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REPORT ON

RESPONSE TO SCHEDULE 4 NOTICE DATED 20 DECEMBER 2005 WITHYHEDGE LANDFILL PHASE 2

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INTRODUCTION

This document sets out the response of Resources Management UK Ltd (RML) to the Schedule 4 Notice dated 20 December 2005 raised by the Environment Agency. The questions raised in the Notice are reproduced below, and RML's response follows each question.

Question 1

It is proposed that drift and shale will be removed from the site as each cell is constructed. The depth of extraction will be limited to leave a 1 m thick unsaturated zone. Given that no groundwater management is proposed, provide details on the how the conceptual site model detailing the groundwater elevation and fluctuations have been measured. For example locations, number of occasions (seasons/timing), and methodologies, to support the maintenance of the 1 m unsaturated zone proposed in the landfill design.

Response

A review of the groundwater data available from previous monitoring rounds has revealed that further data is required to delineate the location of the groundwater table at the site more accurately. It is therefore proposed to undertake further site investigations at the site, including the installation of new groundwater monitoring wells, with a view to improving understanding the elevation of the groundwater table, the groundwater flow direction and the interactions between the groundwater and the surface water at the site and in the direct vicinity. The site investigations will be carried out within 6 months of permit issue. After review of the obtained data, an updated conceptual model describing the interactions of groundwater and surface water at the site and the potential implications of waste deposition on groundwater elevation will be established.

An overview on the most recent groundwater data available for the period May 2005 to January 2006 is given in Appendix S4R1. The available data and all additional data will be assessed in preparation of the updated conceptual groundwater model.

Question 2

Provide details of proposed ongoing control measures that will be undertaken to ensure a minimum 1 m unsaturated zone will be left in-situ during excavations of new cells.

Response

A strategy outlining the measures for maintaining a 1 m unsaturated zone below the landfill at all times during landfill operation will be developed once the updated conceptual model described in the response to Question 1 above has been established.

Question 3

Given the sensitivities of the leachate head and potential for overtopping within a short period of time a revised robust leachate drainage design where pipe work can be inspected and maintained must be installed. Drainage layers, pipework and geotextile separation layers are potentially susceptible to silting and to blockage by biomass growth and chemical accretions. A fundamental design criterion is that the leachate removal system should by accessible to CCTV and jetting so that any blockage in the collection pipework can be investigated and removed. Your current proposals include a herringbone design using a combination of vertical and upslope risers to extract leachate. Traditional herringbone designs of pipework can be difficult to inspect and maintain unlike radial or parallel spine systems in which the length of drainage runs is limited to that practical for jetting. Vertical risers also have potential issues with accessibility for inspection and maintenance and are prone to damage due to settlement.

Please revise the design of the drainage pipework or provide evidence that the current proposed drainage system can be inspected and maintained in its entirety. A revised design for the proposed vertical risers along the edge of the waste where these have potential issues with accessibility for inspection and maintenance must also be supplied. Upslope risers should be installed wherever possible.

Response

Whilst we accept that it may be considered best practice to be able to access the leachate drainage pipework we consider the drainage blanket alone is sufficient to transmit leachate to the collection sumps even if the leachate drainage pipework were to become redundant.

The ability of the leachate drainage blanket to transmit leachate can be calculated using Darcy's Law:

$Q = k\ i\ A$

Where:

Q is the flow rate of leachate (m^3/s);
k is the permeability of the leachate drainage blanket (m/s);
i is the hydraulic gradient (-); and
A is the cross sectional area of the drainage blanket in the direction of flow (m^2).

The required minimum hydraulic conductivity of the drainage blanket is $1x10^{-4}$ m/s (Question B2.2.9 of the Part B Application Form). The hydraulic gradient in the drainage blanket will be the slope on the base if the blanket is to remain unsaturated; in this case it is 1 in 50 or 0.02

(Question B2.2.9). The cross section area of the drainage blanket is the product of its thickness (0.5 m) and at its width, which is taken to be at least 40 m.

The potential flow rate of leachate through the drainage blanket is therefore at least 4×10^{-5} m^3/s or 3.5 m^3/day or 1,262 m^3/year.

The infiltration to the largest cells, which are in Phase 2A, is predicted to be 50 mm over 1.72 Ha (Table HRA5 and Table HRA4 of the Hydrogeological Risk Assessment submitted as part of the permit application) or 860 m^3/year.

The drainage blanket is therefore capable of transmitting the predicted infiltration through the cap of the largest cells to the sumps without becoming saturated even if the leachate drainage pipework were to become redundant.

Having consulted with various specialist contractors, we believe that it is possible to inspect leachate pipework from the vertical extraction/monitoring points. The minimum diameter for CCTV access is 60 mm, so the proposed 150 mm diameter pipework would be sufficient to accommodate such inspections. We concur with your view that the use of upslope riser pipes would facilitate such inspections more easily and therefore we propose that each cell will have an upslope riser in addition to the vertical extraction points detailed in the permit application. These additional upslope risers will be located around the perimeter of each cell and will be the same diameter as, and will be connected to, the main spine drain in each cell. Details of the upslope risers are given in a revised Drawing ESID7B included with this report.

Question 4

The proposed leachate drainage layer design (150 mm thick 5-20 mm gravel overlain with 350 mm thick 2 to 125 mm gravel) is noted. Recent work published by Kerry Rowe entitled 'Clogging of Tire Shreds and Gravel Permeated with Landfill Leachate 'within the Journal of Geotechnical and Geoenvironmental Engineering [June 2005] has highlighted problems with clogging of drainage blankets due to Calcium Carbonate precipitation. A landfill site in Wales that was recently excavated after only six months of waste deposits demonstrated that the drainage blanket had become completely redundant in certain areas. Research also suggests that clogging occurs more rapidly where there are smaller particles and smaller pore sizes and also more rapidly for well graded materials compared to uniformly graded materials. The blanket you propose appears to comprise of two layers of well graded material with relatively small particle sizes which will significantly increase the risk of rapid redundancy of the drainage blanket. Leachate management is particularly critical at this site as demonstrated within the Hydrogeological Risk Assessment.

Please provide a revised design of the drainage blanket that will be less prone to clogging. The research would point towards the use of a uniformly graded aggregate of a larger size (between 16 mm and 30 mm as per Agency guidance[1]) as being the most suitable.

Response

The composition of the deposited waste and the leachate generated in the proposed development of the site will be similar to the composition of waste and leachate in the existing site to the east of the proposed development. The design of the landfill drainage blanket for Withyhedge Landfill Phase 2 has therefore been detailed taking into account previous practice at the site. The drainage blanket of Cell 15 in the existing landfill comprises 150 mm thick 5-20 mm gravel overlain by 350 mm thick 2-125 mm gravel, as stated in the CQA report for Cell 15[2]. The design of this drainage blanket has been accepted and approved by the Environment Agency in writing[3] and has therefore been proposed for the new development.

