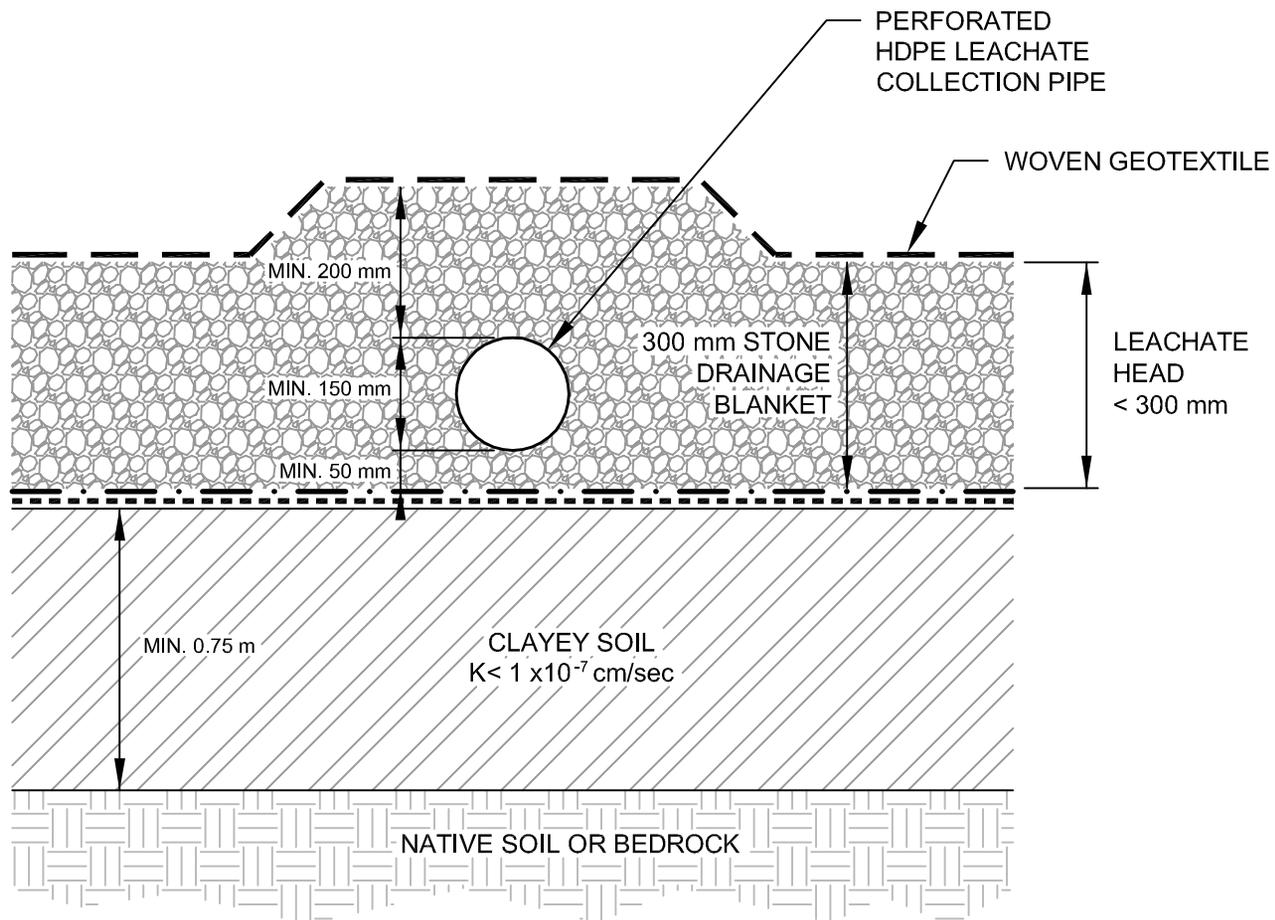
- Soil containing minimum 25 percent clay and minimum 60 percent silt and clay by weight.
- A minimum compacted thickness of 750 mm.
- Compacted hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec or less.
- Organic carbon content of at least 0.1 percent.
- Clay structure and permeability to remain stable when exposed to leachate.

The secondary compacted clay liner may be replaced by an equivalent performing GCL. An alternative landfill base liner may also be approved as per Section 2.3 (Exemptions).

## 5.5 LEACHATE COLLECTION SYSTEM

A leachate collection system is to be constructed above the landfill base liner. The leachate collection system is to provide a free draining layer that allows for collection of leachate and eliminates the buildup of a leachate head on the landfill base liner. The leachate collection system is to be designed to minimize clogging and allow for maintenance of the leachate collector pipes. Minimum design requirements for a leachate collection system are:

- The leachate collection system shall be constructed of a continuous 0.3 m thick stone drainage blanket with perforated collector pipes with protective geotextile layers.
- The stone drainage blanket shall be constructed of 50 mm diameter clear stone with minimal fines. The stone shall be chemically stable and inert rock.
- A non-woven geotextile shall be placed on top of the geomembrane liner prior to placement of the stone drainage blanket to protect the geomembrane liner.
- A woven geotextile shall be placed above the clear stone drainage blanket to maintain separation of the waste from the clear stone and to minimize the potential for ingress of fines into the stone drainage blanket.
- Perforated high density polyethylene leachate collector pipes shall be placed within the stone drainage blanket as detailed on Figure 5.4.
- Leachate collector pipes are to be installed at a lateral spacing that provides a maximum spacing of 15 m and maximum drainage path of 50 m.
- The collector pipes shall be sized to handle leachate flows based on site-specific leachate generation calculations but shall be a minimum 150 mm diameter in all cases.



**NOTE:**

MINIMUM COLLECTOR PIPE SLOPE 2%

MAXIMUM COLLECTOR SPACING 15.0 m

MAXIMUM DRAINAGE PATH 50.0 m

figure 5.4  
LEACHATE COLLECTION PIPE

- The pipe wall thickness shall be designed based on the site-specific loadings from the mass of the waste and final cover soils.
- The collector pipes shall be installed at a minimum slope of 2 percent along primary leachate flow paths.
- Clean outs are to be provided at each end of the leachate collector pipes.
- The collector pipes shall drain to a collection header and sump to allow for the removal of collected leachate. Leachate shall be removed to maintain a leachate head of less than 0.3 m at any point on the landfill base liner.

Continuous QA/QC inspection shall be carried out during installation by a Qualified Professional during the construction of the leachate collection system. The collected leachate shall be managed in accordance with the approved Leachate Management Plan (Section 10.3.3).

## **5.6 SURFACE WATER MANAGEMENT WORKS**

Surface water management works shall be designed and constructed in accordance with a Surface Water Management Plan (Section 10.3.2) prior to commencement of landfill site operations. Surface water management works are to:

- Convey and direct surface water runoff away from the active operation area within the landfill footprint to minimize surface water contact with waste.
- Minimize potential for on-site erosion and sediment loading to downstream water courses.
- Control peak flows from the landfill to minimize the downstream flood risk.
- Prevent surface water run-on onto the landfill footprint.

Hydrologic modeling is required to assess the performance of the surface water management works under minor and major storm events and is to be completed for 5-, 10-, and 100-year design storm events. This modeling is required to identify the hydraulic requirements for the design of the ditches, ponds, coffer dams, check dams, and outlet structures needed within the site-specific design to meet the performance requirements of the Surface Water Management Plan.

Surface water management works shall be designed in accordance with the following criteria:

- All components of a surface water management system, including surface water management ponds, are to be designed to promote settling of sediment and infiltration of retained storm water for groundwater recharge.
- Ponds are to be designed with low flow control structures and high flow overflow channels.
- Surface water ditches and retention ponds shall be designed for the control and retention of a 1:100-year, 24-hour storm event.
- The design shall make allowances for additional water that may result from snow melt.
- Surface water runoff generated from active areas of the landfill (i.e., areas that are not capped with final or interim cover but containing waste) shall be managed as leachate. Cofferdams are to be used where required to minimize clean surface water contact with active waste disposal areas.
- All ditch surfaces are to be armoured (rip rap, erosion control matting, or vegetative cover) to prevent erosion of ditch bottom and side slopes.
- All ditches are to maintain a minimum 1 percent grade to prevent sedimentation and maintain hydraulic design capacity. Ditches shall be designed to accommodate localized settlement (no grade reversals).
- Check dams are to be used for sediment control as required.
- Mid slope drainage ditches/swales shall be constructed on the final cover surface as required to prevent erosion of final cover soils.

## **5.7 LANDFILL GAS MANAGEMENT WORKS**

Landfill gas management works generally include an active or passive landfill gas collection system, a methane destruction system (flare, boiler, reciprocating engine, upgrader or biofilter), and landfill site perimeter soil gas monitoring probes.

As per the requirements of the Landfill Gas Management Regulation, landfill owners required to prepare a landfill gas management facilities design plan must design, construct, and operate landfill gas management facilities in accordance with the BC Landfill Gas Management Facilities Design Guideline.

The guidance document entitled "Technologies and Best Management Practices for Reducing GHG Emissions from Landfills Guidelines" provides guidance for the

selection of technologies and best management practices for reducing GHG emissions from landfills.

