COMPLEX CONTAINMENT DESIGN FOR LONG-TERM ENCAPSULATION OF RADIOACTIVE WASTE

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ABSTRACT

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic low-level radioactive waste in the Municipalities of Port Hope and Clarington. The Port Granby Project includes the construction of a long-term low-level radioactive waste management facility, the transfer of the contaminated material to the new facility from existing storage, construction and operation of a new waste water treatment facility, and monitoring and maintenance of the facility for a period of several hundred years. A key component of the new long-term facility is a highly-engineered containment mound incorporating a composite base liner, a leachate collection system, and a multi-layer final cover system. Issues of interest include the details of the design, the evolution of the design, as well as the field quality assurance measures that will be specified to ensure that the design is correctly implemented.

1. INTRODUCTION

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic low-level radioactive waste (LLRW) in the Municipalities of Port Hope and Clarington. The PHAI projects, Port Hope and Port Granby, are to clean up approximately 1.2 and 0.43 million m^3 of waste in the Municipalities of Port Hope and Clarington, respectively.

The LLRW stored in Clarington consist of waste by-products from uranium processing operations undertaken in Port Hope over the period from 1955 to 1988. The LLRW is currently located at the Port Granby Waste Management Facility (PGWMF) situated on the shore of Lake Ontario at the southeastern boundary of the Municipality of Clarington.

The materials stored at the PGWMF consist of the LLRW, and associated wastes. The materials stored at the PGWMF do not pose an immediate unacceptable risk to human health and the environment. However, the ongoing maintenance burden at the PGWMF, its close proximity to Lake Ontario, the presence of steep grades, and the soft, paste-like nature of the wastes could lead to future impacts on Lake Ontario. The contaminants of greatest concern associated with the LLRW at Port Granby have been identified as antimony, arsenic, cobalt, copper, fluoride, lead, nickel, Ra-226, Th-230, Th-232 and uranium.

An Environemental Assessment (EA) to select the best solution for the long-term management of the materials at the PGWMF began in 2002. The outcome of the EA was development of a plan to relocate the waste to a new, nearby site located approximately 700 m north of Lake Ontario. The plan includes the construction of a long-term low-level radioactive waste management facility (LTWMF) near the existing PGWMF, the transfer of the contaminated material to the new facility from the PGWMF, construction and operation of a new waste water treatment facility, and monitoring and maintenance of the facility for a period of several hundred years. The general layout of the LTWMF is shown in Figure 1.

A key element of the new LTWMF is a highly-engineered containment mound (CM) incorporating a composite base liner, a leachate collection system, and a multi-layer final cover system. The design and construction of the containment mound is the subject of this paper.

2. CONTAINMENT MOUND DESIGN BASIS

The overall design objective for the LTWMF is to manage the wastes in an environmentally safe, socially acceptable and appropriately controlled containment system for the long term. Key criteria for selecting the location of the LTWMF were:

- Close proximity to the existing PGWMF to minimize waste haul distance and to avoid use of municipal roads for waste transport;
- Adequate set-back from the Lake Ontario shoreline to eliminate the possibility of shoreline/bluff erosion encroaching on the facility over its design life; and,
- Locating the CM over a relatively low permeability glacial till (termed the ‘Upper Till Unit’) deposit, which will serve as a natural diffusion barrier and adsorption media which can contribute towards minimizing impacts in the unexpected event that the base liner system deteriorates.

Based on these general requirements the following technical criteria were determined to be relevant to the design the containment mound:

- The CM shall be designed to accommodate all LLRW and associated waste at the PGWMF. Furthermore, the CM shall be designed to allow closure of the mound progressively for a range of final waste volumes, depending on the final volumes of waste generated through the remediation activities at the existing PGWMF;
- The design life for the LTWMF shall be approximately 500 years following the Construction and Development Phase;
- The design shall be aesthetically pleasing and compatible with the local area and topography.

3. CONTAINMENT MOUND DESIGN DESCRIPTION AND EVOLUTION

3.1 Overall design and general configuration

The preliminary design for the LTWMF and CM was developed and evaluated during the EA and presented in *Design and Operations Port Granby Project* [1.] The EA was a comprehensive undertaking the approval of which allowed the project to proceed to the detailed design and licensing stage. The detailed design of the CM was developed considering that if the requirements and criteria stated in the EA documents are implemented, the CM’s performance requirements will be met. Specific CM performance requirements and related evaluations are presented in the the *Screening Report, The Port Granby Long-Term Low Level Radioactive*

Waste Management Project [2.]. Performance requirements identified in the EA included Ontario Ministry of the Environment air and water quality standards, among others.

The CM is sized for a volume capacity of 518,500 m^3 and will consist of two adjoining and contiguous cells of equal size. The cells will be constructed and filled over a 6 year construction period.

Following commencement of detailed design work the PHAI MO confirmed that the containment mound shall have a more naturalized form than was presented in the preliminary design. The above-grade portion of the mound was reshaped from a rectangular pyramid to a more natural form as shown in Figure 1.

Each cell will incorporate environmental protection measures including a composite liner system, leachate collection system and a multi-layer final cover system. The base liner system is the barrier that will limit the release of contaminants to the subsurface and groundwater. The leachate collection system serves to control the accumulation and mounding of leachate and hydraulic head on the base liner system. The final cover will reduce infiltration into the waste and hence leachate generation, and limit the release of contaminants to the atmosphere. The final cover also eliminates exposure to direct contact with the waste and provides gamma shielding. The individual components used in the liner and cover designs are similar to materials and methods used in modern landfill site construction.

3.2 Base liner system

The base liner is a composite liner system consisting of an 80 mil (2 mm) thick High Density Polyethylene (HDPE) geomembrane overlying a 750 mm thick compacted clay liner (CCL) having a design hydraulic conductivity of not more than 1×10^{-7} cm/s. Typical cross-sections through the base liner system are shown in Figures 2 and 3. This system is similar in concept to the composite base liner system (60 mil HDPE geomembrane with 750 mm thick clay liner) of the Generic Design Option I in Ontario Regulation 232/98, the Ontario Landfill Standards. Although Ontario Regulation 232/98 is intended to regulate municipal waste landfill design in Ontario, the regulation is recognized as providing useful guidance for the design and construction of waste containment systems in general.