The recent publication cited by the Agency[4] shows the clogging by precipitates of laboratory columns filled with uniformly graded tyre shreds and gravel as observed after 2 years of flushing with leachate. The authors state that calcium carbonate is the main constituent of the clogging material that reduces the hydraulic conductivity in the column filled with gravel, which has the potential to impair the capability of the material to conduct leachate. However, it has been noted that the leachate used, collected from a landfill site similar to Withyhedge Landfill Site, has been spiked with calcium, resulting in calcium concentrations in the range of 500 mg/l up to a maximum of 1500 mg/l for much of the experiment, and at all times during the column experiment exceeding by far the median concentration of calcium at Withyhedge of 99.4 mg/l.

The equilibrium between solid and dissolved calcium carbonate is strongly dependent on the concentrations of calcium in solution, and an increase in dissolved calcium concentration in leachate will lead to a higher rate of precipitation. The calcium concentration of the Withyhedge leachate alone is compared to the calcium concentration of the leachate cited, although it is recognised that concentrations of carbonate play an important role in determining the calcium carbonate equilibrium. This approach has been taken because of the absence of carbonate concentration data for the leachate cited and the fact the median total alkalinity at Withyhedge is relatively low (1,030 mg/l). Furthermore, the fact that limestone

[1] Landfill Engineering: Leachate Drainage, Collection and Extraction Services R&D Technical *Report Pl-397/TR*

[2] AIG 2004: CQA Withyhedge Landfill Site Cell 15 Construction Quality Assurance Certification Report. Report No. UK04/2139/3, November 2004.

[3] Environment Agency 2005, Letter to RML dated 19 January 2005, Ref. EAWML/34147.

[4] Rowe, K. & McIsaac, R. 2005: Clogging of Tire Shreds and Gravel Permeated with Landfill Leachate. *Journal of Geotechnical and Geoenvironmental Engineering, 131 (6), 682–693.*

gravel was used in the experiments will yield higher calcium carbonate precipitation rates than at the site, where the gravel contains less than 10% $CaCO_3$. It is concluded that the results stated in the cited paper with regard to calcium precipitation cannot be readily applied to Withyhedge because dissolved concentrations in leachate of crucial species are unlikely to be in favour of similarly high $CaCO_3$ precipitation rates.

As stated by Rowe & McIsaac, the flow rate of leachate per unit area through the columns was kept at 146,000 mm/yr (0.4 m^3/m^2/day) throughout the experiments, which lasted for 2 years. The total amount of leachate passed through the columns at the point of analysis is therefore 292,000 mm (2 yrs x 146,000 mm/yr). Considering an average period of 10 years of active landfilling at Withyhedge Landfill Site during which the waste is potentially exposed directly to precipitation and a rainfall of approximately 1,200 mm/yr (Appendix 2, Section B of the PPC Application), a total of 12,000 mm/yr will infiltrate waste during active landfilling. Subtracting this value from the total amount of leachate passed through the drainage material in the experiments, and dividing this result by an assumed infiltration rate of 50 mm/yr through the landfill cap converts the artificial infiltration rate applied in the experiments into 5600 years of true infiltration at the site. It is assumed that most contaminants will have been leached out of the waste body and that the leachate strength will have decreased to such a degree that a risk to groundwater quality is no longer posed and an operable leachate drainage blanket is no longer required.

It is therefore considered that clogging as described in the paper cited does not impair the suitability of the proposed leachate drainage layer due to the different conditions at the site and the required design life, and that the proposed design, as used previously at the site, is appropriate.

Question 5

Drawing ESlD7B shows the cross section of the proposed leachate drainage pipe work arrangement and specification. It will not be acceptable to place drainage pipe work on top of well graded materials due to the potential for compaction of this material and differential settlement along the entire length of pipe. The bedding and haunch aggregate material must be uniformly graded. It is also noted that your propose 150 mm diameter main spine drains which appears to provide little redundancy capacity when considering chemical accretions and bioclogging.

Please provide revised cross section design drawings of all pipe work including the specification and layout arrangement of the bedding aggregate. The cross section drawings of the 'Leachate drainage blanket detail 'and 'Upslope riser extraction riser detail' also conflict as the position of the spine drain differs. Please address in your revised submission. Please confirm that the drainage pipe work design adequately considers reduction in available capacity due to inevitable bioclogging and precipitation etc.

Response

We do not believe there to be a conflict on Drawing ESID7B, however the drawing has been revised to clarify the position of the pipe and this is included in this report. It is now proposed that the pipework should be placed closer to the base of the drainage layer on a bedding of 150 mm of bedding aggregate.

The leachate drainage pipework has been designed to have a degree of redundancy. The flow capacity of the leachate drainage pipe system at the site has been estimated using the equation proposed by Colebrook & White (1937)[5]:

$$v_{\max} = -2\sqrt{2idg} \times Log\left(\frac{R_H}{3.7d} + \frac{2.51\upsilon}{d\sqrt{2idg}}\right)$$

where: v_{max}: maximum flow velocity [m/s]; i: pipe gradient [-]; d: diameter of the pipe [m]; g: gravitational acceleration constant [m/s^2]; R_H: roughness factor [m]; and υ: kinematic viscosity [m^2/s]. The calculated velocity was then converted into a flow rate by applying:

$$Q_{\max} = v_{\max}\left(\frac{d}{2}\right)^2 \pi \times 86400$$

where: Q_{max}: maximum flow capacity of the pipe [m^3/day]. The justifications for input parameter values are shown in Table S4R1.

Table S4R1: Justification of Input Parameters for Maximum Flow Capacity Calculations

Parameter	Value	Unit	Justification
Pipe gradient i	0.01	-	Lowest value stated in Section B, PPC Application
Pipe diameter d	0.15	m	Value stated in Section B, PPC Application
Roughness R_H	6×10^{-4}	m	Typical roughness for rough pipe
Kinematic viscosity υ	1×10^{-6}	m^2/s	Standard value for water

A relatively high roughness value (representative for concrete pipes) was chosen to take into account potential precipitation on the inner pipe walls reducing the smoothness of the wall surface. This is a conservative approach as the high density polyethylene pipes proposed will be smoother. The results of the calculation are presented in Table S4R2. To take into account that the leachate drainage pipes are prone to partial clogging, a second calculation has been carried out assuming a reduced pipe diameter of 0.1 m, which is equal to more than 50% reduction in cross sectional area.

[5] Colebrook, C.F., White, C.M., 1937, Experiments in fluid friction in roughened pipes, Proceedings of the Royal Society, Series A, London, 161, pp. 367-381.

Table S4R 2: Maximum Flow Capacity of Leachate Drainage Pipes

Pipe inner diameter (m)	Maximum flow capacity (m^3/day)
0.15	1,532
0.1	521

An assumed precipitation of approximately 1,200 mm/year (Appendix 2 of Section B of the PPC Application), infiltrating over the average cell size of approximately 1.8 ha, will lead to a daily amount of leachate of 59.2 m^3/day. This value is one order of magnitude lower than the calculated maximum flow capacity, even if the cross sectional area is significantly reduced by clogging. An unusually high rainfall event of 80 mm/day would yield approximately 4 m^3/day, which is two to three orders of magnitude below the maximum pipe flow capacity.