## 5.8 FINAL COVER DESIGN

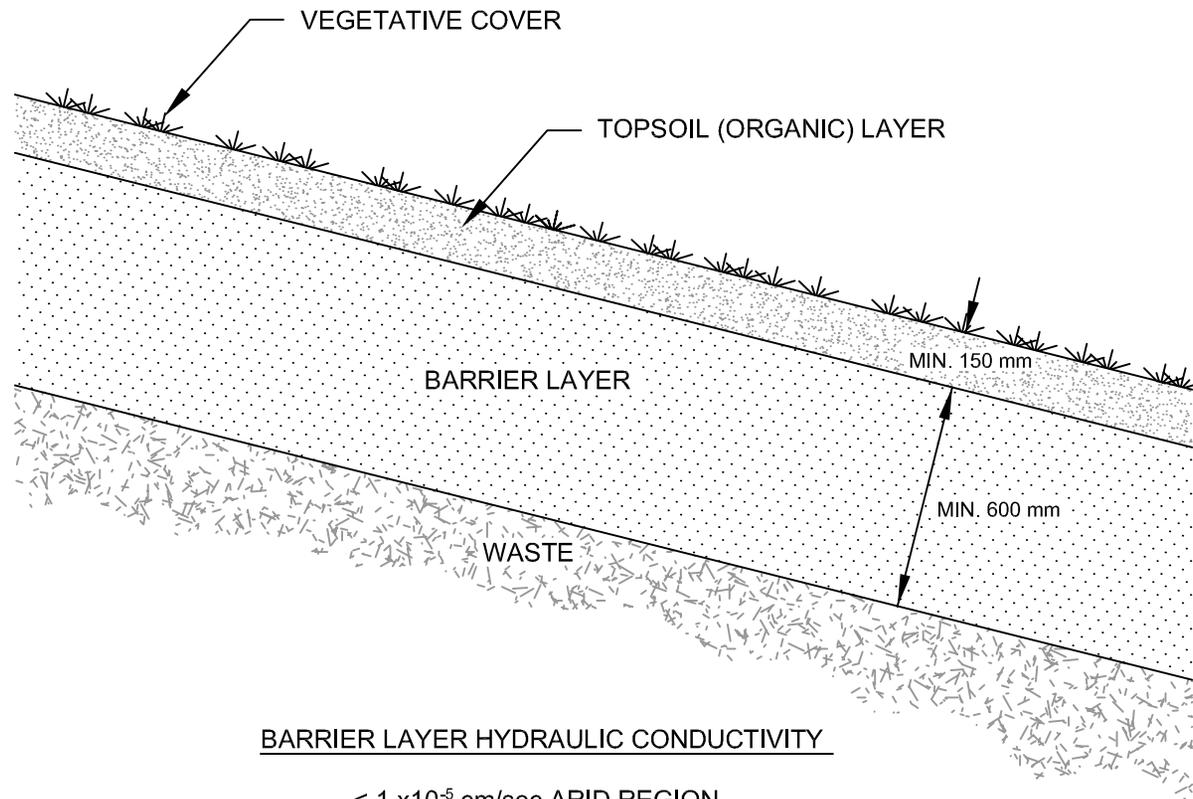
The final cover is to achieve the following objectives:

- Prevent exposure of humans and/or wildlife to MSW.
- Control infiltration of precipitation.
- Minimize the uncontrolled release of methane to the atmosphere.
- Limit erosion and release of sediment to surrounding surface waters.
- Control the release of odours.
- Minimize oxygen infiltration and fire risk.

The final cover must be compatible with the end use planned for the landfill site.

The minimum final cover shall consist of a barrier layer, providing a maximum hydraulic conductivity of  $1 \times 10^{-5}$  cm/sec for landfill sites located in arid regions and  $1 \times 10^{-7}$  cm/sec for landfill sites located in non-arid regions. The final cover barrier layer shall have a compacted thickness of 0.6 m measured perpendicular to the slope with a 0.15 m topsoil layer capable of establishment and sustained growth of the vegetative cover. The minimum final cover requirements are illustrated in Figure 5.5a. Requirements are site-specific, depending on the amount of precipitation received annually.

Based on the landfill performance assessment and the requirements of the Leachate Management Plan the maximum allowable leachate generation rate must be identified. The final cover system is to be designed to ensure the maximum allowable leachate generation rate is not exceeded but will allow for waste stabilization during the post-closure period. Hydrologic modeling of the "final cover" performance using the applicable climatic setting for the landfill site must be completed to demonstrate the final cover stability under design storm conditions and consistency with the Leachate Management Plan. A lower permeability barrier layer or the addition of a geomembrane, as illustrated in Figure 5.5b, may be required to control leachate generation rates to be consistent with those identified in the Leachate Management Plan. The final cover design must also be coordinated with the LFG management facilities including LFG collection or venting facilities.



BARRIER LAYER HYDRAULIC CONDUCTIVITY

$\leq 1 \times 10^{-5}$  cm/sec ARID REGION

$\leq 1 \times 10^{-7}$  cm/sec NON-ARID REGION

SLOPES

SIDE SLOPE 3H:1V

PLATEAU 10H:1V

figure 5.5a  
FINAL COVER DETAIL

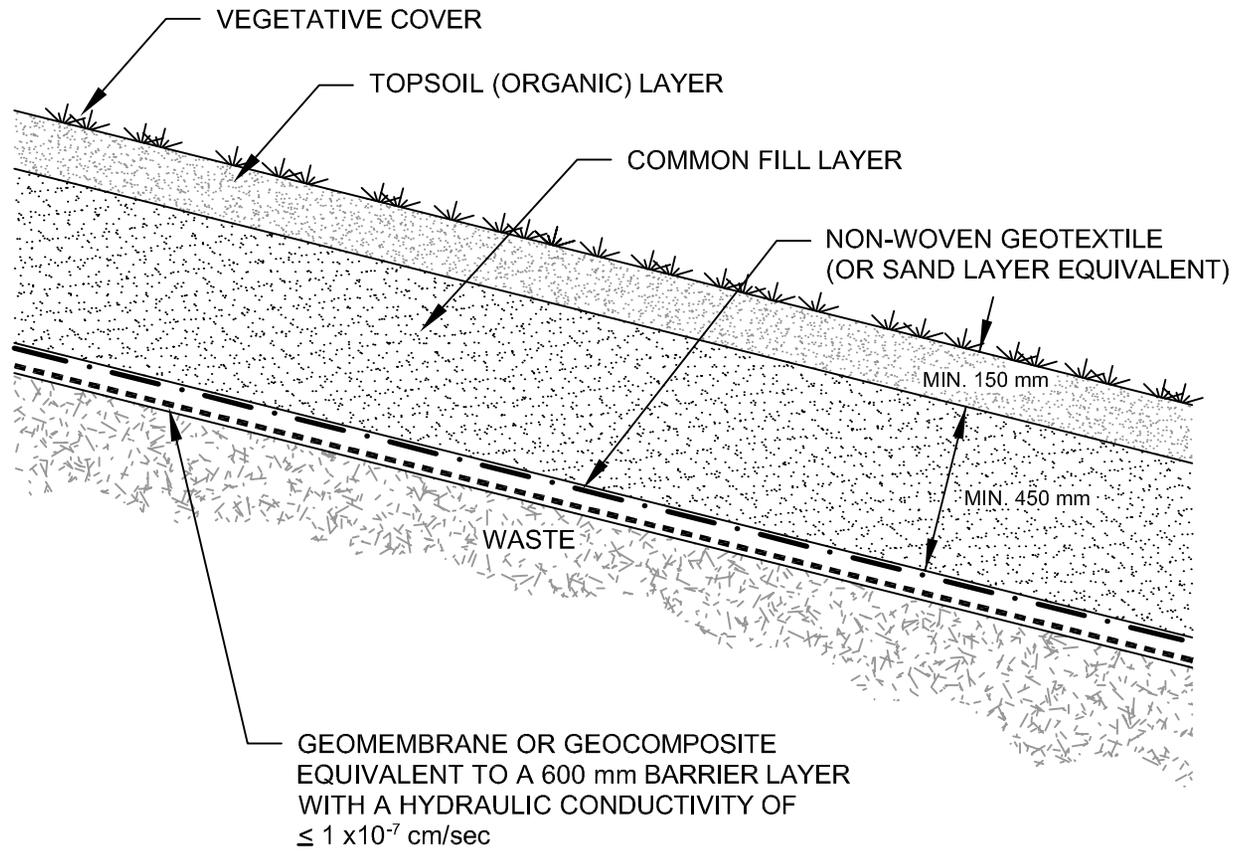


figure 5.5b

GEOMEMBRANE FINAL COVER DETAIL

## **Topsoil Layer**

A topsoil layer shall be the top layer in the final cover. The topsoil shall be comprised of a soil horizon that will provide the moisture retention and nutrients required to support healthy vegetative growth in the long term. The topsoil can be comprised of suitable soil or a fabricated growing medium produced from an appropriate mix of soil, a carbon source, and a nutrient source such as biosolids. If biosolids are used as a soil conditioner, the fabricated growing medium mix shall be developed by a Qualified Professional, and in compliance with BC's Organic Matter Recycling Regulation.

## **Vegetation**

A completed final cover shall be seeded or hydroseeded at the first opportunity that will result in successful germination and sustainable growth. The seed mix shall achieve erosion control, low maintenance, and end use objectives. Reseeding and fertilization shall be carried out periodically until such time that a sustainable vegetative cover is fully established.

## **5.9 FINAL CONTOURS**

The final contours of a landfill will affect the landfill site capacity and the performance of the final cover system. Maximum recommended slope length should depend on soil type, slope steepness and climate. More gradual slopes will reduce surface water runoff and cover soil erosion but result in increased infiltration and leachate generation. Steeper slopes reduce infiltration but may result in increased erosion and slope stability concerns. Final contours of the landfill shall be constructed at grades not steeper than 3H:1V (33 percent). The top plateau of the landfill must have a slope not less than 10H:1V (10 percent) above the final landfill side slope. Figure 5.2 provides an example profile schematic of the final contours.

Surface water control benches to intercept surface water run-off shall be provided on the landfill final contours every 15 m vertical or less. Benches shall be graded in a way that will effectively convey surface water run-off from the landfill refuse via ramps, down-chutes, or spillways and shall account for anticipated settlement.