The HDPE geomembrane will perform as the primary hydraulic and diffusion barrier over the design life of the CM and will meet the requirements of the Geosynthetics Research Institute (GRI) Standard GM13 as well as Ontario Regulation 232/98 Schedule 3. The geomembrane will typically be smooth at the bottom of the liner system and shall be double-sided textured on the 25% (4:1) slopes.

The CCL will be constructed from a low-activity clayey soil and will have a maximum hydraulic conductivity of 1.0×10^{-7} cm/s as determined through testing of samples of the as-constructed liner using ASTM D5084-03. The mineralogy and exchangeable cation distribution of the clay liner material will be tested prior to construction to confirm compatibility with the expected range of leachate quality, such that the hydraulic conductivity of the clay liner will not increase with time in the event of direct contact with leachate (i.e., in the event of failure of the geomembrane liner).

Laboratory hydraulic testing on samples of the proposed clay liner material will be conducted to confirm that the design hydraulic conductivity can be achieved. Furthermore, a trial liner will be constructed before full scale construction of the CCL to confirm that the design hydraulic conductivity can be achieved in the field using the equipment proposed. Construction specifications and installation procedures of the compacted clay liner will meet the requirements of Ontario Regulation 232/98 Schedule 4.

Electrical conductivity sensor nests will be installed within the clay liner at eight locations to monitor the performance of the base liner system. Each nest will have a sensor (four stainless steel electrodes) at 0.1 m intervals from 0.1 m to 0.5 m depth below the liner surface. The sensor wire leads will be bundled and routed to the surface of the clay liner at the nest location and then be extended to monitoring stations along the perimeter of the mound.

3.3 Leachate collection system

A leachate collection system that facilitates leachate/liquid monitoring, collection and removal will be constructed on top of the composite base liner system. The leachate collection system will consist of drainage layers with a network of coarse sand and gravel drains (stone drains) leading to a sump area in each cell to facilitate the monitoring, collection and removal of leachate as shown in Figure 4.

3.3.1 Drainage layers

The drainage layers will consist of a geocomposite drainage layer embedded between two 0.3 m thick granular drainage layers consisting of concrete sand. The lower granular layer has been added during the detailed design stage to act as a cushion layer for the geomembrane to prevent the ribs of the geocomposite pressing directly on the geomembrane. The geocomposite drainage layer of the leachate collection system will have an initial minimum transmissivity of $1x10^{-3}$ m^2/s. The geocomposite will be an HDPE geonet with a polyester or polypropylene non-woven geotextile bonded to both sides of the geonet.

3.3.2 Stone drains

The stone drains are drainage trenches 5 m wide by 0.8 m thick consisting of 6.2 mm coarse sand and gravel (chip stone). The stone drains slope at 2.5% from the high side (east) at the base of the mound to the low side (west) and then toward the leachate collection sump of each cell as shown in Figure 4.

Within each cell at the base of the mound, apart from sloping 2.5% from the eastern side to the western side, the leachate collection drainage layers also slope at 2% or 3% toward the central stone drain. The layout of the drains has been optimized during detailed design by increasing the slope in the north half of Cell 2 (north cell) to 2%. This change improves the flow of leachate in the drainage layers by increasing the slope and reducing the length of the drainage pathway between stone drains.

Along the perimeter of the mound, the leachate collection system and the liner system will be on 25% (4 horizontal to 1 vertical) side slopes.

3.3.3 Divider berm

The preliminary design reflected a temporary divider berm between Cell 1 and Cell 2 comprised of a geomembrane barrier. The berm configuration was optimized during detailed design to provide additional containment to prevent the escape of leachate from Cell 1 into the adjoining area before Cell 2 is developed. Along the divider berm, there will be a toe drain that clearly defines the limit of waste in Cell 1. This sand and gravel toe berm also helps to convey flow to the leachate collection sump via a stone drain. The revised divider berm design also facilitates the connection of the new liner system and leachate collection system in Cell 2 to the existing systems. Connection of all elements of the liner system and the leachate collection system will be on the ‘clean’ side of the divider berm away from the waste.

3.3.4 Leachate collection sump

Within each cell, all stone drains direct leachate towards a leachate collection sump as shown in Figures 5 and 6. The preliminary design of the sumps was optimized during detailed design in order to provide greater redundancy which is deemed appropriate for the required 500 year design life of the mound. The design was optimized as follows:

- Three leachate extraction pipes (one main pipe and two contingency pipes) will be incorporated in each sump rather than two. Provision of different access locations in the sump allows leachate to be collected at different locations in the event the central pipe becomes less efficient for leachate removal. The multiple access locations to the sump also provide a better arrangement for maintenance flushing of the leachate removal system.
- The size of the extraction pipes is increased from 200 mm diameter to 324 mm (12 inch IPS size). These modifications allow multiple access points to the sump as well as more space for sump operation and maintenance respectively.
- The leachate extraction pipes will be embedded in a 0.75 m thick layer of 13.2 mm concrete stone rather than 0.6 m to accommodate the larger pipe diameter.
- The area of the sump with the 0.75 m thick layer of 13.2 mm concrete stone is also enlarged to 43 m by 20 m from 20 m by 20 m, to allow the three leachate extraction pipes to be spaced apart in different locations within the sump.
- A geotextile is added as a separation layer on top of the chip stone layer to provide more protection of the chip stone from disturbance during the operation of the temporary leachate sump and during the filling of the temporary leachate sump with waste.

On the side slope at the location of the central leachate extraction pipe, the 1.45 m thick layer of concrete sand provides thermal protection of the 324 mm leachate extraction pipe.

Each sump has a capacity of not less than 4,000 m^3 which accommodates the potential runoff volume from a 1 in 100 year, 24 hour storm.