The results indicate that the size and gradient of the leachate drainage pipes are appropriate to conduct the generated leachate.

Question 6

There are currently no target pads proposed at the installation. The Agency would expect a target pad to be installed within each cell. Please provide details of the design, size and location of target pads to be installed that will allow the retro-drilling of vertical extraction wells in the event of failure of the leachate drainage system. The Agency would anticipate that the design would comprise of a significant local increase in drainage blanket thickness and the use of liner protection material.

Response

It is agreed that it is good practice to include target pads in each cell. Target pads will be installed in each cell and will comprise 3 m by 3 m concrete slab 300 mm thick. The target pads will be located towards the low point of each cell 5 m horizontally away from the existing leachate extraction points. The leachate drainage blanket will be locally thickened to be 1 m thick on each target pad.

Question 7

ESID7B states that the extraction well is perforated but does not provide details as to the extent of perforation. Please clarify. Walls with slots for leachate ingress should only be present in the bottom 2 m. Please also provide further information on the specification of concrete and any re-enforcement to be utilised.

Response

Further details of the extraction well, together with upslope riser details are given in the revised Drawing ESID7B which is included with this response.

Question 8

Detailed contingency measures must be in place to cope with the high rainfall and risk of overtopping and for the inspection and maintenance of the leachate extraction system. Please provide detailed contingency measures within a leachate contingency plan.

Response

It is not considered likely that a high rainfall event will lead to breakout of landfill leachate at the perimeter of the active waste-phases. With the average values for field-capacity and porosity of the waste assumed in Section B of the PPC Application of 0.18 and 0.12, respectively, even an event of very high rainfall of 80 mm will not be able to generate a leachate head that is higher than approximately 1.30 m. Considering the inward slope of the cell-bunds, leachate is expected to move towards the centre of the active cell, where the leachate control and trigger levels ensure that appropriate action is taken if leachate levels are exceeded. Nevertheless, to safeguard against the unlikely event of leachate breakout, current and future practice includes creating a v-shaped drainage ditch of approximately 0.5 m depth. Leachate build-up in the ditch is removed by means of a vacuum-tanker.

Question 9

The construction of the inert wedge to provide separation of the two landfill phases and a uniform landfill restoration profile. The design and timing of installation of this inert wedge could have a significant influence on landfill stability and effective leachate management of both phases. If there is a delay in the proposed installation of the 'wedge' we would also wish to receive details of temporary capping arrangements. No details of the design and construction of the 'wedge' have been included within the current application.

Please provide the following information on the design and specification of the 'inert wedge 'that will be constructed between Phase 1 and 2:

a) A cross section drawing detailing the design of the 'wedge 'and its interface between both phases. Cross section slope profiles should also be included;
b) Assessment of the stability of temporary waste slope profiles (if relevant depending on method and timing of installation);
c) Specification of construction materials including granular /cohesive, compaction, min strengths, density range etc.;
d) Method of installation including timetable for construction;
e) Detail the implications for the capping of existing wastes and the timing and capping of the engineered fill;
f) Details of the plans for the boreholes installed along the location of the valley feature, will these be extended or re-drilled? It will not be acceptable for groundwater monitoring to cease within the valley feature for any prolonged period (i.e. longer than two months); and
g) Measures to be put in place to determine if any lateral migration of leachate is taking place.

Response

a) Details of the inert wedge were previously submitted to the Environment Agency on 27 August 2004. These details are also presented in Drawing S4R1 included in this response;

b) The gradient of the temporary waste slopes that form the valley between the existing Cell 15 and the proposed Withyhedge 2 are 1 (vert.) in 3 (horiz.), see Drawing S4R1. The stability of the temporary waste slopes for the first area in the proposed landfill were assessed in Section 2.7.4 of the Stability Risk Assessment (SRA) submitted as part of the permit application. In addition, the stability of the Cell 15 temporary waste slope was assessed in the Section 2.7.4 of the Cell 15 SRA submitted to the Environment Agency on 16 September 2005. Both sets of analyses indicate that the proposed 1 in 3 waste slopes will remain stable;

c) The infill materials will comprise suitable inert materials. At this stage the exact nature of the material cannot be determined. The inert materials will be placed and compacted in layers using the same plant as the operational landfill;

d) The infilling will commence as soon as the first cell in Phase 2 is filled to final height and capped, and will continue at a rate consistent with the availability of inert materials;

e) Capping of the existing wastes will be carried out when the cell has been filled to its pre-settlement restoration level. The timing of the cell capping will be governed by the prevailing weather conditions at the time. Capping of the engineered fill will be carried out after completion of filling to the final restoration levels. It is envisaged that this may take a number of years to achieve, depending on the availability of inert material locally. Drainage measures will be installed at the base of the engineered fill to control any rainfall or surface water infiltration through the engineered fill;

f) It is proposed that the existing groundwater monitoring boreholes installed between the existing landfill and the new landfill are extended as the engineered fill is placed. This will be carried out in accordance with Construction Quality Assurance (CQA) procedures, submitted in advance to the Agency for approval. The monitoring borehole extension works will be supervised by a CQA engineer and a CQA report detailing the works will be submitted to the Agency on completion of each extension lift and prior to the placement of engineered fill against the newly extended borehole. As these monitoring boreholes will be extended as the engineered fill is placed, there will be no cessation in monitoring for any prolonged period; and

g) As both the existing landfill (Cell 15) and the proposed new landfill will be capped with a linear low density polyethylene geomembrane that will be tied into the side wall lining systems, there is little scope for lateral migration of leachate. However, it is proposed that the outlet of the drainage pipework be installed at the base of the engineered fill be monitored at regular intervals.

Question 10

The leachate storage tank must be located within the installation boundary. Provide revised plans to detail the new proposed location of the leachate tank. Provide details of all associated pollution prevention measures, to include details of the tank capacity, bund construction and capacity, details of all associated pipework and fill/drain points and the ground cover (i.e. concrete, tarmac etc.). Details of maintenance and integrity testing of the tanks (including methodology) should also be supplied.

Response

The installation boundary has been revised to include the leachate storage tank, see Drawing ESID6A Revision 1 attached. The principal means of pollution prevention is the careful handling and storage of potentially polluting substances such as leachate. The leachate storage tank is a 23,000 gallon capacity steel tank, on an engineered clay base and surrounded on three sides by an engineered clay bund. The clay base falls towards the bunded end and has a capacity in excess of 110% of the capacity of the tank. All filler pipes, vents, outlet pipes are kept within the bunded area. Leachate will be pumped from the site by vacuum tanker and leachate will then be transferred into the holding tank by pumping directly from the vacuum tanker.