## **5.10 SITE SECURITY AND FENCING**

Landfill security fencing is required to discourage unauthorized access to the facility outside of the landfill operating hours.

Security fencing shall be established around the entire perimeter of the landfill on the landfill site boundary. The minimum size fence shall be a 1.2 m post and wire fence. Along the landfill site boundary where vehicle access can be achieved from the outside a minimum 2 m chain link fence is recommended. Entrance gates with vandal proof locking mechanisms are required at all access points to the landfill site that are accessible to the public. The gates shall be maintained in a locked position outside landfill operating hours.

## **5.11 ACCESS ROADS**

Landfill access roads must be designed and constructed to provide safe all-weather access to on-site facilities and for conducting inspection and maintenance of the landfill site infrastructure during the operating and post-closure periods of the landfill.

During the operating life of the landfill site, safe public access shall be maintained to all material drop-off and waste disposal areas. Recessing the entrance into the landfill should be considered to minimise vehicle queuing along public roads. The access roads at the landfill site entrance shall be designed and constructed to prevent the tracking of mud or waste from the site onto public roadways.

The size and grade of the access roads are to be designed to meet the traffic load and vehicle type within the open and controlled areas of the landfill site. The following design criteria should be adopted:

- Access road traffic surface to be minimum 4 m wide for one lane and 7 m for two lanes.
- Roads for public and commercial traffic shall not exceed 8 percent grade.
- Roads for construction/internal off-road equipment traffic shall not exceed 15 percent grade.
- All roads sloped steeper than 2 percent shall have armoured ditches.

**5.12**      **VECTOR AND WILDLIFE MANAGEMENT AND NUISANCE CONTROLS**

A landfill site must be designed to satisfy the operation criteria with respect to vector and wildlife management and nuisance controls.

## 6.0 OPERATIONS CRITERIA

This section of the Criteria presents the objectives and minimum requirements for operation of landfill sites to ensure the landfill performance criteria are met.

### 6.1 AUTHORIZED WASTES

MSW shall be approved for disposal in the landfill. In general, waste disposed in the landfill shall not contain Hazardous Waste as defined in the Hazardous Waste Regulation. The following types of Hazardous Waste may be specifically approved for disposal by the director:

- Waste asbestos managed according to Section 40 of the Hazardous Waste Regulation.
- Hydrocarbon-contaminated soils managed according to Section 41.1 of the Hazardous Waste Regulation. Details of contaminated soil disposal are provided in Appendix B.

Disposal of controlled waste is generally prohibited. Controlled waste, if approved for disposal, requires special handling. Burial of specified controlled waste in dedicated trenches may be approved in instances where it has been demonstrated that there is no other viable alternative for the waste stream such as treatment/disposal, recycling, reprocessing or composting. The DOCP shall identify the controlled waste to be received at the landfill site and the additional controls to be implemented for the receipt and disposal of such wastes.

Many materials found in the MSW waste stream such as cardboard, beverage containers, scrap metal, drywall, etc. are recyclable. Although not banned by these Criteria, many regional districts and municipalities have implemented SWMPs and by-laws to ban a wide range of substances from being disposed of in a landfill. Commonly banned materials include:

- Metal.
- Cardboard.
- Gypsum drywall.
- Yard waste.
- Clean wood.
- Concrete.
- Wood from construction and demolition sources.

- Organics from commercial and residential sources.
- Product categories under the BC Recycling Regulation.

Recovery of recyclable and reusable materials to avoid placement of these materials in a landfill is encouraged.

## **6.2 LANDFILLING OF WASTES**

All waste shall be placed within the landfill footprint in accordance with the filling plan. The active face shall be kept at a minimum while providing sufficient area for the safe unloading of waste by incoming waste haulage vehicles.

Specifications for the active face size and uncompacted lift heights are provided in Appendix A.

Wastes are to be spread in thin layers (0.6 m or less) on the active face and compacted. Normally, 3-5 passes of the compacting equipment over the wastes are sufficient to achieve adequate compaction.

General guidance is provided regarding the following wastes that may be approved for disposal in the landfill footprint:

### **Waste Asbestos**

Waste asbestos as defined by the BC Hazardous Waste Regulation must be transported in compliance with the Transportation of Dangerous Goods Act and Regulations and disposed of in accordance with Part 6, Section 40 of the HWR (including the Director's requirements), and any landfill-specific asbestos handling and management policies.

Currently, section 40(2) of the HWR requires:

A person must not deposit waste asbestos in a landfill other than a secure landfill unless

- (a) a permit or an approval has been issued under the Act to operate the landfill, or the landfill is operated under a waste management plan,
- (b) the waste asbestos is confined during handling, storage and transportation by
  - (i) dry airtight containment techniques such as
    - (A) packing in 6 mil plastic bags placed within a non-reusable drum and then sealed, or
    - (B) packing in a 6 mil plastic bag placed within a second 6 mil plastic bag and then sealed, or

- (ii) wet containment techniques such as saturation with water and containment in non-leaking sealed drums or equivalent, or
- (iii) approved containment techniques,
- (c) the waste asbestos is disposed of at the landfill by being immediately buried with a minimum of 0.5 m of cover material,
- (d) approval of the landfill owner is received before disposal takes place, and
- (e) the deposit is authorized by a director and carried out in accordance with the director's requirements.

Waste asbestos can typically be deposited into a dedicated asbestos trench excavated into garbage removed from the operating active face, or in a controlled waste trench excavated into native soil within the final landfill footprint and in an area where no further excavation will occur. The trench should be excavated between 2 to 4 m deep.

### **Controlled Waste**

If approved, controlled waste may be disposed of in a 2 to 4 m deep trench excavated into MSW at the active face, or in a trench excavated into native soil within the landfill footprint where no further excavation will occur. The controlled waste shall be immediately covered with a minimum of 0.5 m of cover or MSW.

Slaughter House waste is differentiated into two types. Type 1 waste is considered Specified Risk Material (SRM). SRM is defined as waste that contains body parts from cattle that may contain the BSE prion, including the brain, spinal cord and other body parts. Type 2 waste is cattle waste not at risk of containing SRM and other slaughterhouse waste such as poultry waste. For slaughter industry waste, the federal Canadian Food Inspection Agency (CFIA) requires producers, transporters, and processors to obtain permits for transporting, accepting and disposing of specified risk material (SRM). For information, consult the CFIA.

### **6.3 COVER PLACEMENT**

Cover is required to control vectors, wildlife, fire, litter, odour, infiltration, landfill gas, scavenging, etc.

Daily cover must be placed on the entire surface of the active face at the end of each operating day. If daily cover is soil, it shall be at least 150 mm thick.

Intermediate cover must be placed where the active face will not be scheduled to receive the placement of additional wastes for 30 days or more. If intermediate cover is soil, it shall be at least 300 mm thick (may include the daily cover thickness).

Alternate materials that may be approved as daily or intermediate cover include:

- Reusable (e.g., rigid steel plates, rubber belts, or tarps).
- Left in place and buried (e.g., wood waste, shingles, contaminated soils, thin decomposable plastic films or spray-on covers).

Depending on the type of daily or intermediate cover, surface water that contacts daily or intermediate cover may be considered to be leachate and, if so, must be managed in accordance with the leachate management plan.

Cell construction and use of inert daily and intermediate cover reduces the risk of fire initiation through spontaneous combustion as well as the risk of a fire spreading throughout a landfill facility. However, daily and intermediate cover may lead to the development of perched water tables and limit the vertical flow of landfill gas toward gas collection wells and horizontals. Recognizing these conflicting objectives, stripping of daily and intermediate cover can be undertaken at MSW landfill facilities in order to enhance landfill gas recovery and to prevent leachate breakouts and slope failures. The optional stripping of cover shall be undertaken only immediately before beginning an active face on top and must not result in unacceptable nuisance odours and/or odour complaints.

Final cover must be placed within 180 days on any part of the landfill footprint at final contours. The final cover barrier layer shall be placed at a minimum thickness of 600 mm.

Contaminated soil may be used as waste cover under conditions provided in Appendix B.

#### **6.4 NUISANCE CONTROLS**

The landfill must be designed and operated to prevent nuisance and comply with any local government nuisance bylaws. If the landfill is likely to cause a nuisance or not comply with any local government nuisance bylaws (including due to dust, noise, litter, odour, vectors, wildlife, tracking of mud out of the site entrance, etc.), assessment, modeling and/or monitoring must be conducted to determine predicted and/or actual

nuisance levels, and controls must be designed and implemented to prevent nuisance and comply with the bylaws.

A complaint response procedure is required to be developed and posted on-site for responding to nuisance complaints.

### **Dust**

Any landfill surface, soil stockpile and road surface has the capacity to generate dust. Other potential dust sources are compost grinding operations and the delivery of dusty loads of waste. The magnitude of the resulting impact will depend on the type and size of the operation, the prevailing wind direction and intensity, the presence of any natural or engineered wind breaks and dust control measures implemented, the soil type, and climate.

Dust releases must be controlled on site. Roads on the landfill surface shall be watered as necessary or otherwise treated to control dust emissions. Chloride-containing dust suppressants are discouraged as chloride is a common leachate indicator parameter used in the groundwater and surface water quality monitoring program. Waste oil is banned for use as a dust suppressant.

Landfill supervisory staff shall routinely watch out for dust clouds and shall initiate remedial measures whenever excessive dust is observed.

### **Noise**

Landfill operations generally require the operation of heavy equipment including waste compactors, dozers, heavy trucks and mobile crushers, screens and other plants used in recycling operations. Heavy equipment must operate with back-up alarms that also generate noise. Without proper noise control measures, landfill operations can result in nuisance.

Site operations must minimise noise including:

- Making use of natural and/or constructed features such as vegetated buffers, soil berms, and material stockpiles to dampen off-site noise impacts.
- Constructing main haul roads at 8 percent grade or less to minimize engine noise.
- Scheduling potentially noisy activities during hours that will minimise impacts on the community.