3.3.5 Additional sump features during operations

During the operation of the mound, all surface runoff inside the mound will be contained within the mound. To facilitate the removal of the runoff, additional operational measures will be implemented as follows:

- An additional ‘temporary’ sump will be formed by setting back the waste above the permanent leachate collection sump. A temporary pump will be provided inside this area to remove stormwater concurrently with leachate which will be pumped from the permanent sump. The temporary sump will consist of a 0.3 m thick layer of 100 mm stone over an area of 5 m x 6 m. The temporary sump will be segregated from the remainder of the leachate sump by a 0.3 m high berm around the pad which will limit sediment intrusion into this area.
- An erosion control mat will be laid on the surface of the 4:1 slope of the interim cover to reduce surface erosion and entry of sediment in the sump.

3.3.6 Leachate treatment

Collected leachate and stormwater will be pumped to a new leachate treatment facility which will have the capacity to deal with the storm runoff collected during the operation of the mound and leachate generated during the design life of the mound.

3.3.7 Long-term instrumentation

Five vibrating wire piezometers will be installed on top of the geomembrane and within the concrete sand drainage layer to monitor leachate head/pressures and temperature. Wire leads from these piezometers will extend to monitoring stations located along the perimeter of the mound.

3.4 Final cover system

A multi-layer final cover system that incorporates a capillary barrier system will be constructed over the entire containment mound on completion of filling. A typical cross-section through the cover system is shown in Figure 7. The final cover will minimize moisture infiltration into the waste and hence minimize leachate generation. The key layers in the cover system and their main functions are as follows (from the top layer down):

- Topsoil layer 0.15 m thick that is grassed enhances evapo-transpiration, and reduces soil erosion.
- Soil fill 1.2 metres thick (Upper Till excavated from the mound excavation) provides gamma radiation shielding, a barrier against radon migration, additional water retention and a root zone for grass vegetation, as well as freeze-thaw protection and confining pressure for the GCL.
- Non-woven geotextile serves as a filter to minimize fines migrating into the intrusion layer.
- Intrusion barrier 0.5 metre thick of 50 mm to 300 mm sizes coarse gravel and cobbles to prevent burrowing animals and/or plant roots from reaching the underlying layers.
- Non-woven geotextile serves as a filter to minimize fines migrating into the intrusion layer.
- Sand layer consisting 0.3 m thick concrete sand provides lateral drainage and acts as a cushion layer for geomembrane layer beneath it.
- Outlet drains within the sand layer to reduce drainage length along the sand layer and the geocomposite below. The outlet drains will convey collected water to the perimeter of the mound.
- Geocomposite (biplanar geonet with non-woven geotextile filter on both sides) drainage layer to facilitate drainage.
- Composite barrier, consisting of a geomembrane on top of a GCL, which minimizes moisture infiltration into the waste.
- Capillary barrier system, consisting of a capillary drainage layer and a capillary break layer with a network of outlet drains, provides an additional level of protection against moisture infiltration into the waste. As with the outlet drains situated above the composite barrier, the outlet drains will convey water from the capillary drainage layer to the perimeter of the mound.

During the operation of the mound, a temporary perimeter ditch inside the mound will be provided to contain potential leachate impacted storm runoff within the mound. Furthermore, a temporary perimeter berm shall be provided to prevent potential leachate impacted storm runoff inside the mound from escaping.

The geosynthetic clay liner (GCL) in the final cover will have a maximum hydraulic conductivity of $5x10^{-9}$ cm/s. Laboratory permeability testing of the GCL will be performed to assess potential cation exchange involving the replacement of sodium from the bentonite component of the GCL with calcium leached from the overlying Upper Till cover soil.

There will be 20 instrumented monitoring locations within the cover system. At each location, a theta probe moisture sensor and thermal conductivity sensor (Fredlund Thermal Conductivity Sensor) will be installed. The theta probe moisture sensor will be in the capillary layer outlet drain to measure soil moisture contents. The thermal conductivity sensor will be within the Granular "A" capillary drainage layer adjacent to the outlet drains. Effective performance of the capillary barrier system would be identified by steady/low unsaturated moisture content readings from the theta probes and steady/high suction pressure readings from the thermal conductivity sensors.

3.5 Containment mound construction

Site clearing, regrading, and pre-development preparation works for the overall LTWMF will be completed before excavation at the containment mound. In Year 1, the liner system and leachate collection system will be completed for waste placement to commence in Cell 1. The liner and leachate collection system of Cell 2 will be commenced in Year 1 and completed in Year 2 to permit waste placement as early as possible in Year 2. The estimated total volume (excluding site regrading prior to mound excavation) of excavated soil for the mound is 405,000 m^3. Slope and basal stability has been evaluated and no major concerns are anticipated.

Control of stormwater during mound excavation will be managed as in conventional earthworks construction. Groundwater flow is anticipated to be a very small portion of these volumes.

The normal construction season from spring to fall is preferred for construction of the containment mound thus avoiding freezing temperatures and minimizing inclement weather conditions.

3.6 Filling plan

Filling will commence in Cell 1 in Year 1 and continue in both cells in Year 2 to Year 5. The final cover will be completed in Year 6. Throughout the mound's operating period waste quantities will be closely monitored and filling operations adjusted as required.

Access for filling in the mound will be via access ramps along the eastern perimeter of the mound. Waste hauling trucks will travel inside the mound on internal temporary haul roads such that there is at least 1.5 m separation between the truck tires and the geomembrane. All waste trucks leaving the mound will either remain in an 'exclusion zone' of the project site unless decontaminated according to the appropriate protocols per the approved Environmental Management and Protection, Occupational Health and Safety, and Radiation Protection Plans.

3.7 Waste placement

When the cell is ready for waste placement, selected waste shall be placed progressively as a 1.0 m thick protective layer over the granular (concrete sand) drainage layer in the cell. The waste for this initial 1.0 m thick lift will be selected such that it does not contain any objects with any dimension exceeding 0.3 m, sludge, or material that is sludge-like (wet/soft). This initial lift will be spread by a low ground pressure (35 kPa maximum) tracked bulldozer. On the side slopes, the bulldozer will push waste up the slope. This initial 1.0 m protective lift shall progressively cover the entire cell base and side slopes except at the leachate sump. For Cell 1, this initial protective lift shall also extend to the divider berm. At the end of each day, as a minimum, the surface and the advancing face of the initial lift of waste shall be covered with a minimum 0.2 m thick layer of clean soil.