The tank will be inspected at weekly intervals and prior to transfer of leachate. If the tank is found to be damaged such that a leak may occur, or is leaking, then arrangements will be made immediately to have the tank repaired. If the tank is found to be leaking following commencement of leachate transfer, then the leachate transfer will cease pending repair of the tank.

The tank bund and clay base will be inspected at weekly intervals and prior to leachate transfer. If the bund or base is found to be damaged such that a leak may occur, then arrangements will be made immediately to have the bund or base repaired. If the bund is additionally found to be leaking any drainage that has accumulated, then immediate measures shall be taken to have the bund emptied to minimise further leakage and appropriate measures shall be taken to clear any contamination of ground outside the tank bund. This may include, use of absorbent materials to contain and absorb spillages, or excavation of contaminated ground and disposal as appropriate. Used absorbent material will be excavated and transferred to containers for disposal at an appropriate facility. Where both the tank and the bund are found to be leaking, then immediate arrangements will be made to have the leachate tank contents emptied into other containers or tanks.

Details of the weekly inspections of tanks, bunding and repairs, or remedial measures taken in event of spillage will be recorded in the site diary.

Question 11

Provide details of all associated pollution prevention measures (site report, application form Section B1.3) for those parts of the landfill installation where waste will not be permanently deposited (for example wheel wash, leachate storage tank and associated pipework, fuel storage, quarantine areas.). H7 guidance provides detailed guidance on the information required. Please note that all infrastructure that will be principally used as part of the operation of Phase 2 must be located within the installation boundary. Please amend your installation boundary accordingly.

Response

The non-landfill areas where there are potentially polluting substances are: leachate storage tank, fuel storage tank, hydraulic and lubricating oil storage and quarantine area. There is no wheel wash at the site owing to the distance between the site and the public road negating the need for one. The location of these areas where potentially polluting substances are kept are shown on Drawing ESID6A, and the installation boundary has been revised to include the leachate storage tank and quarantine area. The principal means of pollution prevention is the careful handling and storage of potentially polluting substances such as fuel oil and the contents of the quarantine area.

Fuel Oil

Fuel oil will be stored in a 1,100 gallon plastic tank at the landfill area. The tank will be an integrally bunded design, which incorporates a double skinned fuel storage tank. The volume within the outer skin will be at least 110% of the storage capacity of the inner skin of the tank. The tank will be fitted with a label detailing the contents and the maximum capacity of the tank. A lockable delivery nozzle will be provided which will be kept locked at all times when the tank is not in use.

Access to the space within the outer skin of the tank is easily afforded for the purpose of removing any spillages arising from the inner skin or arising from fuelling operations. Liquid accumulating in the bunded area will be removed at intervals and disposed of in a manner appropriate to the quality of the water removed.

Deliveries of fuel will be supervised by a responsible person. A means will be provided of measuring the quantity of fuel in the tank, either by dipping or by a calibrated gauge. This will be checked prior to a delivery being made and the maximum residual capacity of the tank will be determined prior to the commencement of re-filling, to ensure that the tank is not over-filled. Filling and emptying operations will be supervised by a member of site staff.

The keys for the fuel storage tank will be held by a responsible person who will also maintain records of the quantities of fuel in storage and delivered.

The tank will be inspected at weekly intervals and prior to delivery of fuel oil if this is sooner. If the tank is found to be damaged such that a leak may occur, or is leaking, then arrangements will be made immediately to have the tank repaired. If the tank is found to be leaking following commencement of a fuel delivery, then the fuel delivery will cease pending repair of the tank.

The outer skin of the tank will be inspected at weekly intervals and prior to delivery of fuel oil if this is sooner. If the bund is found to be damaged such that a leak may occur, then arrangements will be made immediately to have the bund repaired. If the bund is additionally found to be leaking any drainage that has accumulated, then immediate measures shall be taken to have the bund emptied to minimise further leakage and appropriate measures shall be taken to clear any contamination of ground outside the tank bund. This may include, use of absorbent materials to contain and absorb spillages, or excavation of contaminated ground and disposal as appropriate. Used absorbent material will be excavated and transferred to containers for disposal at an appropriate facility. Where both a tank and a bund are found to be leaking, then immediate arrangements will be made to have the fuel tank contents emptied into other containers or tanks.

Details of the weekly inspections of tanks, bunding and repairs, or remedial measures taken in event of spillage, will be recorded in the site diary.

Hydraulic and Lubricating Oils

Hydraulic and lubricating oils (in 45 gallon drums or smaller) will be stored in a secure container. The container will contain any spillage and will be enclosed to prevent the ingress of rain water. The container will be kept locked at all times when not in use. All drums stored in the container will be clearly labelled to show their contents.

The keys for the storage container will be held by a responsible person who will also maintain records of the quantities of fuel and lubricants in storage and used, or delivered. Deliveries will be supervised by a member of site staff. Appropriate equipment will be used for the movement and delivery of large containers and drums which cannot be carried. During movement or delivery of drums and containers, all filling/emptying points and vents shall be sealed to prevent leakage. Drums and containers will only be filled or emptied within a contained area, using appropriate means such as a drum pump although in the case of smaller containers, this may be done by hand using a suitable funnel to prevent spillage. Drums will be dipped prior to filling to check capacity.

Drums and containers will be inspected weekly for leaks and prior to filling. Leaking drums and containers will have their contents immediately removed to another suitable container and will be repaired or disposed of at a suitable facility. Absorbent materials will be used to contain and absorb any minor spillages. Used absorbent material will be removed and transferred to containers for disposal at an appropriate facility. The bunding within the container will be emptied as appropriate and disposed of to a suitable facility.

Hydraulic and lubricating oils will be held in drums inside a secure, lockable ISO container. The container will have an integral drip tray which will be able to accommodate 110% of the volume of any single drum. An industrial absorbent will be available to control any spillage.

Details of the weekly inspections of tanks and containers, or remedial measures taken in event of spillage, will be recorded in the site diary.

Quarantine Area

In the event that any materials are found within wastes tipped in the operational area, which are deemed unsuitable for deposit, these will be reloaded into the carrier's vehicle for immediate removal off-site, or otherwise placed in a suitable container, pending collection from site. The quarantine waste container will be located adjacent to the leachate storage tank, and will be an enclosed container of sound construction and suitably labelled. The maximum duration of such storage will be no longer than 3 working days, unless otherwise agreed with the Agency. Details of the rejected waste will be kept on-site. This will include time and date, haulier and vehicle registration, customer, type of waste, Approval Number (if applicable) and reason for rejection.

Leachate Storage Tank

Details of the pollution prevention measures for the leachate storage tank are described in the response to Question 10 above.

Question 12

Provide details on the proposed installation schedule for the gas and groundwater monitoring boreholes. Please confirm the design of the gas wells and the groundwater wells.

Response

The installation of combined groundwater and landfill gas monitoring boreholes is determined by the start dates for waste deposition in the respective phases. Monitoring points relevant for gathering background data on the groundwater quality for a given area will be installed 1 year before waste deposition starts in that area. For the first area of the installation accepting waste, Area A, the relevant monitoring wells will be installed within 6 months of permit issue. Details are given in Table S4R3.