## **Litter**

Exposed litter on the landfill site must be prevented. The performance objectives for landfills in British Columbia are as follows:

- To have no litter migrate beyond the landfill site boundary.
- To pick up all litter on the landfill site at least once per year, or more often if required.

## **Odour**

Landfill site operations shall be carried out in a manner that prevents nuisance from odour. Odour control measures are required for all activities having the potential to cause nuisance odour. Daily and intermediate cover requirements shall be complied with at all times. Control systems shall be installed as necessary where required and maintained according to industry standards. Aeration systems shall be added to all leachate storage ponds and other liquid facilities that generate unpleasant odours. Biosolids and other odorous materials shall be stored, blended, and processed with required odour control measures in place.

## **6.5 VECTOR AND WILDLIFE MANAGEMENT**

Vectors and wildlife must be discouraged from feeding at landfills.

The following operation criteria shall be implemented at landfill sites to minimize the attraction of vectors and wildlife to landfills:

- Landfills shall comply with all daily, intermediate, and final cover requirements to limit the area of exposed waste that typically attracts vectors.
- Landfills situated within 8 km of airports and landfills in areas where birds converge to feed on refuse at any time shall implement an effective bird deterrent program.
- An effective rodent control program shall be implemented and maintained to minimize the population of rodents on the landfill site.
- Landfills situated in bear habitat or where there are signs of bears such as bear scat, footprints or sightings, must have the landfill site and all areas where an attractant is located, enclosed with a bear-proof electric fence. An attractant includes food or food waste, compost, carcass or part of an animal or fish, or other meat, or other waste or garbage, that could attract bears. If bear signs are detected at a landfill that does not have a bear-proof electric fence, a new bear-proof electric fence shall be erected

within 120 days. An electric fence may also be required if other dangerous wildlife (e.g. cougar, coyote or wolf, etc.) is attracted to the landfill.

## **6.6 BURNING**

Open burning of wastes at the landfill site is generally prohibited. However, open burning of clean wood and yard waste may be approved in the SWMP, OC or permit if it can be demonstrated to the director that there is no viable alternative such as reuse, recycling, energy recovery, or composting. A technical assessment report satisfactory to the director must be submitted and the open burning must be approved in the SWMP, OC or permit. Approval must also be obtained from any other applicable fire protection authorities. Guidelines for open burning of clean wood and yard waste are summarized in Appendix C.

## **6.7 LANDFILL FIRE MANAGEMENT**

Landfills shall be operated in a manner that reduces the risk of landfill fires from occurring. The following requirements must be met:

- All landfills shall comply with the daily and intermediate cover requirements that specify placement and compaction of waste in cells and isolation by specified thicknesses of inert daily and intermediate cover. This is particularly important at DLC facilities.
- Fire breaks at least 15 m wide and free of trees, brush, tall grass and other combustible material shall be maintained within the buffer zone within the 20 m closest to the landfill footprint.
- Landfill site should have year-round and immediate access to a water supply capable of a sustained flow of water for firefighting purposes that exceeds 4,000 litres per minute or suitable alternative fire suppression equipment specified in the Fire Safety Plan.

In the event of an unauthorized fire (including any smoldering fire) the landfill owner or operator shall immediately make all reasonable efforts to extinguish the fire including reporting the fire to the fire department with jurisdictional responsibility. Any large fire which poses a threat to public health or to neighbouring property shall be reported to the Provincial Emergency Program.

## **6.8        SCAVENGING**

Scavenging of wastes from the active face is prohibited. This prohibition is not intended to prevent the operation of material recovery facilities within the buffer zone.

## **6.9        SITE HEALTH AND SAFETY PLAN**

The landfill site operations shall meet the requirements of Work Safe BC.

## **6.10       SIGNAGE**

Signage shall be erected and maintained at the landfill site entrance. Signage at the landfill site entrance shall provide the following information.

- Name of Owner/Site Operator.
- Hours of Operation.
- Emergency Contact Information (e.g. Fire, Police, Ambulance 911, Provincial Emergency Program (PEP) Environmental Emergency 24-hour Incident Reporting Hotline:1-800-663-3456, Conservation Officer Service Report All Poachers and Polluters (RAPP) Dial Toll Free 1-877-952-7277).
- Owner/Site Operator Contact Information.
- Waste and recyclable material accepted prohibited, restricted, and tipping fees.

Appropriate traffic control signage shall be posted inside the landfill site boundaries directing public and commercial waste haulers to drop-off, material recovery, and disposal areas of the landfill site.

## **6.11       WEIGH SCALES**

Weigh scales shall be installed at all landfill sites receiving more than 5,000 tonnes of waste per year. The weigh scales shall be maintained in proper working order and meet the requirements of the federal *Weights and Measures Act*.

## **6.12**      **RECORDS**

The landfill owner and/or operator shall record and maintain all relevant records for at least 7 years. The records shall be available on-site for inspection (as practical) and shall be submitted to the director within 14 days of a request from Ministry of Environment staff. Records include the following:

- The Permit or the Operational Certificate.
- All “plans and reports”.
- Inspection records conducted by regulatory agencies.
- Complaint ledger providing source of complaint, nature of complaint, time received and actions taken.
- Waste tonnages and volumes disposed of in a landfill and if available recyclable material data and disposition for each category of waste and recyclable material received and exported from the landfill site.

## **6.13**      **OPERATOR TRAINING**

All landfills shall be supervised and operated by trained qualified personnel. All landfill operators and managers should have specialized professional training in courses such as a SWANA Manager of Landfill Operations course, a Qualified BC Landfill Operator course or similar. Ministry of Environment strongly recommends the continuing education of staff operating a landfill site.

## 7.0 CLOSURE AND POST-CLOSURE CRITERIA

### 7.1 CLOSURE PLAN

A Closure Plan is required for all landfill sites. The Closure Plan shall be included in the DOCP prepared for the landfill site and shall be updated upon the landfill having reached two years of remaining site life. The Closure Plan shall be prepared identifying a specific post-closure land use proposed for the landfill site.

### 7.2 PROGRESSIVE CLOSURE

Each area of the landfill footprint that has achieved final contours shall be closed within 180 days to provide for progressive closure of the landfill site. Closure activities include but may not be limited to constructing final cover, extending surface water ditches and access roads, planting vegetation, erecting or relocating signage. The timing of the progressive closure activities will be based on the filling plan.

### 7.3 POST-CLOSURE OPERATION AND MAINTENANCE

Post -closure operation and maintenance must be done in accordance with the Closure Plan. The post-closure operation and maintenance program as well as an environmental monitoring program are required to be conducted during the Contaminating Life Span of a landfill. Detailed requirements of the program are specified in Section 10.3.4.

### 7.4 CONTAMINATING LIFESPAN

As part of the Closure Plan, the “Contaminating Life Span” of a landfill shall be determined using the latest updated environmental monitoring information.

As a minimum, the Contaminating Life Span of a landfill shall not be assumed to be less than 30 years when determining the requirements for post-closure operation and maintenance and the amount of financial security required for the landfill site.

The Landfill Gas Management Regulation also addresses the permanent shutdown of landfill gas management facilities.

## 7.5 CONTAMINATED SITES REGULATION AND LANDFILL CLOSURE

Part 4 of the *Environmental Management Act* and the Contaminated Sites Regulation (CSR) contain legal provisions that may apply during the closure of a municipal solid waste landfill. The Ministry's Land Remediation (Contaminated Sites) Section administers these provisions. Questions and Answers about landfills provided by the Land Remediation Section are available at:

<http://www.env.gov.bc.ca/epd/remediation/q-a/index.htm>.

Municipal waste landfilling is a specified purpose/activity in Schedule 2 of the CSR. Section 40 of EMA requires, at the time of "decommissioning" (10 days prior to final deposit of waste), that a landfill property owner complete and submit, to the Director, a site profile. In response to receipt of the site profile, the Director may impose a site investigation requirement and, if so, may require a report on the investigation to be submitted within one year.

Typically, if the landfill property is not planned to be used for a new purpose in the future, then the landfill closure process and post-closure monitoring and reporting requirements will be regulated under the Closure Plan developed for a landfill site (Section 10.3.4). If future plans include the landfill property being put to a new use (e.g., municipal park amenity; light industrial complex), then there may be further requirements to ensure that the landfill site is suitable, from an environmental protection standpoint, for the proposed future use.

Further information regarding the Ministry's contaminated site remediation regulatory framework and a staff contact list may be found at:

<http://www.env.gov.bc.ca/epd/remediation/index.htm>.

## **8.0 FINANCIAL SECURITY**

Financial security is required for all privately-owned landfills.

For publicly-owned landfills a closure fund should be established to promote local government accounting that ensures taxpayers are appropriately funding the future liability associated with the landfills. This is not considered financial security.

### **8.1 AMOUNT OF FINANCIAL SECURITY**

Financial security for landfills shall match liabilities throughout the life of the site. The amount shall be adequate to close the site at any point in its operational life and continue with post-closure care for maintenance and monitoring. Liabilities should be estimated for each phase of development such as:

1. Maximum land disturbance as a result of site development before any waste is placed in the landfill.
2. Nearing completion of each phase of the landfill development and including post-closure care costs.
3. Just prior to final closure of the landfill and including post-closure care costs. This will typically be the point of maximum liability.
4. Post-closure care.

The initial financial security deposit will, at minimum, match the estimate determined by number (1). Increasing financial security shall match costs projected and the timeline for each phase of development (2). At the time of site closure, the fund shall be adequate to offset final closure (3) and post-closure care costs (4).