A tracked bulldozer will spread subsequent lifts of waste in 0.5 m thick lifts. Nominal compaction will be applied to the waste with a compactor. To the greatest degree possible, waste will be placed to homogenize leachate generation and to reduce the potential for and the magnitude of differential settlement. No liquid wastes are anticipated to be landfilled.

Objects in the waste with any dimension greater than 0.3 m will be temporarily stockpiled at the excavation site for size reduction which may consist of disassembling, crushing, cutting or other suitable methods to reduce size as well as eliminate any internal void spaces.

3.8 Variability of containment mound capacity

The current design volume capacity of the mound is 518,500 m^3 which reflects a design waste fill volume of 432,000 m^3 and an allowance of 20% (i.e., 86,500 m^3) for daily and interim cover soil. The 432,000 m^3 design waste fill volume includes a contingency factor of 15% on a currently estimated volume of 375,600 m^3 of waste fill to be placed in the mound. The contingency factor is intended to account for a bulking factor as well as additional waste/soil to be stored but not included in the current estimates.

The volume of waste that has been filled, as well as the waste remaining to be excavated will be reviewed on an annual basis to confirm that the CM has sufficient capacity to accommodate all of the waste to be moved. If additional capacity over the 518,500 m^3 design capacity is needed, the final slopes in some or most of the central part of the mound may be increased from 5% to 10%. This design change can provide up to 15% additional volume capacity.

4. CONSTRUCTION QUALITY ASSURANCE OF ENVIRONMENTAL CONTROLS OF CONTAINMENT MOUND

As is appropriate for a project of this nature, detailed and comprehensive quality control and assurance testing will be undertaken for each component of the liner, leachate collection system, and final cover system. In general, the materials that will be used fall into two categories – natural materials (e.g., clay soil, granular) and geosynthetics (geomembranes, geosynthetic clay liners, and geocomposite drainage layers). The construction specifications that have been prepared specify requirements for material properties, how the material is installed in the works, as well as quality testing requirements. An overview of the parameters specified for each component is presented as follows:

A. Natural Materials

- Clay:
  - material properties including particle size, standard proctor density, water content, Atterburg limits;
  - clay/leachate compatibility testing;

    - laboratory and field testing of in situ permeability;
    - construction methods including:
        - construction equipment requirements;
        - trial liner construction prior to full scale construction;
        - placement and compaction requirements including lift thickness, removal of stones, moisture management;
        - protection of constructed CCL.
- Granular products:
    - particle size;
    - permeability;
    - mineralogical composition;
    - durability;
    - construction methods including lift thicknesses, compaction, and placement methods to avoidance of damage to adjacent layers.

B. Geosynthetic Materials

- Geomembranes:
    - material properties including thickness, texture, puncture and tear resistance;
    - environmental properties including stress crack resistance, carbon black content and dispersion, oxidative induction time, UV resistance;
    - construction methods including:
        - material storage, protection, and handling;
        - preparation of subgrade;
        - installation including fusion/extrusion seaming;
        - non-destructive seam testing including vacuum box and air pressure testing;
        - destructive seam testing including field and laboratory seam strength testing;
        - protection of installed geomembrane.
- Geotextiles:
    - material properties including UV resistance, mass per unit area, thickness, tear and mullen burst strength, apparent opening size;
    - construction methods including:
        - material storage, protection, and handling;
        - subgrade preparation;
        - placement and seaming;
        - field and factory seam strength;
        - placement of overlying backfill.
- Geosynthetic clay liners:
    - geotextile properties;
    - bentonite properties including potential for cation exchange;
    - tensile, peel, and internal shear strength;

  - permeability;
  - construction methods including:
    - material storage, protection, and handling;
    - preparation of subgrade;
    - installation including overlap and powdered bentonite application at overlaps;
    - application of confining layer prior to swelling.

- Geocomposite drainage layers:
  - geotextile properties;
  - geonet core properties including thickness, density, melt flow index, carbon black content, and tensile strength;
  - transmissivity;
  - construction methods including:
    - material storage, protection, and handling;
    - subgrade preparation;
    - connection of panels;
    - placement of overlying backfill.

- Geogrids:
  - material properties including tensile strength, grid type, carbon black content, creep behaviour;
  - construction methods including:
    - material storage, protection, and handling;
    - connection of panels;
    - placement of overlying backfill.

5. SUMMARY

The Port Granby Project will implement a safe, local, long-term management solution for 0.43 million cubic metres of historic LLRW and associated wastes currently stored at the PGWMF in the Municipality of Clarington. The outcome of an Environmental Assessment (EA) which commenced in 2002 and which was approved in 2009 was a plan to relocate the waste at the PGWMF to a new, highly engineered facility located approximately 700 m away from Lake Ontario. A key element of the new LTWMF is a highly-engineered Containment Mound (CM) incorporating a composite base liner, a leachate collection system, and a multi-layer final cover system.

A preliminary design for the CM was developed as part of the EA and was advanced to a detailed design and construction documents in 2011. The design evolution included optimization of various components of the base liner, leachate collection system, and final cover systems to improve redundancy and robustness in recognition of the facility’s 500 year design life. The construction specifications incorporate comprehensive quality control and quality assurance testing requirements to ensure that facility is built as per the approved design. The testing addresses materials and methods that will be used in all aspects of CM construction.

REFERENCES

[1.] Golder Associates Limited., "Design Description Volume 2: Design and Operations Plan Port Granby Project, 4502-01340-DD-001", 2009.

[2.] Natural Resources Canada and the Canadian Nuclear Safety Commission., "Screening Report, The Port Granby, Long-Term Low Level Radioactive Waste Management Project", 2009.