Table S4R3: Schedule for Installation of Monitoring Boreholes

Cell	Boreholes to be Installed	Timing
Area A	BH1, BH2, BH3, BH20, BH21, BH22, BH23	Within 6 months of permit issue
Area B	BH4, BH5	1 year before start of waste placement
Area C	BH6, BH7, BH8, BH9, BH10, BH11, BH12	1 year before start of waste placement
Area D	BH13, BH14	1 year before start of waste placement
Area E	BH15, BH16, BH17, BH18, BH19	1 year before start of waste placement

Details of the proposed installations are given in Drawing S4R2. The wells will be installed at least 20 m from the boundary of waste deposition.

Question 13

Provide clarification for when the proposed spring diversion will be completed.

Response

The timing of the spring diversion is dependent on the refined conceptual groundwater model for the site discussed in the response to Question 1, and a detailed plan for the spring diversion based on a water balance taking into account the groundwater surface water interactions at the site will be submitted together with the conceptual groundwater model. Further monitoring will be carried out at the new boreholes, and the conceptual model will be continuously verified and, if necessary, updated based on the collated data.

Question 14

Detailed information on the groundwater monitoring, suites and schedules, phasing timing and installation of the proposed boreholes.

Response

Details for the timing of monitoring rounds of groundwater wells are given in Table S4R4. The start of the sampling schedule is determined by the timing of installation of boreholes according to when Phases Area A to E are active; refer to Table S4R3 for details. Groundwater samples will be obtained for the whole suite of analysis given in Table S4R4 on a quarterly basis before and during landfilling and in the closure/aftercare phase. In addition, a monthly analysis of pH, temperature, electrical conductivity, dissolved oxygen, ammoniacal nitrogen and chloride will be carried out during the landfilling phase.

Table S4R4: Groundwater Monitoring Frequency, Analytical Determinands and Detection Limits

Parameter	Landfilling phase		Pre-landfilling and closure/ aftercare phase	Detection limit (mg/l)
	Monthly	Quarterly	Quarterly	
pH	●+	●+	●+	0.01
Temperature	●*	●*	●*	0.01 °C
Electrical conductivity 20°C	●+	●+	●+	1 µS/cm
Dissolved oxygen	●+	●+	●+	0.1 mg/l
Ammoniacal nitrogen	●	●	●	0.02 mg/l
Chloride	●	●	●	10 mg/l
COD		●	●	10 mg/l
TOC		●	●	0.1 mg/l
Sulphate		●	●	10 mg/l
Alkalinity		●	●	5 mg/l
Nitrate (for TON)		●	●	1 mg/l
Nitrite (for TON)		●	●	1 mg/l
Sodium		●	●	0.1 mg/l
Potassium		●	●	0.1mg/l
Calcium		●	●	0.1 mg/l
Magnesium		●	●	0.1 mg/l
Iron		●	●	0.1 mg/l
Manganese		●	●	0.1 mg/l
Cadmium		●	●	0.2 µg/l
Copper		●	●	0.002 mg/l
Chromium		●	●	0.01 mg/l
Lead		●	●	0.001 mg/l
Nickel		●	●	0.01 mg/l
Zinc		●	●	0.01 mg/l
Ionic balance		●	●	-
Groundwater level	●	●	●	-

Key : + denotes field or laboratory measurements (subject to availability of field equipment, samples may be sent for laboratory analysis instead);
** denotes field only measurements.*

Question 15

Provide details for the samples taken for attenuation and retardation properties, sample descriptions and the locations from which they were collected.

Response

Table S4R5 lists the locations, depths and lithology of the samples analysed for retardation properties. The locations are marked on Drawing S4R3. The original results from the laboratory analysis are shown in Appendix S4R4.

Table S4R5: Description of Samples Analysed for Retardation Properties

Sample ID	Location	Depth (mbgl)	Description
2	TPGA1	1.8	Light orange brown sandy CLAY with many sub-angular gravel (DRIFT DEPOSITS)
5	TPGA2	1.5-1.8	Light orange brown sandy CLAY with occasional rounded gravel (DRIFT DEPOSITS)
6	TPGA2	2.2-2.8	Orange grey moderately weathered shale comprising platey angular gravel and cobble sized fragments (WEATHERED SHALE)
7	TPGA3	1.5-1.9	Light grey mottled orange CLAY (DRIFT DEPOSITS)
10	TPGA4	3.9-4.2	Firm to stiff black weathered shale (WEATHERED SHALE)

Question 16

There is a requirement to set leachate quality action levels at the maximum concentrations used in the HRA, please review Table HRA22 'Trigger Values and Control Levels for Leachate Monitoring', where the action levels (referred to as triggers) proposed in Table HRA22 are not acceptable, as these are greater than the leachate quality used in the HRA detailed in Appendix HRA3. Please resubmit the table with the appropriate action levels used in the HRA.

Response

Proposed revised action levels for leachate monitoring are presented in Table S4R6.

Table S4R6: Action Levels for Leachate Monitoring (mg/l)

Ammoniacal Nitrogen	Chloride	Cadmium	Mecoprop	Naphthalene	Nickel	Phenol
3,840	7,760	0.105	0.14	0.042	2.21	12

The concentration of contaminants used in the LandSim model representing normal operating conditions, in the Hydrogeological Risk Assessment (Section B of the PPC Application), were adjusted to represent the values set as action levels for mecoprop, naphthalene and phenol in Table S4R6. The LandSim model has been rerun for these three species and the values of all other parameters remain unchanged; the model input is shown in Appendix S4R3.

The point of compliance for the List I substances mecoprop and naphthalene is defined as the base of the unsaturated zone (Section 2.5.1.1, Section B of the PPC Application). The results show that naphthalene is not predicted to reach the base of the unsaturated zone. The model predicts that mecoprop concentrations at the 95%ile at the base of the unsaturated zone under each phase will be below the MRV of 4×10^{-5} mg/l (Table S4R7). The highest modelled mecoprop concentration is calculated beneath Area 2A at 2.4×10^{-5} mg/l.

Table S4R7: List I Model Results at the Base of the Unsaturated Zone (Normal Operating Conditions)

Mecoprop		
Phase	**Peak concentration (mg/l) (95%ile)**	**Time to peak impact (years)**
Phase 2A	2.4×10^{-5}	14
Phase 2B	5.8×10^{-6}	31
Phase 2C	1.3×10^{-5}	38
Phase 2D	1.2×10^{-5}	53
Phase 2E	1.4×10^{-5}	65

Cumulative concentrations of phenol, a List II substance, have been assessed at a down gradient location between the site boundary and Rudbaxton Water. This allows the discharge of phenol to be quantified prior to being diluted within the receptor. If the concentration of phenol is less than the respective quality standards, the ultimate concentration within the receptor will be less. The calculated concentration for phenol at the 95%ile at the point of compliance is 4×10^{-9} mg/l, which is below the EAL.

