3. THE CONSTRUCTION WORKS AND THEIR IMPLEMENTATION

3.1 Introduction

3.1.1 This Section outlines the mode of construction and the statutory procedures for implementation of new sites and extensions.

3.1.2 Formation of the new sites and extensions options involves three different modes of construction, comprising:

- Artificial Island.
- Land based Filling.
- Coastal Reclamation.

3.1.3 *Table 3.1*, below, shows the method of construction for each proposed site, together with the site-name abbreviations used throughout the remainder of this Report:

Table 3.1: Long-Listed Sites

<table>
<tr><th>Type</th><th colspan="2">Location</th><th>Abbrev.</th><th>Method of Construction</th></tr>
<tr><td rowspan="13">New Sites</td><td>M.1</td><td>Deep Bay Island Landfill</td><td>DBIL</td><td rowspan="12">Artificial Island</td></tr>
<tr><td>M.2</td><td>Sha Chau Island Landfill</td><td>SCIL</td></tr>
<tr><td>M.3</td><td>Lantau Northwest Island Landfill</td><td>LNWIL</td></tr>
<tr><td>M.4</td><td>Soko Islands Landfill</td><td>SIL</td></tr>
<tr><td>M.5</td><td>South Cheung Chau Island Landfill</td><td>SCCIL</td></tr>
<tr><td>M.6</td><td>Lamma Breakwater Island Landfill</td><td>LBIL</td></tr>
<tr><td>M.7</td><td>East Tung Lung Island Landfill</td><td>ETLIL</td></tr>
<tr><td>M.8</td><td>Eastern Waters Island Landfill</td><td>EWIL</td></tr>
<tr><td>M.9</td><td>Tai Long Wan Offshore Island Landfill</td><td>TLWOIL</td></tr>
<tr><td>M.10</td><td>Southeast Offshore Island Landfill</td><td>SEOIL</td></tr>
<tr><td>M.11</td><td>Lamma North Island Landfill</td><td>LNIL</td></tr>
<tr><td>M.12</td><td>Lamma South Island Landfill</td><td>LSIL</td></tr>
<tr><td>L.1</td><td>Pillar Point Valley North Landfill</td><td>PPVNL</td><td rowspan="2">Land based Filling</td></tr>
<tr><td rowspan="2">Extension Sites</td><td>E.1</td><td>NENT Landfill Extension Site</td><td>NLES</td></tr>
<tr><td>E.2&3</td><td>WENT Landfill Extensions Sites</td><td>WLES</td><td>+ Coastal Reclamation</td></tr>
</table>

3.1.4 The SEA for each of the above sites will include an implementation programme in order to provide greater clarity on implementation issues.

3.2 Artificial Islands – Construction

3.2.1 Sites constructed as artificial islands are envisaged to be “co-disposal sites”, i.e., designated initially as a public filling area, to be followed by development and operation as a landfill.

3.2.2 A typical island site would range from 200 to 900 hectares in size and could accommodate a landfill with a capacity varying from around 40Mcum to 150Mcum. The island would be constructed in cells such that, on completion of the first phase of reclamation in Cell 1, landfilling operations could commence while the next phase of island formation is being carried out. This also allows for phased restoration and landscaping as each area of waste disposal is completed.

3.2.3 Construction and subsequent operation as a landfill would entail the following:

- Construction of an encircling seawall and shoreline protection in a series of two or three cells.
- Public filling of the area behind the encircling seawall for a number of years in order to form an "artificial" island to provide the necessary land for subsequent landfill development.
- Settlement / surcharging of reclamation.
- Site preparation for landfill development.
- Construction of a marine waste reception area and passenger / vehicle jetty.
- Phased development of landfill, including environmental pollution control systems (leachate treatment, landfill gas management/utilisation, waste water treatment, etc.).
- Provision of utilities.
- Construction of offices, canteen, welfare facilities, etc.
- Construction of landfill infrastructure (weighbridges, wheel washing, vehicle cleaning, vehicle maintenance, etc.).
- Delivery of solid waste by marine vessel for landfilling.
- Operation of landfill (compacting waste, placing daily cover, road construction, etc.).
- Operation of landfill gas treatment facilities (including landfill gas utilisation) leachate treatment plant, etc.
- Phased landfill restoration and landscaping.