### **8.2 CALCULATING FINANCIAL SECURITY**

The amount of financial security shall be calculated as the sum of the following costs:

- Cost of emergency closure or planned closure, whichever cost is greater.
- Cost of post-closure operation, maintenance, monitoring and reporting for the contaminating Life Span.
- Cost of implementing contingency measures.

Each task or activity associated with closure and post-closure cares shall be detailed and estimated in performing financial security calculations. Costs for each task or activity should be determined by multiplying the unit cost by the number of units (e.g. cost to develop a well X number of wells). All costs shall be identified individually and tabulated for each phase of landfill development. Estimates shall include costs associated with administration, engineering assessment and construction oversight.

The estimated costs shall not be reduced by the value of any assets. A contingency of 20% shall be added to the total estimated costs.

### **Closure Costs**

Activities to be considered in the closure costs include:

- Compaction, grading of the landfill surface area.
- Final cover placement and the establishment of vegetation.
- Installation of fences, gates, surface water control works, passive LFG venting system and construction of any other monitoring and control works that may be required for the post-closure period.

### **Post-Closure Costs**

Activities to be considered in the post-closure cost estimate are:

- Management and maintenance of the landfill final cover including fertilizing, irrigating and re-seeding of the vegetative cover as anticipated.
- Operation and maintenance of any on-site or off-site leachate management facilities.
- Operation and maintenance of landfill gas management facilities.
- Operation and maintenance of site infrastructure including surface water control works, roads, fences, etc.
- Construction or replacement of any monitoring or control works as required.
- Annual environmental monitoring and reporting.

### **Contingency Measures Cost**

Activities to be included are the costs of implementing and maintaining the contingency measures included in the DOCP.

### **8.3 POST-CLOSURE PERIOD**

The post-closure period for which post-closure care will be determined is the contaminating lifespan of the landfill. (e.g. the time period during which leachate collection or landfill gas management or monitoring is necessary). In the absence of technical rationale to determine the contaminating lifespan, 1000 years shall be used as the default. In no case shall the post-closure period be less than 30 years.

### **8.4 COST TO BE PRESENTED IN CURRENT DOLLARS**

All cost estimates should be presented in net present values and adjusted for inflation and discount rates. Inflation rates shall be based on the *British Columbia Consumer Price Index* averaged over the preceding 10 year period or as recommended by a qualified professional. Discount rates shall be based on the current *Government of Canada Long Term Bond Yield* or as recommended by a qualified professional.

The default for the real rate of return (i.e. the difference between the discount rate and inflation rate) shall be 2% unless otherwise determined by a member of *Canadian Institute of Actuaries* or other qualified professional with comparable expertise.

### **8.5 REVIEW PERIOD**

Cost estimates should be reviewed at the commencement of a new landfill phase or where there has been a significant design revision. Regardless, the period for review should not exceed 5 years.

### **8.6 TYPES OF FINANCIAL SECURITY**

An irrevocable letter of credit is the preferred type of financial security. Contact ministry staff for additional information on that and other acceptable forms of financial security.

## 9.0 MONITORING CRITERIA

A detailed Environmental Monitoring Plan (EMP) for leachate, groundwater, surface water, and landfill gas must be prepared and conducted during landfill operation, closure and post-closure. The EMP must be prepared and conducted to:

- Demonstrate compliance with the performance criteria.
- Demonstrate that monitoring results are consistent with the plans and reports including the groundwater and surface water impact assessment.
- Address the need for monitoring within 1 km of the landfill footprint.

The EMP shall be developed in accordance with the "Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills" for groundwater, surface water, leachate, and soils and vegetation or its approved replacement.

### 9.1 LEACHATE MONITORING

Leachate monitoring is required to establish site specific leachate chemistry and contaminants and to ensure these contaminants are included in the groundwater and surface water monitoring. Monitoring of leachate levels within the landfill shall be conducted to ensure that landfill gas extraction wells (or horizontals) are not flooding, the waste is not becoming saturated and excessive pore pressures are not developing to trigger slope instability.

Leachate chemistry is also required to assist with determining the Contaminating Lifespan of the landfill at the time of closure.

### 9.2 GROUNDWATER AND SURFACE WATER MONITORING

The EMP for groundwater shall be developed based on the Hydrogeology and Hydrology Characterization Report, the Groundwater and Surface Water Impact Assessment, and the expected landfill performance. The EMP for surface water shall be developed to monitor the performance of the surface water control works constructed and operated on a landfill site. The groundwater and surface water monitoring results are to be assessed for compliance with the applicable Criteria as stipulated in Section 4.1.

### **9.3            LANDFILL GAS MONITORING**

Landfill gas monitoring is required to ensure the health and safety of the landfill operations personnel, the public and any other sensitive on-site and off-site receptors.

The EMP for landfill gas shall follow the requirements in the BC Landfill Gas Management Facilities Design Guidelines as this guidance document supersedes the landfill gas section of the “Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills”.

## 10.0 PLANS AND REPORTS

All plans and reports must be prepared at the appropriate time, certified by a Qualified Professional, kept up-to-date, retained for inspection and/or submitted to the director, as required.

The landfill must be planned, designed, constructed, operated, monitored, and closed in accordance with the plans and reports.

The following plans and reports must be prepared:

- Landfill Criteria Upgrading Plan, (for existing landfills see Section 2.2).
- Hydrogeology and Hydrology Characterization Report.
- Construction report(s).
- Design, Operation and Closure Plan (DOCP).
- Landfill Gas Generation Assessment, if required under the Landfill Gas Management Regulation.
- Landfill Gas Management Facilities Design Plan, if required under the Landfill Gas Management Regulation.
- Annual Operations and Monitoring Report (s).

## 10.1 HYDROGEOLOGY AND HYDROLOGY CHARACTERIZATION REPORT

The purpose of the Characterization Report is to characterize the geology, hydrogeology, and surface hydrology at and near the landfill site.

The minimum requirements of a Characterization Report are:

1. **Map and cross-sections** - A geologic map and geologic cross-section of the landfill site showing lithology and structural features. Cross-sections shall be referenced to the geologic map and shall be located to best portray geologic features relevant to the landfill site.
2. **Geologic Structure** - A description of the natural geologic structure of materials underlying the landfill site and its surroundings.
3. **Hydraulic Conductivity** -The in-place hydraulic conductivity of soils immediately underlying the landfill footprint including:
  - Hydraulic conductivity data, in tabular form, for selected locations within the landfill footprint.

- A map of the landfill site showing test locations where these hydraulic conductivity data were obtained.
  - An evaluation of the test procedures and rationale used to obtain these hydraulic conductivity data.
4. **Groundwater Flow Direction** –the perennial direction(s) of ground water movement within the ground water aquifer(s) within 1 km of the landfill footprint.
  5. **Groundwater Flux** –the groundwater flux within the aquifer(s) beneath the landfill site.
  6. **Springs/ Groundwater Discharge** – A map showing the location of all springs and groundwater discharge locations within 1 km of the landfill footprint.
  7. **Surface Hydrology** – A study of water and contaminant transport over the earth’s surface, and through near-surface soils within 1 km of the landfill footprint.
  8. **Water Quality** – An evaluation, supported by water quality analysis, of the baseline water quality within 1 km of the landfill footprint.
  9. **Background** – A tabulation of background water quality for all applicable monitoring parameters and indicator parameters identified in the Environmental Monitoring Program.
  10. **Land and water use**
    - **Well map** – a map showing the locations of all wells including water supply monitoring, oil and gas wells, geothermal, etc. within 1 km of the landfill footprint.
    - **Well information** – well information, where available, for each water well indicated on the well map including, but not limited to:
      - Total well depth.
      - Diameter of casing at ground surface and at total depth.
      - Type of well construction (cable-tool, rotary, etc.).
      - Depth and type of perforations.
      - Name and address of well driller.
      - Year of well construction.
      - Use of well (agricultural, domestic, livestock watering, etc.).
      - Depth and type of seals.
      - Lithologic, geophysical, and other types of well logs, if available.
      - Water levels, pump tests, water quality, and other well data, if available.
    - **Land use** – Current and allowed land uses within 1 km of the landfill footprint including:
      - Types of land use (e.g., residential, commercial, industrial, agricultural, recreational, etc.).
      - Types of crops.
      - Types of livestock.
      - Number and location of dwelling units.

- **Groundwater and Surface water uses** – Existing and potential future uses of groundwater and surface water within 1 km of the landfill footprint.

**10.2 CONSTRUCTION REPORT(S)**

Construction report(s) must be prepared after the construction and/or significant modification of landfill facilities. Construction report(s) must demonstrate the landfill has been constructed in accordance with the plans and reports and confirm that the geologic conditions encountered are as expected and used in a Groundwater and Surface water impact assessment. Construction report(s) must include all inspection and quality assurance/quality control testing results, and as-built record drawings showing the lines, grades, and as-built elevations of the landfill. The results of all soil test data including field and laboratory data shall be contained within the construction report. The geologic inspection report containing information as per Section 5.4 shall be included in the Construction Report prepared for the landfill site.

Before and during the construction or significant modification of landfill facilities (e.g. landfill base, landfill base liner, leachate management facilities, landfill gas management facilities, surface water management works, final cover, etc.), inspections and quality assurance/quality control testing must be conducted, and any concerns addressed.

For example, the following inspections and testing are recommended:

Landfill Facility	Inspections and testing
Landfill base	Geologic inspection and soil testing
Landfill base liner	Continuous QA/QC inspection during geomembrane installation and subsequent geomembrane coverage to limit occurrence of undetected defects. Each seam should be individually tested using non-destructive methods.
Leachate collection system	Continuous QA/QC inspection
LFG Collection System	Continuous inspection, testing and adjustment

Final Cover System	QA/QC for geomembrane cover installation, regular inspection for cover integrity, health of vegetation, undesirable plant species, burrowing animals, erosion, settlement, etc.
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Construction reports are to be kept up to date as the landfill development occurs and must be retained for inspection and, upon request, submitted to the Director.