On the basis of the modelled data presented, the risk posed by mecoprop, naphthalene and phenol at the respective points of compliance is considered to be acceptable at the site, so long as the leachate quality does not breach the revised action levels.

Question 17

Provide information on the proposals for surface gas emissions monitoring in accordance with the Agency guidance.

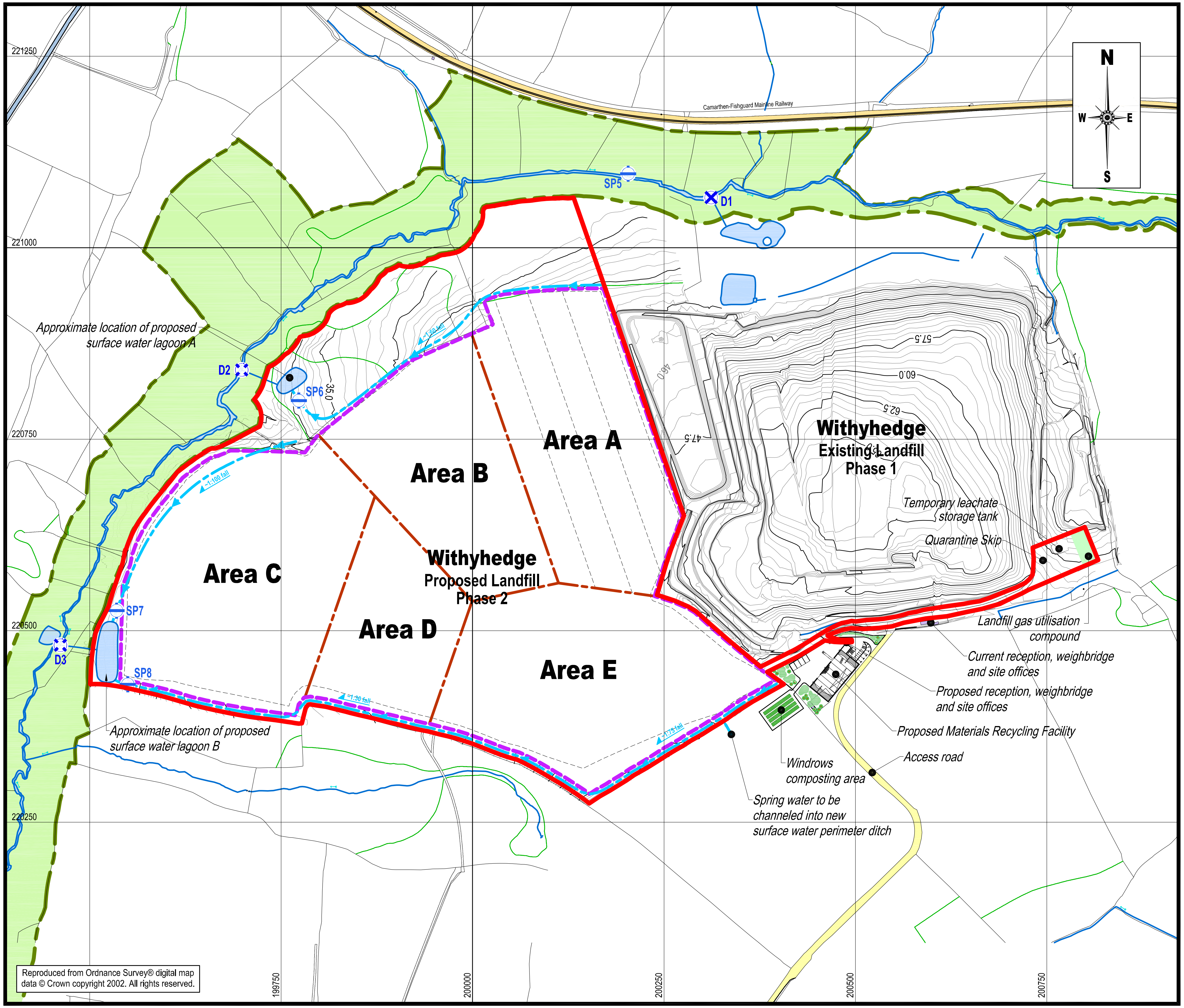
Response

A surface emissions monitoring and action plan is attached as Appendix S4R4.

SUMMARY

Should the Agency not be fully satisfied with any of the response given above, RML request that the Agency informs them of any outstanding issues. Further, we understand that the Agency may seek to address any further issues by way of pre-operational conditions.

DRAWINGS



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NOTES

1. Basal liner (all cells) 1000mm thick engineered clay liner with a maximum permeability 1x10 $^{-9}$ m/s and a 2mm thick HDPE geomembrane liner.
2. Capping system (all cells) to be 1mm thick LLDPE welded geomembrane.

LEGEND

- Installation boundary
- Limit of waste disposal
- Afonydd Cleddau SAC boundary
- 60.0 Ground contour (mAOD)
- Break of slope
- Surface water drainage ditch
- Current location of surface water discharge point to Rudbaxton Water
- Proposed location of surface water discharge point to Rudbaxton Water
- Surface water monitoring point

RML

Resources Management UK Limited
Withyhedge Landfill, Bowling Farm
Rudbaxton, Haverfordwest SA62 4DB