3.2.4 In order to reduce the overall environmental impacts to the water column during construction, the design approach for the formation of the island sites is to eliminate the need for dredging of underlying muds during the reclamation process. Consequently the construction sequence allows for adequate settlement of the marine muds under the loading of reclamation fill and surcharging.

3.2.5 To provide suitable foundations, granular columns would be installed in the underlying muds to support the seawalls. Whilst this "no-dredge" technique is considered suitable for seawalls in sheltered areas, the ability of this approach to provide adequate stability for seawalls in more exposed locations is subject to verification. Some of the sites, (particularly those in southern and eastern waters) will be exposed to considerable wind and wave action and may require a dredged foundation trench to ensure adequate stability. For the purposes of this SEA and the water quality modelling exercise, a "worst case" approach was adopted that includes for dredging of the seawalls at sites in eastern and southern waters. However, the viability of the no-dredge option for all seawalls should be confirmed in subsequent stages of the project.

3.2.6 The sequence and method of construction for an artificial island with dredging for the "exposed" seawalls would be as follows:

(a) The first cell (cell 1) of the island would be constructed first; this typically would be an area of 200 to 350 hectares and would be in the most exposed part of the island. Once constructed, it would provide shelter for the remaining works.

(b) Dredging of the marine muds to form a foundation trench for the most exposed seawall sections of cell 1 would be carried out.

(c) The dredged foundation trench would be filled progressively with screened inert C&D material as the dredging progresses.

(d) The seawall mound would be placed over the filled dredged foundation trench using screened inert C&D material. Oversize material (rock and concrete fragments) would be placed as outer protection on the seaward side of the mound.

(e) With protection provided by the first section of seawall, the granular column reinforcement of the seabed under the footprint of the seawall on the more sheltered sides of the cell 1 could proceed. Any adverse water quality impacts (such as elevated suspended solids) arising from the placement of the granular columns would be monitored, to ensure water quality remained within an acceptable limits.

(f) After the granular column ground reinforcement is completed, the seawall mound for the those parts of the cell 1 island would be constructed. The seawall mound would be progressed until it encircled the cell 1 island, but leaving a entry and exit point for barges on the least exposed side of the island. The entry and exit point would be protected by a floating boom and silt curtain to minimise the transport of sediment and floating litter.

(g) With an encircling seawall formed, a 2 to 3m granular blanket layer would be put down over the seabed marine muds by barge bottom dumping across the footprint of the first area to be reclaimed within the encircling seawall. This granular blanket layer could be produced by processing C&D material through one of CED's Material Sorting Facilities that includes a crushing plant.

(h) Vertical band drains would be installed through the granular blanket layer into the underlying marine muds using barge mounted equipment.

(i) Layers of C&D materials (unscreened) would be placed by bottom dumping over the completed granular blanket layer and vertical band drains.

(j) The reclamation would be raised to, say, +8mPD (this includes a 2 m surcharge layer) and be left for a final 12-month settlement/surcharge period.

(k) Surcharge would be removed.

(l) Following completion of an area of reclamation sufficient to allow landfilling to commence (say, 50ha), a further area of reclamation within the cell 1 island would be reclaimed and the process continued until the reclamation of cell 1 was completed.

(m) Subsequently the seawall would be extended to construct cell 2 and the process repeated.

3.2.7 The sequence and method of construction for an artificial island without seawall dredging would be as follows:

(a) The first cell (cell 1) of the island would be constructed first; this typically would be an area of 200 to 350 hectares and would be in the most exposed part of the island. Once constructed, it would provide shelter for the remaining works.

(b) Granular column reinforcement of the seabed would be installed along the alignment of the cell 1 seawall.