### 10.3 DESIGN, OPERATIONS AND CLOSURE PLAN

The landfill owner shall prepare and maintain a current DOCP. The plan shall be reviewed and updated as needed at least once every five years. The DOCP shall demonstrate that the facility will be planned, designed, constructed, operated, monitored, and closed in compliance with the Criteria. The facilities specified in the DOCP shall be developed, operated, and closed in accordance with the plan and under the oversight of a Qualified Professional who must ensure that the required works are fully and properly executed.

The DOCP shall include the following:

1. **Topography** – a map of the landfill site and its surrounding region within 1 km of the landfill footprint showing elevation contours, natural ground slopes, drainage patterns, and other topographical features.
2. A **Physical Summary** that describes the physical setting, including geology, hydrogeology, hydrology and climatic conditions (from the Hydrogeology and Hydrology Characterization Report).
3. A **Geotechnical and Seismic Assessment** of the landfill site that includes:
  - Bearing capacity, differential settlement, slope stability during construction, operation, and post-closure.
  - Seismic and fault activity risk assessment.
  - Any effects on the landfill base liner and leachate collection system.
  - Conclusions and recommendations regarding the suitability of the landfill site.
4. A **Groundwater and Surface Water Impact Assessment** that includes:
  - Groundwater and surface water impact assessment at and beyond the landfill site boundary, or within 150 m of the landfill footprint, whichever is closer, including to existing and potential future uses of groundwater and surface water within 1 km of the landfill footprint.

- Contaminant concentrations, mass loadings, assimilative capacity and cumulative impacts.
5. A **Site Plan** that for at least the area within 1km of the landfill footprint includes:
    - The landfill property, landfill site boundary, landfill footprint, and buffer zone.
    - All applicable features in the siting criteria and corresponding distances from the landfill footprint.
    - Legal property boundaries, right-of-way and other easements.
    - Topographic contours (1.0 or 0.5 m).
    - UTM Grid (100 -m spacing), north arrow and scale.
    - All existing structures and infrastructure.
    - Tree line areas.
  6. A **Site Layout Plan** that includes:
    - The landfill site boundary, landfill footprint, and buffer zone.
    - Current and final landfill contours, waste thickness and design volume.
    - Landfill facilities including site entrance, fencing, roads, gatehouse, weighscale, waste and recyclable drop off and recycling facilities, leachate management works, surface water management works, landfill gas management works, etc.
  7. **Landfill Design** that demonstrates the landfill will satisfy all sections of the Criteria, along with necessary plans, specifications, drawings, elevations, sections, etc.
  8. A **Filling Plan** showing planned development of individual phases and cover borrow areas in a sequence that provides for the practical development of the landfill. Section 10.3.1 provides detailed information on the requirements of the Filling Plan.
  9. A **Progressive Closure Plan** that documents how progressive closure will be implemented. Details of the requirements for the Progressive Closure Plan are:
    - Phasing Plan showing areas to be progressively closed.
    - Plan area of each progressive closure.
    - Schedule for each progressive closure.
    - Proposed cover system profile, defining materials and material properties for each cover system layer. Specifications for the revegetation strategy should also be included.
    - Stability analysis demonstrating cover system will be stable under design storm conditions.
    - Analysis of landfill gas production and the need for venting of LFG from beneath the cover system.
    - A materials management plan indicating the quantity of each material required for closure, where it will be sourced, and where it will be stored on-site during closure construction.
  10. A **Lifespan Analysis** table that projects the annual waste tonnage to be received, reused, recycled, burned, and landfilled and the annual air space consumed. The

- calculation shall account for air space consumed by waste, cover, road material, settlement, and environmental control works including landfill base liner, leachate and landfill gas collection works, and final cover.
11. A **Contaminating Lifespan Assessment** of the site for key contaminants. The assessment shall demonstrate that the service life and Contaminating Lifespan (Section 5.2) will be satisfied for the facilities particularly those identified in the design criteria.
  12. A **Surface Water Management Plan**. See Section 10.3.2.
  13. A **Leachate Management Plan**. See Section 10.3.3.
  14. A **LFG Management Plan** that demonstrates the LFG management facilities will satisfy the criteria. If required under the Landfill Gas Management Regulation, a Landfill Gas Management Facilities Design Plan can be submitted as a part of the DOCP to satisfy this requirement.
  15. An **Environmental Monitoring Plan**. See Section 9.
  16. A **Facility Operations Plan** that demonstrates how the facilities will be operated in compliance with the operation criteria. The design of the nuisance control measures is to be included in the plan.
  17. A **Closure Plan**. See Section 10.3.4.
  18. A **Fire Safety Plan** that:
    - Is submitted to the Fire authority that would respond to the fire.
    - Describes how fire risks will be minimized.
    - Includes an emergency response plan to quickly extinguish a fire if one develops.
    - Identifies a suitable water supply, firefighting and heavy equipment resources.
  19. An **Emergency Response Plan** that shall document strategies for dealing with emergencies at the site including HAZ-MAT incidents, spills, power outages, and extreme climate events. The landfill site shall also meet the requirements of Work Safe BC.
  20. A **Financial Security Plan**. See Section 8.
  21. A **Contingency Plan** that includes:
    - Possible failure and non-compliance scenarios of the leachate, surface water, and landfill gas management facilities.
    - Practical and implementable contingency measures to address any failure or non-compliance with the performance criteria.
  22. A **Land Survey** is required to be prepared for all landfill sites and included in DOCP. The land survey is required to identify and establish the location of the landfill site boundary and the landfill footprint. The limits of the landfill footprint and landfill site boundary are to be established and maintained in the field.
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### **10.3.1 Filling plan**

A Filling Plan must include volumes associated with each phase and must be designed to take into account the following:

- Generation and collection of leachate.
- Control of storm water.
- Control of litter during the various seasonal conditions.
- Interim slope stability and safety.
- Vehicle access to the active waste disposal area.
- Progressive closure of the landfill footprint.
- Minimization of nuisance impacts such as dust, nuisance weeds, etc.

A Filling Plan shall describe how the active phase of a landfill will be filled on a lift by lift basis. The filling plan shall identify the development of cells, strips and lifts and provide full details on cell geometry and cell size. It shall contain requirements and plans for cover, including daily cover, intermediate and final cover. Plans for any proposed stripping and reuse of cover layers and road materials shall be fully described. The target compaction density, waste to cover ratio, and air space utilization factor should be provided. The Filling Plan shall be illustrated on a series of engineered drawings that provide for the progressive closure of the landfill footprint.

### **10.3.2 Surface Water Management Plan**

A Surface Water Management Plan must be prepared for the landfill site and shall demonstrate how it will satisfy performance criteria (Section 4). The potential for surface water impairment and resulting impacts must be addressed. The Plan must also demonstrate a full understanding of the local and regional watershed including identification of all relevant natural surface water bodies and drainage features.

The Surface Water Management Plan is to:

- Preserve the natural hydrologic cycle for the landfill site.
- Document how surface water will be managed on site, including both run-on and run-off.
- Promote diversion of clean water to minimize leachate production and groundwater recharge.
- Protect the surface water quality in the off-site surface water bodies receiving drainage from the landfill site.

- Provide a design for surface water control works that will ensure drainage coming onto and leaving the landfill site does not result in interruptions to the site operations.
- Provide a design that will maintain run-off from the site sediment free and at rates that are consistent with pre-development flows.
- Identify the surface water management works required for the control of erosion, sediment transport, flood risk, water quantity and water quality.
- Provide the meteorological data applicable to the site, results of the hydrologic modeling stipulated in Section 5.7 and the detail design of ditches, down-chutes, settlement/retention ponds, culverts, and other surface water control infrastructure.

The Surface Water Management Plan must address the management of surface water throughout the operating and post-closure period of the landfill. The Surface Water Management Plan is to be prepared in a manner that is consistent with the water management requirements and strategies utilized in developing the Leachate Management Plan and the Groundwater and Surface Water Impact Assessment.

### **10.3.3 Leachate Management Plan**

An engineered liner system, leachate collection, and Leachate Management Plan are required for all new and expanding landfills and new active landfill phases at existing landfills.

A Leachate Management Plan shall:

- Present the most appropriate method of leachate collection, storage, treatment, and discharge on a site-specific basis that meets the requirements of the landfill design that is protective of groundwater, surface water and the surrounding environment.
- Demonstrate the performance criteria (Section 4) will be satisfied.
- Perform the assessment of alternatives for off-site or on-site leachate treatment and identify the preferred treatment method.
- Demonstrate that the preferred alternative is practical and implementable and provide an implementation schedule of the preferred alternative.
- Identify required approvals for implementation of the Leachate Management Plan if off-site disposal/treatment is proposed.

The Plan must consider the quantity and quality of leachate to be generated at the landfill site during the operational and post-closure phases of the landfill. The leachate

quantity assessment shall identify the expected leachate quantities that will be generated by the facility on a Phase by Phase basis, both under average and extreme conditions. The leachate quality assessment shall predict the expected concentrations of key leachate parameters throughout the lifespan. At a minimum, the assessment shall consider concentrations of ammonia, BOD, chloride, iron, manganese, and TSS.

At a minimum, the Leachate Management Plan shall address the following:

- Leachate generation quantities (annual, monthly and peak flows).
- Leachate chemistry profiles (actual and expected).
- Landfill liner strategy (including leachate compatibility and lifespan).
- Leachate collection strategy (including protection from clogging).
- Leachate collection system efficiencies.
- Treatment System Selection and Design. The Plan should also include:
  - Identification of Management Alternatives including opportunities for moisture reduction, on-site treatment, off-site treatment, and recirculation.
  - Evaluation of Management Alternatives including required level of treatment, availability of infrastructure, economics, sustainability and environmental risks.
- Sludge Management.
- Treatment system performance monitoring and maintenance.
- Leachate discharge strategy.
- Leachate management contingency plan.