A SIZE 8.5" x 11" (215.9mm x 279.4mm)

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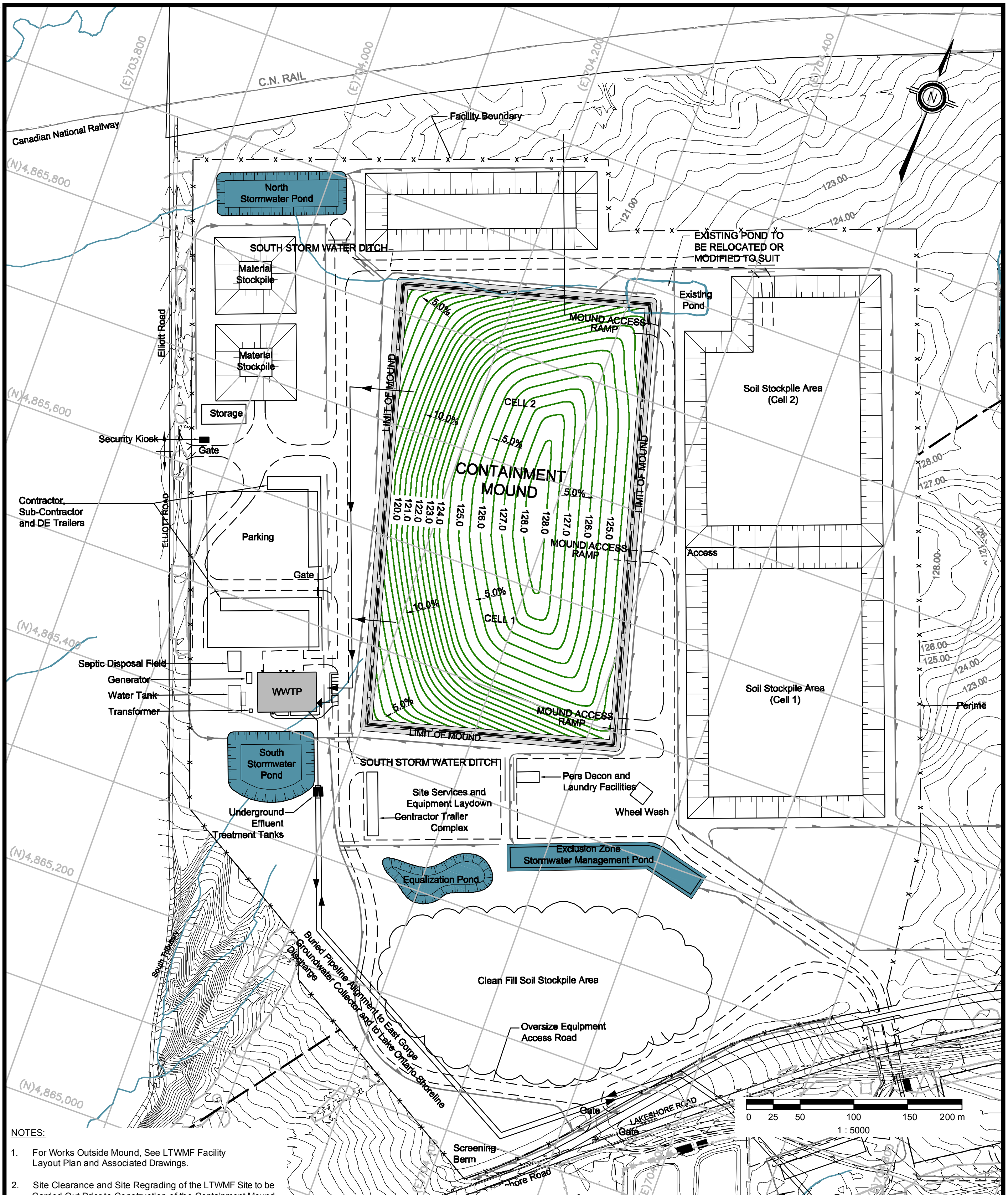

NOTES:

1. For Works Outside Mound, See LTWMF Facility Layout Plan and Associated Drawings.

2. Site Clearance and Site Regrading of the LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

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LAYOUT PLAN

Legend

123.00	Existing Groud Surface Contours (0.5m Interval)
116.0	Proposed Top of Fill Contours and Elevation (0.5 m interval)
	Proposed Limit of Mound
3.0%	Direction of Drainage for Top of Fill Contours
	Proposed Temporary Perimeter Berm - See Mound Perimeter Details Drawing
	Proposed Perimeter Stormwater Drainage Ditch and Flow Direction

PROJECT NUMBER

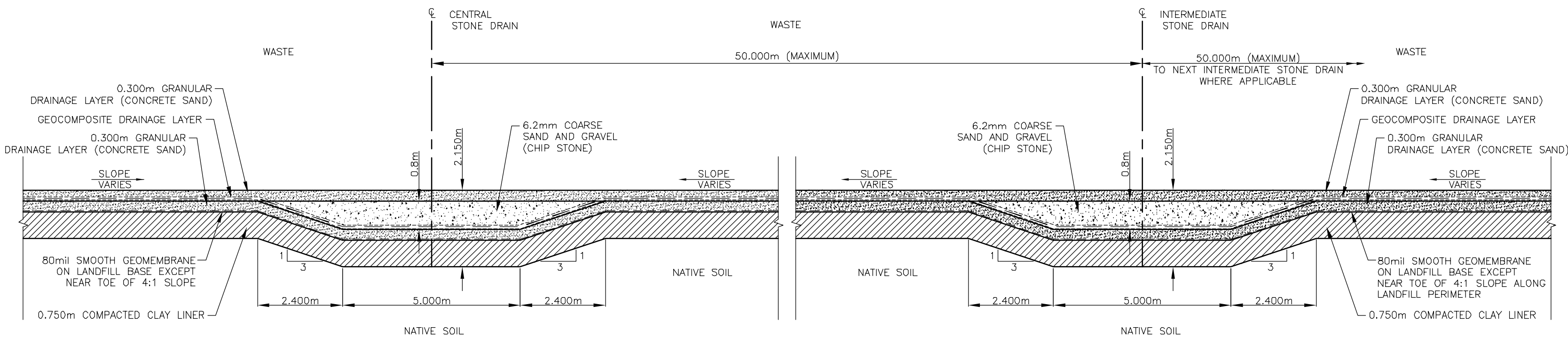
DATE
August, 2011

FIGURE
1

FILE NAME: FIGURE 01.DWG

N:\usr\wangv\PG\FIGURE 01.dwg Layout:FIG 1 Plotted: Aug 05, 2011 @ 4:57pm by WangV

PLOT: 8/5/2011 4:58:40 PMA SIZE 8.5" x 11" (215.9mm x 279.4mm)



TYPICAL SECTION OF LINER AND LEACHATE COLLECTION SYSTEM ON BASE OF LANDFILL

scale = 1:200

NOTE:
FOR LAYOUT AND GRADIENT, SEE LEACHATE COLLECTION SYSTEM PLAN.