(c) As granular column reinforcement proceeds, the seawall mound would be constructed over the prepared foundation by the placing of screened inert C&D material. Oversize material (rock and concrete fragments) would be placed as outer protection on the seaward side of the mound.

(d) The granular column reinforcement and the seawall mound construction would proceed until the encircling seawall of the cell 1 island was formed, but leaving a entry and exit point for barges on the least exposed side of the island. The entry and exit point would be protected by a floating boom and silt curtain to minimise the transport of sediment and flotsam.

(e) With an encircling seawall formed, a 2 to 3 m granular blanket layer would be put down over the seabed marine muds by barge bottom dumping across the footprint of the first area to be reclaimed within the encircling seawall. This granular blanket layer could be produced by processing C&D material through one of CED's Material Sorting Facilities that includes a crushing plant.

(f) Vertical band drains would be installed through the granular blanket layer into the underlying marine muds using barge mounted equipment.

(g) Layers of C&D materials (unscreened) would be placed by bottom dumping over the completed granular blanket layer and vertical band drains.

(h) The reclamation would be raised to, say, +8mPD (this includes a 2m surcharge layer) and be left for a final 12-month settlement/surcharge period.

(i) Surcharge would be removed.

(j) Following completion of an area of reclamation sufficient to allow landfilling to commence (say, 50ha), a further area of reclamation within the cell 1 island would be reclaimed and the process continued until the reclamation of cell 1 was completed.

(k) Subsequently the seawall would be extended to construct cell 2 and the process repeated.

3.3 Artificial Islands – Outline Planning and Implementation Programme

Statutory Approvals

3.3.1 The island sites are not covered by any statutory plans. To facilitate the proposed reclamation project, preparation of a new statutory plan under the provisions of the Town Planning Ordinance to cover the proposed site would be required.

3.3.2 The reclamation would need to be gazetted under the Foreshore and Sea-bed (Reclamations) Ordinance.

3.3.3 The necessary feasibility studies (including marine traffic impact, environmental impact, ground investigations and preliminary design) as well as procedures under the Town Planning Ordinance (TPO) and the Foreshore and Sea-bed (Reclamations) Ordinance (FSRO) would need to be completed before final approval.

3.3.4 Assuming the necessary feasibility studies commence in 2004, ExCo Approval is envisaged in 2009. This programme is based on the guidance given in Planning, Environmental and Lands Bureau Technical Circular No. 3/97, and recognises that:

- The TPO was amended in April 1998 to the effect that a submission of a draft plan to the Chief Executive in Council (CEC) can be made within 9 months after the expiration of the exhibition period of the draft plan, and of any subsequent amendment to the draft plan. Also, on application by the Town Planning Board, the CEC may extend the 9 months period for not more than 6 months.

- Any artificial island project would be controversial and, for planning purposes, a 39-month period has been included in the programme for the parallel processing of a scheme under the TPO and the FSRO up to ExCo approval in view of the complexities involved in resolving possible objections, especially from Green Groups and the Fishing Industry.

3.3.5 As the landfill would be classified as a Designated Project (DP), under the EIAO the EIA would need to be issued for public inspection, prior to final approval and issue of an Environmental Permit (EP) under the EIAO. Works cannot commence unless a valid EP is in place. For any DP, the proponent needs to take in to consideration the requirements of Works Bureau Technical Circular No. 18/98, (also issued as Planning Environmental and Lands Bureau Technical Circular 10/98). This Circular has been updated and amended by Works Bureau Technical Circular No. 33/2001 and Works Bureau Technical Circular No. 19/98A issued in December 2001. The amendments to the procedures allow for statutory gazettal of public works projects in parallel with the EIA process, rather than on completion of the EIA process, as was previously the case. The decision as to whether the gazettal procedures should run in parallel, however, rests with the Works Director of the DP. If, as a result of the EIA, changes are necessary to the gazetted scheme, then re-gazettal may be required.

3.3.6 At this stage of this Study, and in view of the expected complexities in approvals, it is envisaged that gazettal in parallel with the EIAO would not be carried out.