Project
Section A: Environmental Setting and Installation Design

Location
Withyhedge Landfill Phase 2

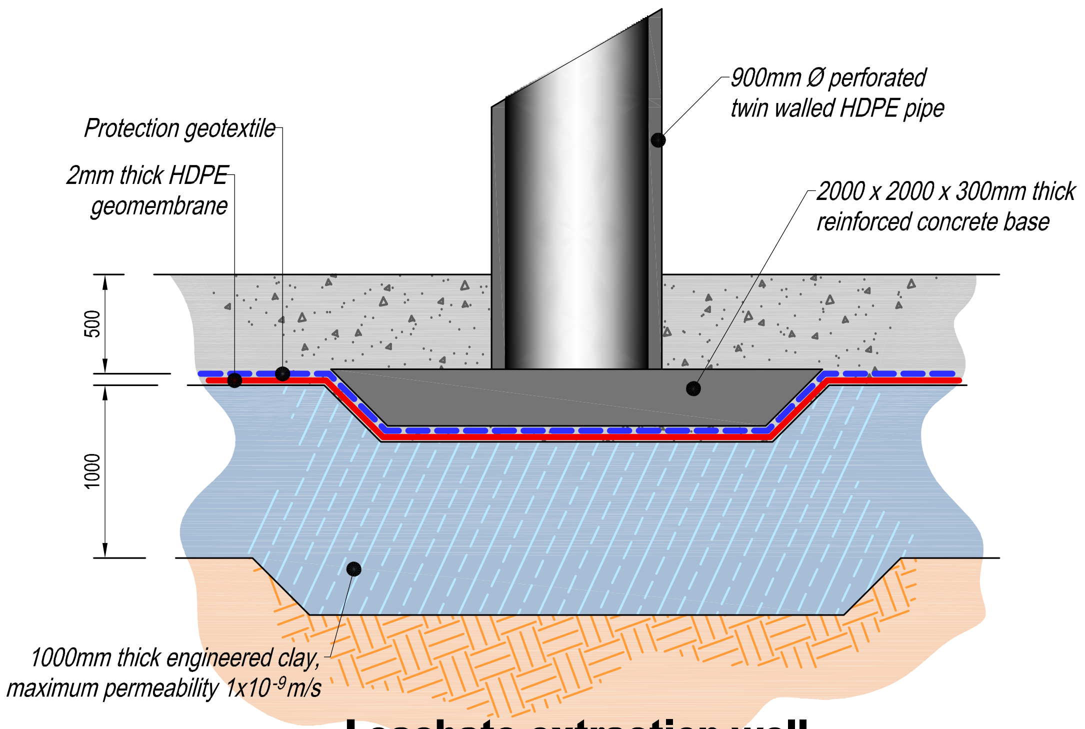
Title
Installation Plan

Project No.	04529421	Engineer	RL	Drawing No.
File No.	5223655r1	Reviewed by	DRWJ	ESID6A
Created by	R.W.			