NOTES:

1. For Works Outside Mound, See LTWMF Facility Layout Plan and Associated Drawings.
2. Site Clearance and Site Regrading of the LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.
3. See Leachate Collection System Plan for Location of Divider Berm and Typical Section.

0 1 2 4 6 8 m
1 : 200

Legend

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LINER AND LEACHATE COLLECTION SYSTEM SECTIONS

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PROJECT NUMBER	DATE	FIGURE
	August, 2011	**2**

FILE NAME: FIGURE 02 & 03.DWG

N:\usr\wangv\PG\FIGURE 02 & 03.dwg Layout:FIG2 Plotted: Aug 05, 2011 @ 4:58pm by WangV

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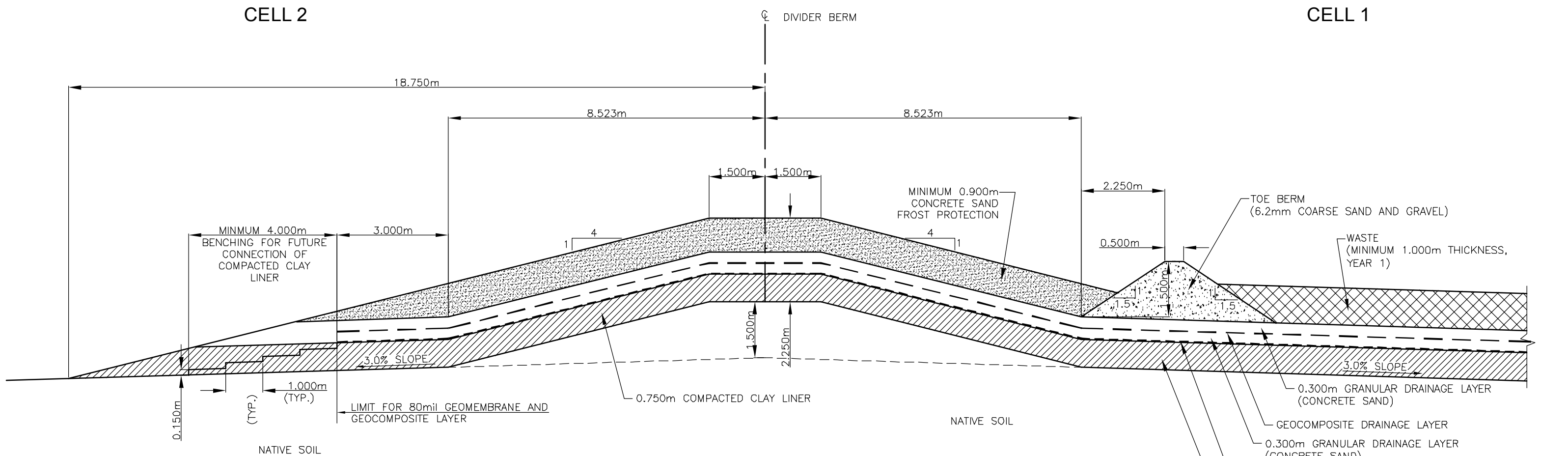

DIVIDER BERM BETWEEN CELLS 1 AND 2

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NOTES:

1. For Works Outside Mound, See LTWMF Facility Layout Plan and Associated Drawings.
2. Site Clearance and Site Regrading of the LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.
3. See Leachate Collection System Plan for Location of Divider Berm and Typical Section.

0 1 2 4 6 8 m
1 : 200

Legend

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LINER AND LEACHATE COLLECTION SYSTEM
DIVIDER BERM

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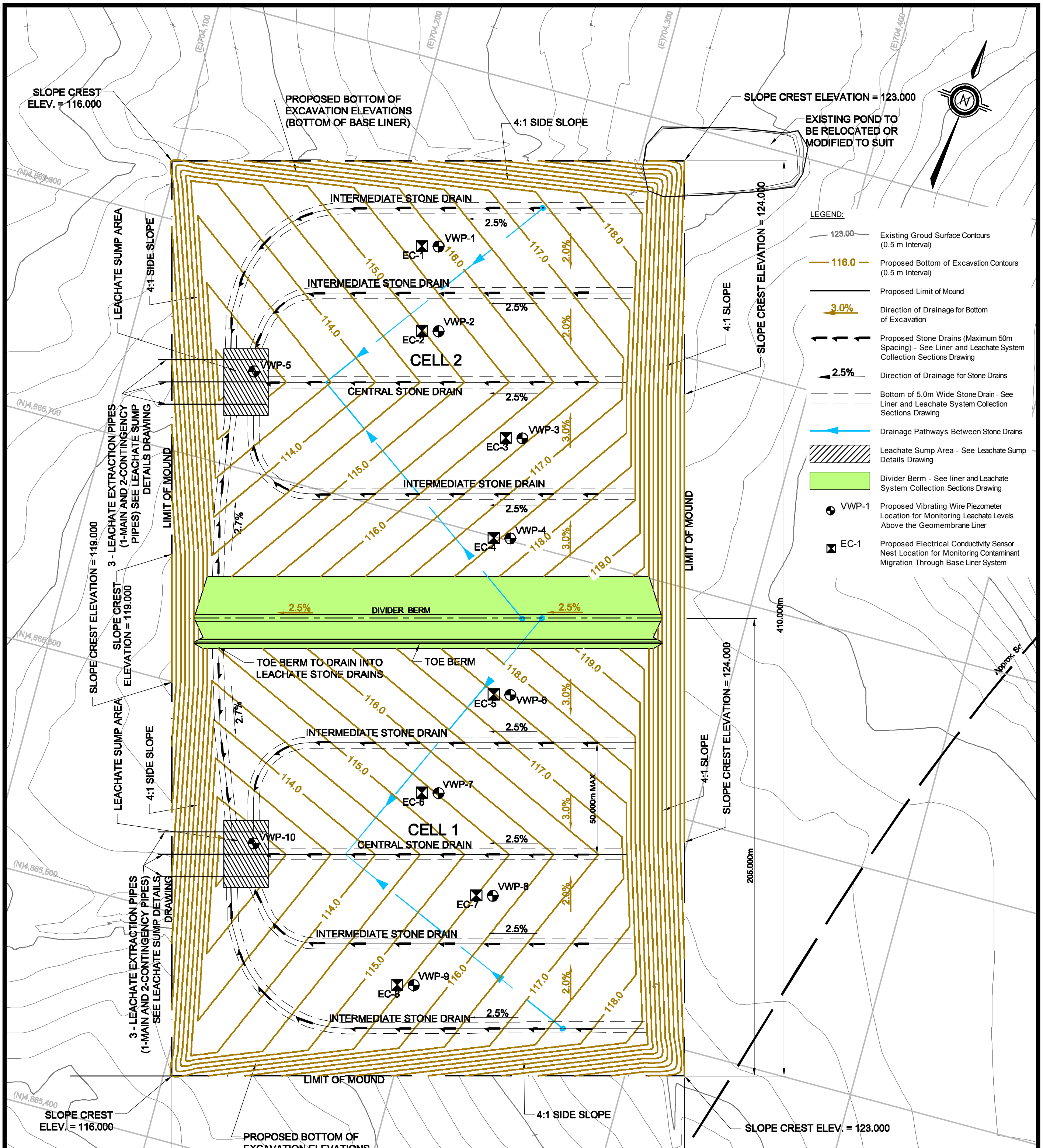
PROJECT NUMBER	DATE	FIGURE
	August, 2011	3