3.3.7 The feasibility studies would include a Recommended Outline Development Plan (RODP), based on which Planning Department (PlanD) would prepare an OZP for the proposed reclamation. Subject to agreement by the Town Planning Board (TPB), and after consulting relevant District Councils, the draft OZP would be published for public inspection.

3.3.8 In parallel with the preparation of the draft OZP, the proponent would follow the procedures laid down for authorisation under the FSRO. Upon completion of the feasibility studies, the proponent in consultation with the Lands Department (LandsD) would prepare a plan and notice for gazetting the reclamation under the FSRO. The gazetting of the reclamation under the FSRO would, as far as practicable, be at the same time that the draft OZP was published for public inspection.

3.3.9 After expiry of the public inspection period for the draft OZP, the TPB would consider and hear any objections received. The draft OZP, together with any unwithdrawn objections and a schedule of the amendments made to meet objections, would then be submitted to the CEC, who would consider whether or not to approve the OZP or refer it to the TPB for further consideration or amendment.

3.3.10 Similarly, after expiry of the objection period under the FSRO, the proponent, in consultation with LandsD, would consider objections received and seek to meet or overcome the objections. After giving the objectors an opportunity to express any further views, the proponent would submit the plan and scheme to the CEC, who would consider whether or not to approve the plan and reclamation, with or without amendments.

3.3.11 Ideally, submission to the CEC under the TPO and FSRO would be carried out simultaneously although Town Planning procedures must be completed prior to formal authorisation of the reclamation under the FSRO.

3.3.12 The proponent could submit a Public Works Sub-committee (PWSC) paper for partial upgrading of the PWP project to Category A for funds for consultants fees and detailed investigations in advance of, or in parallel with, the preparation of the submissions to the CEC.

3.3.13 If the CEC approves the OZP for the reclamation under the TPO and authorises it under the FSRO, the Secretary for the Treasury could then submit the finalised paper to PWSC immediately after the authorisation.

Implementation Process

3.3.14 Once the project is in PWP Category A, a design for the reclamation for the public filling area could be finalised and construction tenders called. The Preliminary Implementation Programme is based on a seawall and reclamation contract for cell 1 of the island being awarded 15 months after ExCo and Finance Committee give their approval to the project.

3.3.15 This reclamation contract would utilise inert C&D material received from the various Public Filling Barging Points that should by then be set up around the SAR.

3.3.16 Accounting for the "additional" filling necessary to accommodate the settlement of the mud under sites, it is envisaged that a 900ha artificial island could take over 20 years to fill.

3.3.17 The island would be divided into two or three cells, each of which is say 200 to 300ha.

3.3.18 Within the cell 1 island, following completion of at least 50ha of reclamation, a 12-month surcharge and settlement period would be necessary, recognising that the reclamation (and subsequent landfilling) would be constructed over marine muds without dredging.

3.3.19 Subsequent to the surcharge period, it is envisaged that the landfill contractor would commence development of the landfill infrastructure, and within a further 24 months waste deposition could commence.

3.3.20 In parallel with the landfill development, the reclamation work to form the remainder of cell 1 of the artificial island would continue. Following completion of cell 1, the other cells would be formed in a similar way. Based on the start date for construction on the Preliminary Implementation Programme of 2011, completion of the entire island could be in the period 2020 to 2040, depending on the size of the island and the delivery rate of public fill.

3.3.21 If the landfill started to accept waste in 2019 and assuming it was accepting 15,000 tonnes of waste per day, it would have a life of about 20 years (based on a 100Mcum capacity), i.e. it would be full by say 2040. Nevertheless progress on the reclamation of the artificial island would need to match the intake of waste into the site.

3.4 Land Based Filling – Construction

3.4.1 Sites falling under this category include:

- Pillar Point Valley North Landfill.
- NENT B Landfill Extension.
- WENT A Landfill Extension.
- Land based area of WENT B Landfill Extension.