Leachate captured by the leachate collection system shall be treated prior to discharge to the environment. Some form of leachate treatment is mandatory for all landfills. The level of treatment required and method of treatment are site specific and will greatly depend on the strength of the leachate, the nature of the final discharge and the climatic conditions at the landfill site. In general, leachate treatment methods used at landfill sites include the following:

- Leachate recirculation back into the waste at dry sites where the evaporation rate is greater than annual precipitation.
- Leachate pre-treatment if necessary, and directed to a sanitary sewage collection system where a sewage collection system is in reasonably close proximity to the landfill. If discharging to a sanitary sewer, the leachate shall meet the applicable water quality limits established for influent to the waste water treatment plant (WWTP) or sewer discharge bylaws, where such bylaws exist. The WWTP must have sufficient hydraulic and loading capacity to treat the leachate. A treatability study is required to confirm the composition of the leachate will not cause an upset

of the treatment system. Flow equalization and pre-treatment shall be provided as required.

- Leachate treatment on-site using an appropriate treatment methodology. Typically, on-site treatment will require flow equalization, biological treatment, filtering, and on-site polishing. Not all steps are needed for every site. In some cases lined evaporation ponds will sufficiently serve for treating leachate. Biological treatment can be provided in aeration ponds (pre-treatment) or sequencing batch reactors. Filtering and final polishing can be accomplished with a sand filter, an engineered wetland, or a phyto-remediation area. The treated leachate shall meet the following discharge specific standards:
  - If discharging to a groundwater infiltration system, leachate shall meet applicable groundwater quality standards as specified by the Director.
  - If leachate discharge is to a stream or river then the discharge shall meet applicable surface water quality standards as specified by the Director.
  - All leachate discharges to surface waters shall comply with the requirements of the federal *Fisheries Act*.

Information on the requirements for leachate treatment and leachate recirculation for bioreactor landfills is provided in Appendix D.

#### **10.3.4 Closure Plan**

A Closure Plan must document how the facility will be operated and maintained post closure to ensure that all required environmental control systems will continue to function and all performance criteria will be met.

The post-closure operation and maintenance program shall include:

- Maintenance of the final cover including vegetation and the repair of damage due to erosion, leachate breakouts, slope failures, settlement and burrowing animals.
- Where applicable, operation and maintenance of surface water management works, including repairs required due to settlement.
- General site maintenance including maintenance of access roads and fencing.
- Where applicable, operation and maintenance of leachate collection and on-site leachate treatment facility or leachate haulage program.
- Where applicable, operation and maintenance of landfill gas management facilities, including repairs to infrastructure damaged by settlement.
- An environmental monitoring program to be carried out during the Contaminating Life Span.

- Practical and implementable contingency measures to address any failure of the works or non-compliance with the performance criteria. Contingency measures may include the following measures:
  - Extraction and treatment of groundwater downgradient of the landfill site.
  - Establishment of monitored attenuation zones.
  - Repair and/or installation of shallow leachate collection system.
  - Installation of landfill gas collection or barrier systems.

#### **10.4      LANDFILL GAS GENERATION ASSESSMENT**

The Landfill Gas Management Regulation requires municipal solid waste landfills with 100,000 tonnes or more of waste in place or with an annual waste acceptance rate exceeding 10,000 tonnes to undertake an assessment of landfill gas generation and to submit the results to the Ministry. For the detailed requirements, procedure and report format see guidance documents provided under the Landfill Gas Management Regulation.

#### **10.5      LANDFILL GAS MANAGEMENT FACILITIES DESIGN PLAN**

If according to the Landfill Gas Generation Assessment Procedure a regulated landfill site is estimated to generate annually 1000 tonnes or more of methane, the owner or operator of that site is required to complete a LFG management facilities design plan and to install the designed facilities at the landfill site. For timelines and detailed requirements see the Landfill Gas Management Regulation and the Landfill Gas Management Facilities Design Guidelines.

#### **10.6      ANNUAL OPERATIONS AND MONITORING REPORT**

The Annual Report should contain two essential components:

1.      The Annual Environmental Monitoring Report.
2.      The Annual Operations Report.

Both of these reports shall assess the performance of and report on the operational status of the landfill for a specified year period.

The Annual Environmental Monitoring Report must include:

- Results of the environmental monitoring program.
- Data tabulation, comparison to performance criteria, interpretation, trend analysis, graphs, etc.
- Identification of any current or predicted future non-compliance with performance criteria.
- Conclusions, recommendations and proposed changes to the environmental monitoring program.

The Annual Operations Report should include at a minimum:

- Total volume, tonnage, and types of waste discharged into the landfill for the year.
- Types and tonnages of waste that were not directly disposed of into the landfill such as open burned, recycled, composted, etc.
- Leachate quantities collected, treated and discharged.
- Landfill gas quantities collected flared and utilized. If applicable, an annual report should be done in the format required by the Landfill Gas Management Regulation and submitted either separately or as a part of the Annual Report.
- Operational plan for the next 12 months.
- Remaining site life and capacity.
- Closure works completed.
- Any changes from approved reports, plans and specifications.
- Any complaints received and the action taken as a result of a complaint.
- Financial Security Plan update.
- Identification of any non-compliance with the Solid Waste Management Plan, operational certificate or permit, and a proposed action plan and schedule to achieve compliance. The plan should include a monitoring program to measure the performance of the proposed measures in achieving compliance.
- Where applicable, progress report on efforts to resolve previously determined non-compliance conditions.

In addition, landfill owners are encouraged to track and report the following parameters to assess the overall operational efficiency of their landfill:

- Compaction, waste to cover ratio, waste to road ratio and airspace utilization factor.
- Operation and maintenance expenditures.

By tracking these parameters and comparing results to best practices, the landfill owner or a Qualified Professional can identify areas where operations can be made more

efficient, adding to the landfill lifespan, contributing additional revenue, and reducing per-tonne operating costs.

## APPENDIX A

### LANDFILL FILLING PLAN

The following provides guidance for the landfill filling plan:

#### Active Phase Area Size

As landfill gas emissions and leachate production are generally proportional to the active landfill phase area, phased landfill development and progressive closure is encouraged. Based on the incoming annual tonnage, the size of the active phase at a landfill site shall be limited to the following:

<10,000 tonnes/year	1 Ha
10,000 – 20,000 tonnes/year	2 Ha
20,000 – 50,000 tonnes/year	4 Ha
50,000 – 200,000 tonnes/year	6 Ha
200,000 – 500,000 tonnes/year	8 Ha
>500,000 tonnes/year	10 Ha

#### Cell Volume

The volume of MSW placed in individual cells shall be roughly equivalent to 20 operating days of incoming refuse. Maximum recommended cell sizes are as follows:

<10,000 tonnes/year	1,000 m <sup>3</sup>
10,000 – 20,000 tonnes/year	2,000 m <sup>3</sup>
20,000 – 50,000 tonnes/year	4,000 m <sup>3</sup>
50,000 – 100,000 tonnes/year	6,000 m <sup>3</sup>
100,000 – 200,000 tonnes/year	15,000 m <sup>3</sup>
200,000 – 500,000 tonnes/year	20,000 m <sup>3</sup>
>500,000 tonnes/year	40,000 m <sup>3</sup>

#### First Lift

The first lift of waste is to be placed on top of the leachate collection system in a 1.5- to 2.0-m lift. The first lift is to consist of MSW containing a minimal amount of fines or soil

in order to provide a relatively high permeability waste layer directly over the leachate collection system. The first lift of waste is to be free of large pieces of wood, metal, or other debris that could cause damage of the leachate collection system or liner components if placed directly on the prepared base. No cover soil is to be placed within the first 1.5- to 2.0-m lift of waste. Following placement of the first lift of waste in the new cell, the waste is to be covered with a 150-mm layer of daily cover soil. Waste compaction equipment shall not operate on the first lift of waste.

### **Lift Height**

The height of individual lifts dictates the size of the active face and operational cover requirements. Small landfills operate more efficiently on small lifts (e.g., 1.5 m) while large tonnage landfills operate most efficiently on lifts as high as 5.0 m. The following lift height guidance is provided to achieve efficient landfill operations:

<10,000 tonnes/year	1.5 m
10,000 – 20,000 tonnes/year	2.0 m
20,000 – 50,000 tonnes/year	2.5 m
50,000 – 100,000 tonnes/year	3.0 m
100,000 – 200,000 tonnes/year	4.0 m
200,000 – 500,000 tonnes/year	4.5 m
>500,000 tonnes/year	5.0 m

### **Active Face Area**

The goal of efficient landfill operations is to minimize the active face while providing sufficient area to unload incoming loads safely and to efficiently spread refuse on the active face as it comes in. Excessively large active face dimensions generally result in problems with litter, vectors, and odours. They also consume more operational cover than necessary. The following maximum active face area dimensions are recommended to achieve efficient landfill operations:

	<i>Lift Height m</i>	<i>Slope Distance m</i>	<i>Face Width m</i>	<i>Area m<sup>2</sup></i>
<10,000 tonnes/year	1.5	9.1	10	91
10,000 – 20,000 tonnes/year	2	12.2	12	146
20,000 – 50,000 tonnes/year	2.5	15.2	16	243
50,000 – 100,000 tonnes/year	3	18.2	20	365
100,000 – 200,000 tonnes/year	4	24.3	24	584
200,000 – 500,000 tonnes/year	4.5	27.4	25	684
>500,000 tonnes/year	5	30.4	40	1,217