FILE NAME: FIGURE 02 & 03.DWG

N:\usr\wangv\PG\FIGURE 02 & 03.dwg Layout:FIG3 Plotted: Aug 05, 2011 @ 4:57pm by WangV



NOTES:

1. For Works Outside Mound, See LTWMF Facility Layout Plan and Associated Drawings.
2. Site Clearance and Site Regrading of the LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

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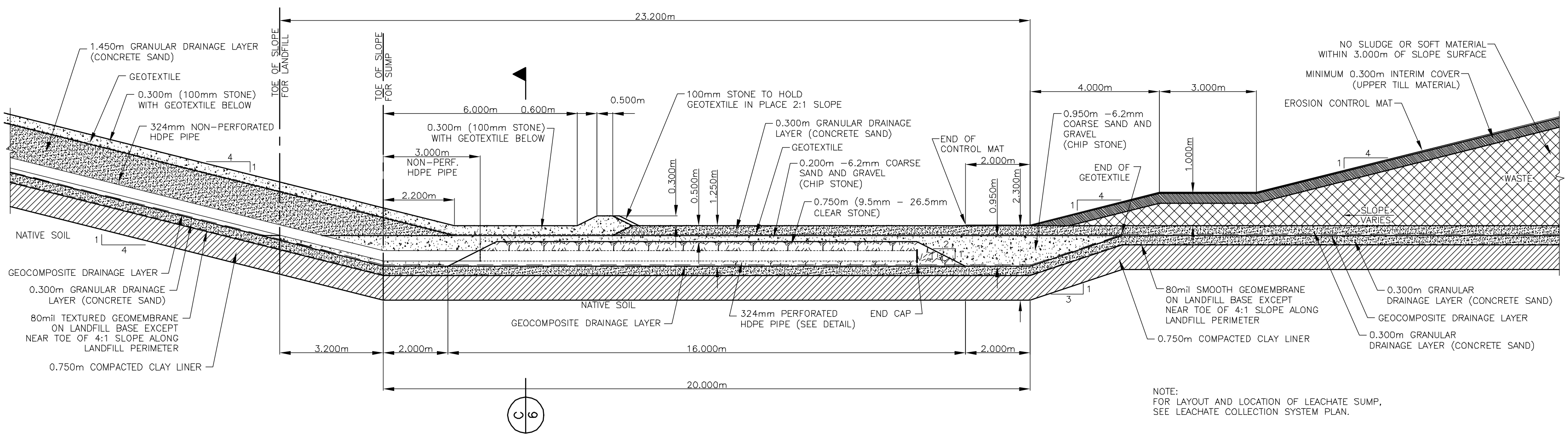
LEACHATE COLLECTION SYSTEM PLAN

Legend

PROJECT NUMBER

DATE
August, 2011

FIGURE
4



LEACHATE SUMP DETAIL

scale = 1:200

Notes:

1. For Works Outside Mound, See LTWMF Facility Layout Plan And Associated Drawings.
2. Site Clearance And Site Regrading Of The LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.
3. See Leachate Collection System Plan For Location of Leachate Sump.

0 1 2 4 6 8 m

1 : 200

Legend

AECOM

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LEACHATE SUMP DETAILS

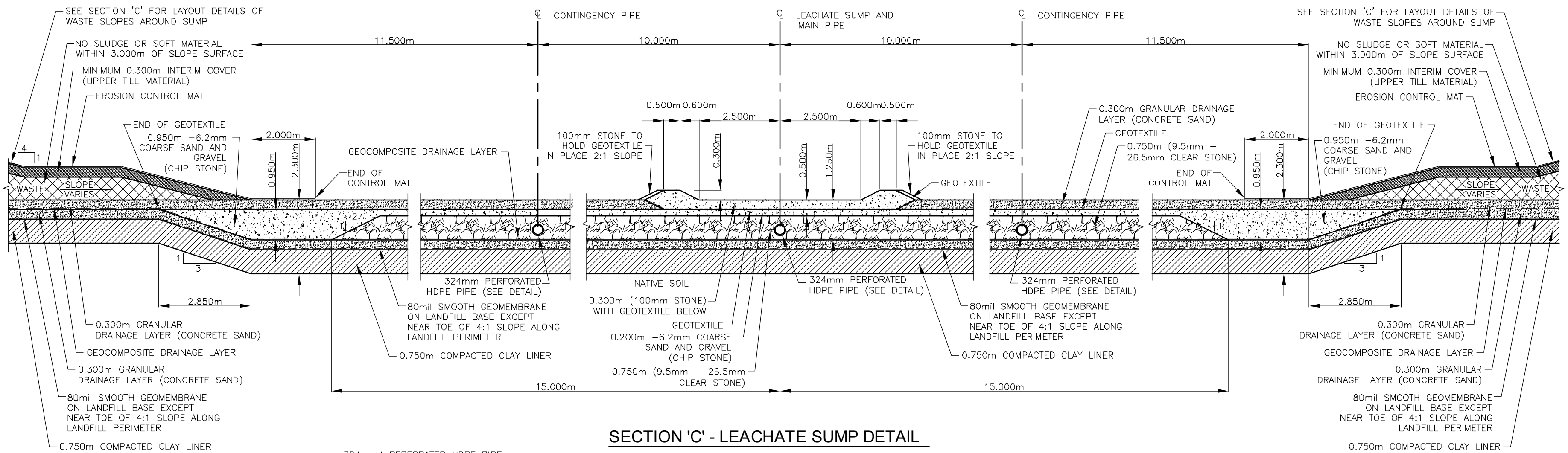
DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