3.4.2 In all cases, the landfill would be developed by excavating a "landfill bowl" that would be lined and waste placed within it.

3.4.3 Construction and subsequent landfilling would entail the following:

- Site clearance and resumption.
- Construction or improvement of site access road as necessary.
- Phased excavation of the landfill bowl, including rock excavation.
- On completion of the first phase excavation, undertake landfill lining works in preparation for waste acceptance.
- On-site reuse of excavated material (public fill) for landfill construction.
- In accordance with phased excavation, conduct phased development of associated facilities such as landfill gas management system, leachate treatment plant, etc.
- Provision of utilities, offices and staff facilities.
- Construction of other landfill infrastructure, including weighbridges, wheel washing and vehicle cleaning facilities.
- Operation of landfill, including compacting waste, placing cover, etc.

- Operation of landfill gas treatment facilities (including landfill gas utilisation), leachate treatment plant.
- Phased restoration landfill and landscaping works as waste cells are completed.

3.5 Land Based Filling – Outline Planning and Implementation Programme

Statutory Approvals

3.5.1 The site of Pillar Point Valley North Landfill is in an area that is not covered by any statutory plan, although access to the site would require construction of a road access through a Green Belt zone under the coverage of the Tuen Mun OZP.

3.5.2 The NENT B Landfill Extension primarily falls within the area of the Wo Keng Shan OZP. For the extension scheme to go ahead a revised OZP would need to be approved.

3.5.3 The WENT A and WENT B Extensions are in an area that is not covered by any statutory plan. The District Planning Office of PlanD has advised that they have no programme to issue an OZP for this area.

3.5.4 Construction of new roads and any roads that require re-alignment would need to be gazetted under the Roads (Works, Use and Compensation) Ordinance.

3.5.5 The necessary feasibility studies (including environmental impact assessment, drainage impact, traffic impact, marine impact, ground investigation and preliminary design) would need to be completed; and would include the preparation of a RODP.

3.5.6 As the landfill would be a Designated Project under the EIAO, the EIA would be published for public inspection, leading to the issue of an Environment Permit (EP) under the EIAO before the construction and operation of the landfill.

3.5.7 Where land resumption is required, action would need to be taken under the Lands Resumption Ordinance.

Sites Requiring OZP or Revised OZP

3.5.8 The RODP prepared under the feasibility studies would be used as basis on which PlanD would prepare an OZP for the proposed development and carry out the necessary procedures under the Town Planning Ordinance. Subject to agreement by the TPB, and after consulting relevant District Councils, the draft OZP would be published for public inspection.

3.5.9 After expiry of the public inspection period for the OZP, the TPB would consider and hear any objections received. TPB may amend the OZP to meet the objections. The draft OZP, together with any unwithdrawn objections and a schedule of the amendments made to meet objections, would then be submitted to the CEC, who would consider whether or not to approve the OZP or refer it to the TPB for further consideration or amendment.

3.5.10 The proponent could submit a PWSC paper for partial upgrading of the PWP project to Category A for funds for consultants fees and detailed investigations in advance of, or in parallel with, the preparation of the submission to the CEC.

3.5.11 If the CEC approves the OZP, the Secretary for the Treasury could then submit the finalised paper to PWSC immediately after the authorisation.

Sites Not Requiring OZP

3.5.12 Once the RODP prepared under the feasibility studies is agreed amongst Government Bureau(x) and Department, and endorsed by CPLD, the development of the site could proceed.

3.5.13 Once the RODP is endorsed by CPLD, the proponent could submit a PWSC paper for upgrading of the PWP project to Category A for funds for consultants fees and detailed investigations.

Implementation Process

3.5.14 Once the project is in PWP Category A and, provided all statutory procedures are completed, tenders documents could be prepared and tenders called for the development and operation of the landfill under a DBO contract (subject to other studies that confirm the DBO form of contract is to be used). An alternative approach could be to let an advance works contract to provide some initial infrastructure followed by the DBO contract. In the case of the Pillar Point Valley North Landfill, an advance works contract could be let for the construction of the access road to the site.