### **Compaction Density**

Compaction of solid waste is an effective way to maximize the use of available capacity. Waste should be placed at the base of the active disposal face and should be pushed up the disposal face to maximize compacted density. Based on current best practice the following ranges of compaction densities are recommended as achievable goals:

<10,000 tonnes/year	0.65 tonnes/m <sup>3</sup>
10,000 – 50,000 tonnes/year	0.75 tonnes/m <sup>3</sup>
50,000 – 200,000 tonnes/year	0.80 tonnes/m <sup>3</sup>
200,000 – 500,000 tonnes/year	0.85 tonnes/m <sup>3</sup>
>500,000 tonnes/year	0.95 tonnes/m <sup>3</sup>

## APPENDIX B

### CONTAMINATED SOIL RELOCATION

The following legislation and regulations include provisions which address the relocation and deposition of contaminated soil:

1. The *Environmental Management Act* (EMA)
2. The Contaminated Sites Regulation (CSR)
3. The Hazardous Waste Regulation (HWR)

Contaminated soil may be deposited at a landfill site under the following conditions:

- A. If the authorization (e.g. SWMP and associated OC, or permit) expressly allows the deposit of contaminated soil, contaminated soil that is not hazardous waste can be deposited at a landfill without a Contaminated Soil Relocation Agreement pursuant to Section 55.5 of the *Environmental Management Act* (EMA). The authorization holder must comply with the authorization including ensuring that the concentration of any substance in the contaminated soil is not greater than or equal to the soil standards expressly allowed in the authorization (permit, SWMP, OC).
- B. If the authorization (e.g. SWMP and associated OC, or permit) does not expressly allow the deposit of contaminated soil and the deposit of contaminated soil is not contrary to the authorization, contaminated soil that is not a hazardous waste can be deposited at a landfill without a Contaminated Soil Relocation Agreement pursuant to section 42 of the CSR. The landfill owner must file a written statement with a director indicating the intended future use of the site and ensure the concentration of any substance in the contaminated soil is not greater than or equal to the soil standards for the intended future use.

If condition A or B is not satisfied, contaminated soil that is not a hazardous waste can be deposited at a landfill in accordance with a Contaminated Soil Relocation Agreement pursuant to section 55 of EMA and Part 8 of the CSR.

- C. If contaminated soil is hazardous waste “hydrocarbon contaminated soil”, it may be approved for treatment, storage or disposal at/in a landfill facility pursuant to section 41.1 of the HWR including the requirements specified by the Director.

Deposit of contaminated soil in the landfill may be approved for mono-filling, co-disposal with other wastes, or use as daily or intermediate cover. Contaminated soil must not be used as final cover unless the concentration of any substance in the contaminated soil is not greater than or equal to the CSR soil standards for the intended future end use specified in the closure plan.

Additional information on relocation of contaminated soil may be found at:  
<http://www.env.gov.bc.ca/epd/remediation/soil-relocation/index.htm>

## APPENDIX C

### OPEN BURNING

As stated in Section 6.6 of the Criteria, open burning of wastes at the landfill site is generally prohibited. However, open burning of clean wood may be approved in the SWMP, OC or permit if it can be demonstrated that there is no viable alternative such as reuse, recycling, energy recovery, or composting. A technical assessment report satisfactory to the director must be submitted and the open burning must be approved in the SWMP, OC or permit. Approval must also be obtained from any other applicable fire protection authorities.

If open burning of clean wood is approved in the SWMP, OC or permit, this Appendix provides some general guidelines to be considered.

#### Open Burning Guidelines:

- Relevant requirements of the Open Burning Smoke Control Regulation are applicable. Notification of the regional MOE office is required, at least 24 hours prior to the open burn event. Additional authorizations for open burning may be required from other government agencies. The open burn process shall satisfy all fire safety and general safety precautions imposed by other agencies.
- The maximum duration of each open burn event shall be limited to the period of dawn to dusk of a single day, after which time the fire shall be extinguished. The wood residue to be burned shall be stacked in piles of a size that may be consumed by the fire in the dawn to dusk time frame.
- Open burning shall not be initiated unless the ventilation index is forecasted as "good" for the day of the planned open burn. The Venting Index may be obtained from the MOE's information line at 1-888-281-2992 or on the Internet at: <http://www.env.gov.bc.ca/epd/epdpa/venting/venting.html>.
- Only clean wood shall be burned. Clean wood means solely wood and:
  - does not include composite wood products including plywood, particle board, fibreboard, hardboard, oriented strandboard, laminated lumber, laminated wood, veneer, laminate flooring, or engineered wood products; and,
  - must not be contaminated with, or have been treated or coated with, antiseptant, preservative, fire retardant, glue, adhesive, laminate, bonding agents, resin, paint, stain, varnish or a substance harmful to humans, animals, plants or the environment.

- The clean wood to be burned shall be segregated from other waste and sorted to ensure that there are no unacceptable materials in the burn pile(s). Unacceptable materials are any materials other than clean wood.
- The clean wood shall be piled in a manner that will promote rapid and hot combustion.
- The operator shall ensure that the open burn is supervised throughout the duration of the burn. Suitable devices shall be available for extinguishing fires to prevent them from spreading to surrounding areas and to extinguish the fire at dusk of the burn day. A fireguard shall be cleared and maintained free of combustible materials.
- The fire shall be started using an accelerant applied about the perimeter of the burn to encourage rapid ignition and reduce smoke generation at the onset of burning. The operator shall promote efficient combustion in the pile by turning it over as the fire diminishes and the pile starts to smoulder. An excavator with a thumb is recommended for active management of the burn pile.
- If smoke is excessive, or for any other reason, the Director may order the operator to immediately extinguish the burn.
- Additional requirements may be imposed by the Director based on site specific circumstances and/or on the performance of open burn events. The Director may rescind the authorization if warranted by the circumstances.

The operator shall within 30 days of completion of the open burn event submit a report to the Director with the following information:

- Weather conditions, including venting index, prevailing wind direction and estimated wind speed.
- Time of ignition (start of burn period).
- Time of completion (or extinguishment) of burn.
- Quantity of material open burned.
- A representative photo record of the open burn including photos of the pile prior to ignition and photos of the burn event at a frequency of at least one photo per hour till completion of the burn.
- Any complaints received and how they were addressed.

The Fire Safety Plan shall provide the site specific conditions and controls for the burning of clean wood if approved.

## APPENDIX D

### BIOREACTOR LANDFILLS

Bioreactor type landfills have been in practice for over three decades. The bioreactor landfills accelerate the waste stabilization in comparison to traditional landfill design. Traditional landfills attempt to entomb the waste by minimizing the infiltration of liquid. This reduces leachate generation but extends the contaminating lifespan of the site. Bioreactor landfills provide a controlled and monitored process to accelerate waste stabilization and reduce the contaminating lifespan primarily through the addition of moisture. Previous experience and research indicates that the control of waste moisture content is the single most important factor in enhancing waste decomposition in landfills<sup>1</sup>. The use of bioreactor landfills in dry climates is dependent on the availability of leachate and/or water to facilitate the decomposition process and sustain waste stabilization activity. A bioreactor landfill may provide a longer site life than a traditional designed landfill due to decomposition and consolidation of the waste providing opportunity to increase the waste density and recover landfill air space.

A full understanding of landfill design and operating systems is required for the operation and management of bioreactor landfills due to the high level of interdependence and interactions of landfill system components. Engineered system components for bioreactor landfills include integrated landfill gas and leachate collection systems, leachate storage, leachate disposal (on-site or off-site), and leachate recirculation systems. Double composite liner systems providing both containment and leak detection are preferred when considering leachate recirculation due to the establishment and maintenance of a leachate mound resulting in increased hydraulic pressures on the liner systems.

Primary implications for bioreactor landfills include nuisance impacts (odour), health and safety issues associated with rapid stabilization (i.e., rapid gas production, rapid settlement, depth of leachate on liner, slope failure due to waste saturation) and excessive leachate mounding that could lead to side slope seepage which must be addressed in the design stages<sup>2</sup>. The applicability of bioreactor landfills requires completion of economic evaluations that include a comparison of landfill design and operating criteria and account for and quantify differences in environmental impacts as well as capital and operating/maintenance expenses.

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<sup>1</sup> Pohland, F.G., "Landfill Bioreactors: Fundamentals and Practice", Solid Waste Association of North America Conference Review, 1996, pp 18 - 22.

<sup>2</sup> Mosher, R., McBean, E., Crutcher, A., and MacDonald, N., "Leachate Recirculation for Rapid Stabilization of Landfills: Theory and Practice", Solid Waste Association of North America Conference Review, 1997, pp 33 - 26.

Leachate recirculation can reduce leachate strength for certain parameters such as organic loading but can increase the levels of certain contaminants such as metals, chloride, and sulphates. Bioreactor landfills require more comprehensive monitoring to evaluate landfill performance. Monitoring requirements for fully engineered bioreactor landfills can include leak detection between liners in a double liner system, groundwater monitoring in the vicinity of the landfill to detect releases, air and gas monitoring for landfill emissions, as well as solids monitoring to determine the level of waste stabilization. Monitoring the leachate head on the liner is important to assess liner performance and the potential for leachate discharge to the environment. Leachate seepage through side slopes should be also monitored as a part of slope stability monitoring and for the potential to negatively impact surface water quality and increase odours.

The key technical components for the design and development of an engineered bioreactor landfill include:

- Geologic/hydrogeologic investigation.
- Determination of leachate generation rates and collection system efficiencies.
- Liner system performance assessment with sustained leachate mound.
- Hydrogeologic impact assessment considering reasonable failure scenarios.
- Geotechnical assessment for soil bearing capacity and slope stability.
- Detailed leachate, water quality, and hydraulic monitoring programs.
- Feasible and implementable contingency measures.