PROJECT NUMBER	DATE	FIGURE
	August, 2011	**5**

PLOT: 8/5/2011 5:01:21 PMA SIZE 8.5" x 11" (215.9mm x 279.4mm)

Notes:

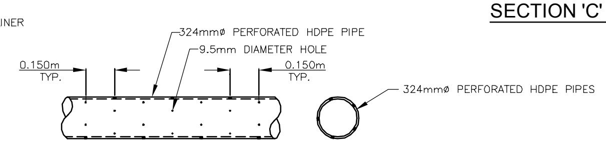
1. For Works Outside Mound, See LTWMF Facility Layout Plan And Associated Drawings.
2. Site Clearance And Site Regrading Of The LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.
3. See Leachate Collection System Plan For Location of Leachate Sump.



SECTION 'C' - LEACHATE SUMP DETAIL

scale = 1:200

NOTE:
FOR LAYOUT AND LOCATION OF LEACHATE SUMP, SEE LEACHATE COLLECTION SYSTEM PLAN.



DETAIL
TYPICAL PERFORATION DETAILS OF PERFORATED HDPE LEACHATE PIPE
SCALE N.T.S.

0 1 2 4 6 8 m
1 : 200

Legend

AECOM

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LEACHATE SUMP DETAILS - SECTION 'C'

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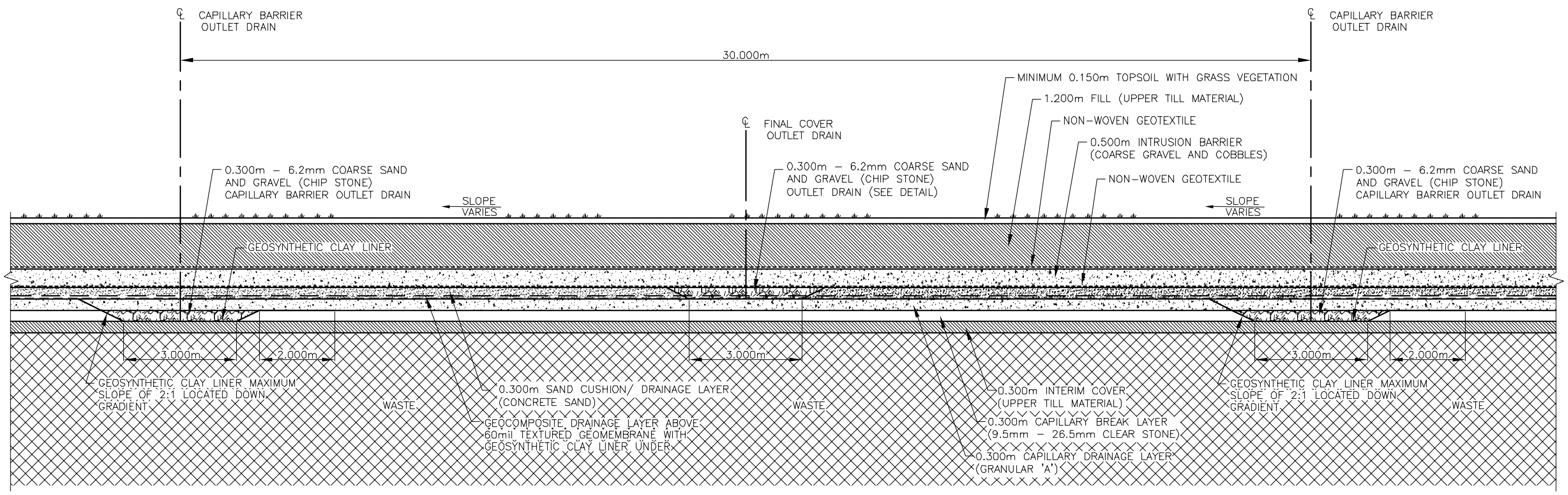
PROJECT NUMBER	DATE	FIGURE
	August, 2011	**6**

FILE NAME: FIGURE 05 & 06.DWG

N:\usr\wangv\PG\FIGURE 05 & 06.dwg Layout:FIG6 Plotted: Aug 05, 2011 @ 5:01pm by WangV

PLOT: 8/5/2011 5:02:43 PMA SIZE 8.5" x 11" (215.9mm x 279.4mm)



TYPICAL SECTION OF FINAL COVER

scale = 1:200

NOTE:
FOR LAYOUT OF OUTLET DRAINS, SEE FINAL COVER PLAN AND CAPILLARY BARRIER OUTLET DRAIN LAYOUT.

0 1 2 4 6 8 m
1 : 200

NOTES:

1. For Works Outside Mound, See LTWMF Facility Layout Plan and Associated Drawings.
2. Site Clearance and Site Regrading of the LTWMF Site to be Carried Out Prior to Construction of the Containment Mound.

Legend

AECOM

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FINAL COVER SYSTEM SECTION

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PROJECT NUMBER	DATE	FIGURE
	August, 2011	**7**

FILE NAME: FIGURE 07.DWG

N:\usr\wangv\PG\FIGURE 07.dwg Layout:FIG 7 Plotted: Aug 05, 2011 @ 5:02pm by WangV