3.6 Coastal Reclamation – Construction

3.6.1 The only site to fall under this category is the WENT B Extension.

3.6.2 The area occupied by the existing CLP Pulverised Fuel Ash (PFA) Lagoons would have to be filled and surcharged. Only the construction methodology for this area is described here, the construction methodology for the remainder of the WENT B Extension is described under Section 3.4.

3.6.3 Construction would entail the following:

- Site clearance of existing CLP area.
- Construction of seawall; it is envisaged that this would involve construction of a new seawall on the alignment of the existing CLP bund or parallel to it.
- Filling of lagoon area behind seawall using public filling material.
- Settlement and surcharging of filled area.
- Site preparation for landfill development and road diversion.
- Phased development of landfill.
- Construction of road diversion.

3.7 Coastal Reclamation – Outline Planning and Implementation Programme

Statutory Approvals

3.7.1 It may be necessary to gazette the lagoon area under the FSRO particularly if the new seawall extends outside the area previously gazetted for the CLP Lagoons. The necessity for any gazettel, if the proposed filling was entirely within the CLP area, would need to be decided.

3.7.2 In any event, CLP have a licence to use the lagoons area until 2047 and currently they have indicated that unless this site is re-provided, they would be reluctant to surrender the site any earlier. Currently CLP use the lagoons area for the deposition of surplus PFA from the burning of coal at the Castle Peak Power Station. Although the Black Point Power Station burns gas, it is understood that an allowance was made in the operation of this power station to permit the fuel to be switched to coal, if economic/financial factors dictate this. Therefore the lagoons could potentially also take PFA from Black Point Power Station as well.

3.7.3 Taking a conservative assumption that the site would need to be gazetted under the FSRO, a similar sequence would need to be followed as that described under Section 3.3.

Implementation Process

3.7.4 The implementation programme for the WENT B Extension has assumed that the landward area would be acquired first and the CLP lagoon area would be surrendered later, say in 2015. It is assumed that agreement would be reached with CLP by early 2004 for surrender of the area of the lagoons in 2015 and allows time for the TPO and FSRO procedures (as necessary).

3.7.5 The Preliminary Implementation Programme for the WENT B Landfill assumes that the landward part of the site would be developed initially and allows landfilling to proceed in that area, with the lagoon area being included in the site in 2015.

3.8 Principal Environmental Construction and Operation Issues

3.8.1 The following sections outline the main issues and design approach to combating the principal environmental impacts associated with landfill construction and operation, namely, good site practice and the management of leachate and LFG. These issues are considered to be fundamental to the pursuit of sustainability in the development, management and aftercare of the landfill, irrespective of its location, and are thus common to all sites.

Good Site Practice

3.8.2 Good site practice is generally recommended to reduce the impacts of construction and operation primarily to air, noise and water. The specific mitigation requirements (if any) at each site would need to be determined during the EIA.

3.8.3 In terms of air quality, good site would include reduction of dust and odour by:

- Paving and subsequent regular sweeping of long-term haul roads within the site.
- Regular dampening of unpaved roads.
- Vehicle washing (both body wash and wheel wash) before leaving site.
- Immediate cover to odorous waste, eg. sludge, after disposal
- Daily covering of the current tipping face with inert material (e.g. selected construction and demolition material, tarpaulin covers, foam spray, etc.).
- Interim cover of any operational areas which are not currently in use.
- Design of enclosed-loop leachate collection / management system;
- Proper design, operation, management and maintenance of landfill gas combustion facilities to ensure destruction of odorous organic compounds.

3.8.4 In terms of noise levels, good site management would include:

- Using powered mechanical equipment with built-in acoustic shielding.
- Not using percussive piling.
- Where necessary, constructing temporary noise barriers and/or earth bunds.

3.8.5 In terms of water quality, good site management would include:

- Providing adequate surface water collection systems (both temporary and permanent) to channel potentially muddy and/or contaminated water away from watercourses.
- Providing sedimentation tanks for surface water prior to discharge to reduce the levels of suspended solids.
- Regular cleaning of sedimentation tanks to ensure they operate efficiently, especially during the wet season.

Leachate Collection and Treatment

3.8.6 The landfilling of waste gives rise to a contaminated liquid known as leachate. As organic waste within a landfill breaks down, it releases a number of highly polluting materials that dissolve in any water that infiltrates or is present in the landfill. The leachate that is formed as a result of this process percolates through the waste, and unless it is controlled, would seep out of the base of the landfill and pollute any bodies of water it mixes with.

3.8.7 The conventional approach to leachate management is that the design and operation of a landfill should minimise the amount of water that enters the waste, and control its migration from the site. The landfill design should provide for containment, with a low permeability liner to the landfill base sides and cap. The design and sequence of components in the liner would be subject to detailed consideration at a later stage. Essentially however, it is likely to require some or all of the following components:

- Filter geotextile.
- Leachate drainage.
- Cushion geotextile.
- Composite low permeability geomembrane.
- Cushion Geotextile.
- Groundwater drainage (if any).

3.8.8 If possible, landfilling should commence early in the dry season, and the active working areas through which water most readily enters the waste should be kept to a minimum. In this way, the quantity of infiltration would be minimised.

3.8.9 Any surface water accumulating on the surrounding land should be prevented from flowing into the landfill and the waste. This would be done by intercepting the surface water that could flow into the site and draining it away from the landfill. During waste disposal operations, "clean" surface water within the landfill area should also be segregated and disposed of separately from contaminated water or leachate.

3.8.10 A capping layer should be laid progressively over the exposed operational areas of waste or the final restoration surfaces of the landfill. The final capping layer should include a low permeability membrane placed on a layer of compacted fill. The membrane should be overlain by a drainage layer, compacted fill and soil/sub-soil.

3.8.11 Within the leachate drainage layer, lying immediately above the basal liner, there would be a series of regularly spaced slotted leachate collection pipes, most likely in a herringbone pattern, leading to a central spine drain in each phase. These main spine drains would run in the direction of the slope of the base, and act as the principal conduits for the collected leachate, which would be extracted from the low point via a sidewall riser pipe and would then drain by gravity or be pumped to the leachate treatment facilities.

3.8.12 The leachate generated by typical Hong Kong waste would likely have a high organic load, high oxygen demand, and high ammonia content and would require some form of treatment to bring it up to an acceptable level for discharge into the local sewage system (for subsequent downstream treatment) or directly into a natural water body.

3.8.13 The risk of settlement of the landfill base (perhaps exacerbated by the "no dredge" construction) would be monitored to ensure the performance of the leachate collection system performance remains unaffected

3.8.14 The performance requirements for the leachate treatment plant should ensure that no unacceptable water quality impacts arise from the effluent – this is fundamental to the operation of the landfill. In case of breaches, or temporary excessive leachate generation within the landfill that exceeds the capacity of the leachate treatment plant, provision should be made to re-circulate leachate within the landfill, or else store it in temporary ponds within the site for treatment at a later date – this is common existing practice within Hong Kong.

3.8.15 There are a number of leachate treatment plants currently operating in Hong Kong at operational landfills and at the restored landfills. The technology employed at each landfill is not necessarily the same – at NENT leachate is treated by aeration lagoons, whereas at SENT, WENT and most or the restored landfills, modular Sequential Batch Reactors with ammonia stripping are utilised. Irrespective of the design, however, all leachate treatment facilities are required to produce an effluent that complies with the performance specification in terms of maximum or minimum values for a range of physical and chemical parameters.

3.8.16 The design of the leachate treatment plant depends upon a number of factors, including:

- Strength of leachate (in terms of physical and chemical properties).
- Leachate production rate (maximum, minimum and seasonal averages).
- Area available to construct the treatment plant.
- Contractor's experience and preference of various technologies.
- Effluent discharge requirements (in terms of total loading).

3.8.17 Given the number of factors that determine treatment plant design, in terms of this SEA the actual technology employed to treat leachate is not as important as the recognition that whatever technology is eventually used, the effluent from the plant should comply with discharge standards specified by EPD and so be deemed acceptable.

Landfill Gas Collection and Utilisation

3.8.18 Combined with air, methane forms an explosive mixture when exposed to an ignition source under suitable conditions. LFG accumulating in a restricted space, such as in a building or a room, presents a risk of suffocation because of oxygen displacement and toxic effects of elevated carbon dioxide. Carbon dioxide is also phytotoxic, and can displace soil oxygen.

3.8.19 The LFG mixture has a density similar to that of air, although this varies according to its exact composition. Upward movement of LFG is usually a result of excess pressure over ambient conditions rather than buoyancy. Changes in atmospheric pressure will influence venting of landfill gas to atmosphere as well as subsurface lateral migration.

3.8.20 Bulk gas movements may be caused by the pumping effect of a rising water table, whereas sub-surface lateral diffusion through semi-porous strata and cracks and faults may also be due to a concentration gradient.

3.8.21 Because of the risks associated with uncontrolled off-site migration, LFG should be positively managed within a landfill by means of a LFG containment and collection system. The landfill liner, primarily designed to contain leachate, should also be designed to restrict any possible off-site migration. Primary control should consist of slotted vertical extraction wells and rockfilled collector trenches constructed within the landfill at regular spacings. The vertical pipework would be connected to horizontal collector systems laid on the final surface of the waste, allowing for extraction to a LFG. Secondary control should be a perimeter system of wells and vent trenches designed to intercept any gas at the boundary of the site.

3.8.22 Based on environmental considerations, energy efficiency and availability of alternative users, as much LFG as possible should be utilised either on site or off site. LFG that cannot be utilised should be flared to reduce odour and emissions of VOCs.

3.8.23 Exhaust emissions from the thermal destruction of landfill gas have the potential to cause air quality impacts in the areas surrounding the thermal oxidiser (flare). The destruction efficiency of landfill gas flares is a function of its design and is affected by the design temperature and the "residence time" of landfill gas within the combustion chamber. All of the strategic landfills and most of the restored landfills in Hong Kong use thermal oxidisation systems for the destruction of landfill gas. Through performance specifications and careful siting of a flare within the landfill coupled with verification through modelling and monitoring, all have been shown to operate within the relevant AQOs

3.8.24 Energy production from LFG generally requires some degree of processing, to remove contaminants. The viability of any off-site gas to energy project is subject to detailed analysis of the associated costs and the local environmental impacts. Such schemes tend to be most effective when the user demands for LFG match the production rates and the user/customer is within close proximity to the LFG source. Typical uses for LFG, both on-site and off-site, include:

- Electricity Generation by Internal Combustion Engines or Turbine Engines – LFG could be used on the landfill site to provide all electricity requirements. Surplus electricity, could be sold directly to off-site users or sold to utilities operators and input to the grid system, however, this off-site use would depend upon the availability of electricity transmission infrastructure in the locality.

- Direct Gas Use in Boilers or Industrial Processes – LFG could be used on the landfill site to provide process heat, for example to ammonia stripping process in the leachate treatment plant. Surplus gas could be directly utilised off-site as a medium-energy fuel for processes such as kiln operations, cement manufacture or asphalt production where the LFG is used as a replacement or supplementary fuel. Again, this off-site use would depend on the nearby location of such industries.

- Natural Gas Pipeline Injection – LFG could be processed and sold to a natural gas supplier. This technique is feasible where large volumes of LFG are available for a significant period of time but again required suitable infrastructure to be in place and a potential market for natural gas close by.

3.8.25 In practice, the most viable LFG utilisation option (other than on-site use) is likely to be the generation of electricity for off-site distribution and sale. This would require the co-operation of the relevant electricity utility company, a sale and purchase agreement, and agreement with Government with respect to the allocation of costs, revenues and risks associated with LFG utilisation.