Description	Date	Revision
Installation Boundary revised	31.01.06	A

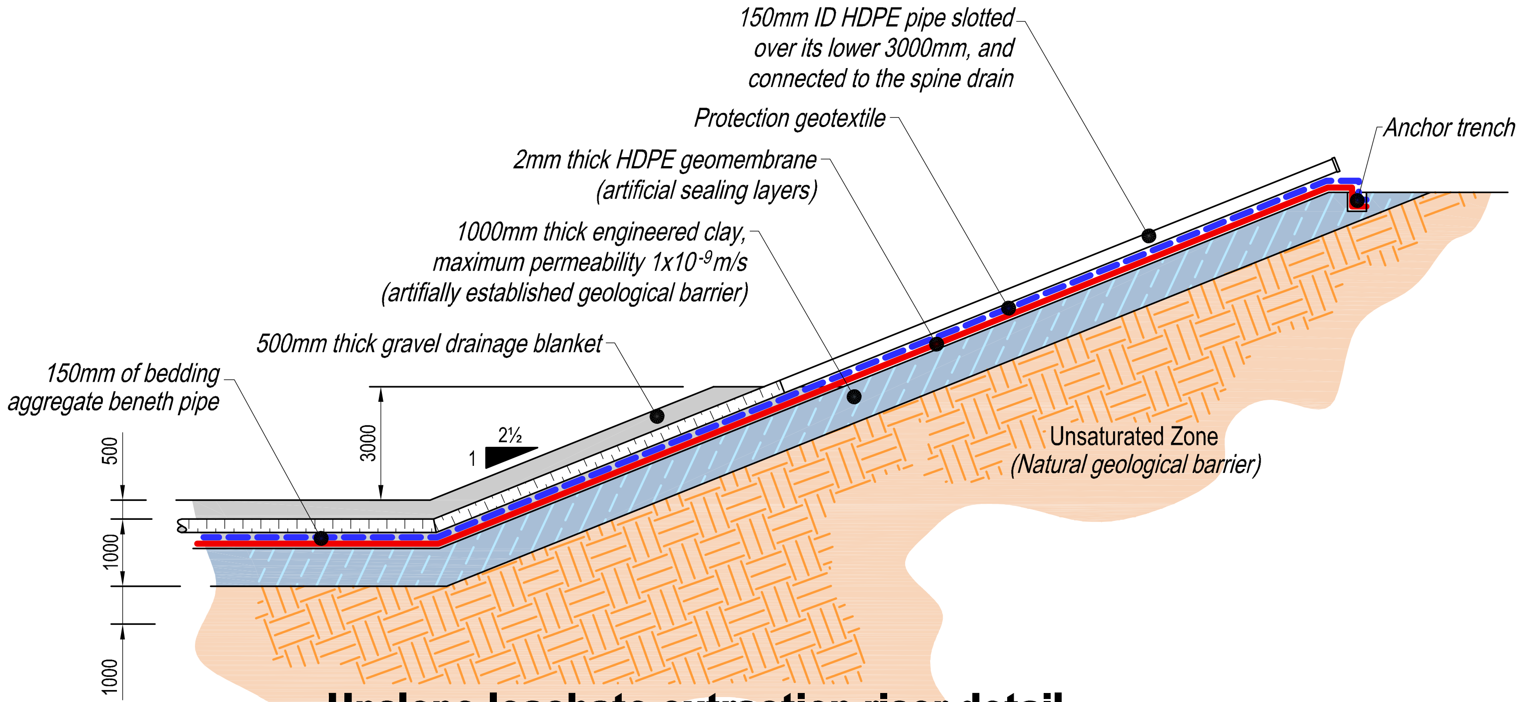
Scale	1:5,000	Date	5th May 2006

Golder Associates



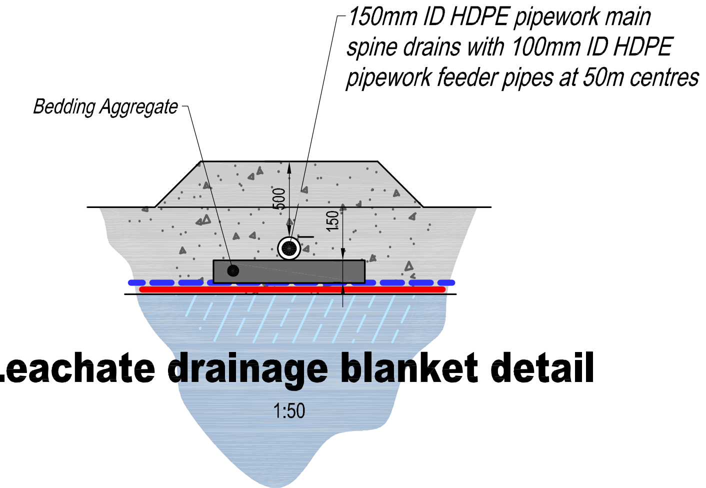
Leachate extraction well

1:40



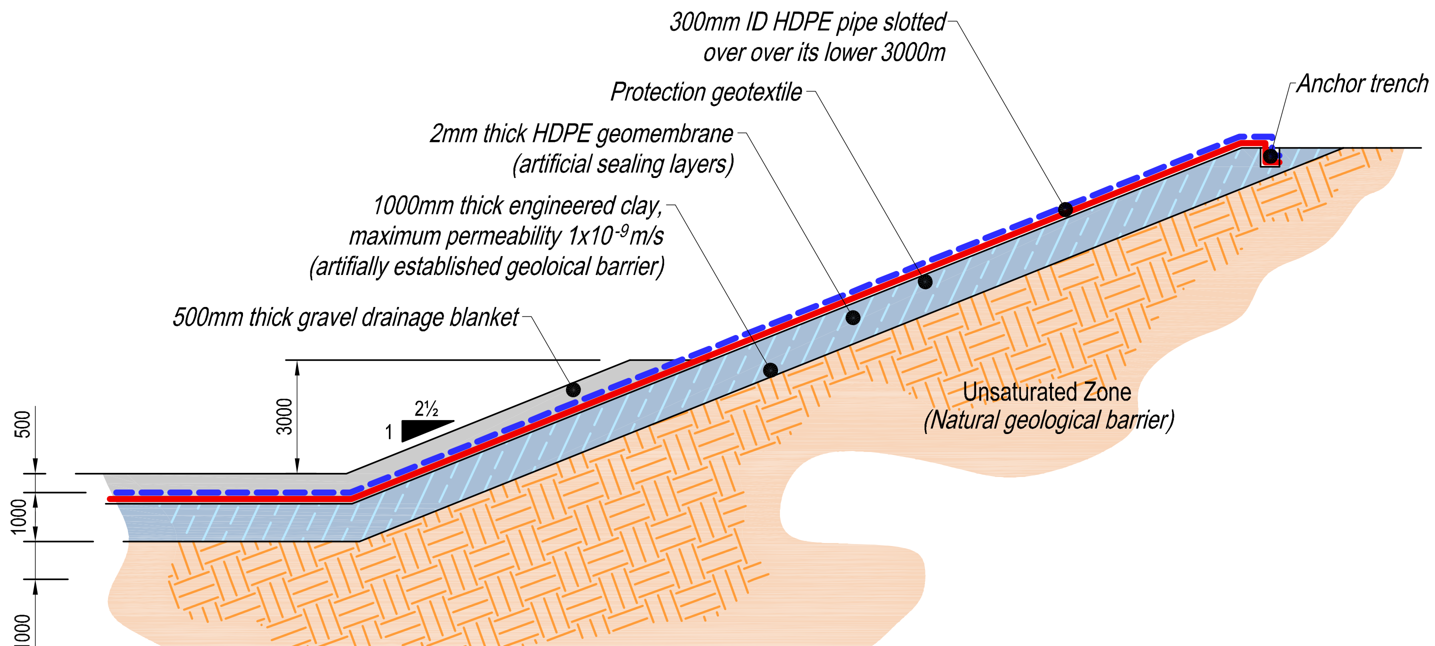
Upslope leachate extraction riser detail

1:200



Leachate drainage blanket detail

1:50



Leachate drainage blanket detail

1:200

RML

Resources Management UK Limited
Withyhedge Landfill, Bowling Farm
Rudbaxton, Haverfordwest SA62 4DB

Project
Section A: Environmental Setting and Installation Design

Location
Withyhedge Landfill Phase 2

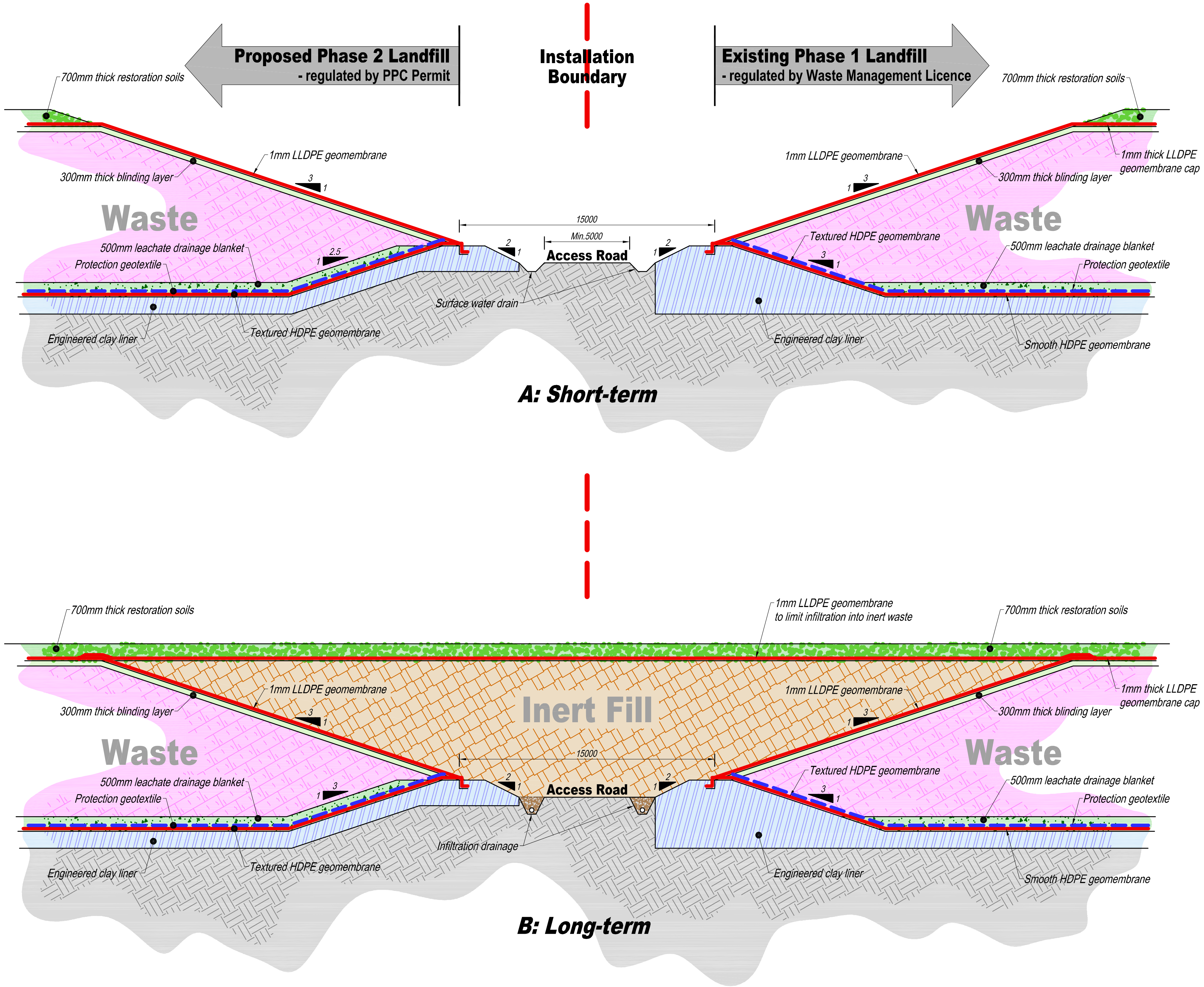
Title
Leachate Management Construction Details

Project No. 04529421	Engineer RL	Drawing No.
File No. 5223658	Reviewed by DRNJ	ESID7B
Created by R.W.		

Description	Date	Revision
Pipework details revised	30.01.06	A

Scale As Shown | Date 5th May 2005

Golder Associates



RML

Resources Management UK Limited
Withyhedge Landfill, Bowling Farm
Rudbaxton, Haverfordwest SA62 4DB

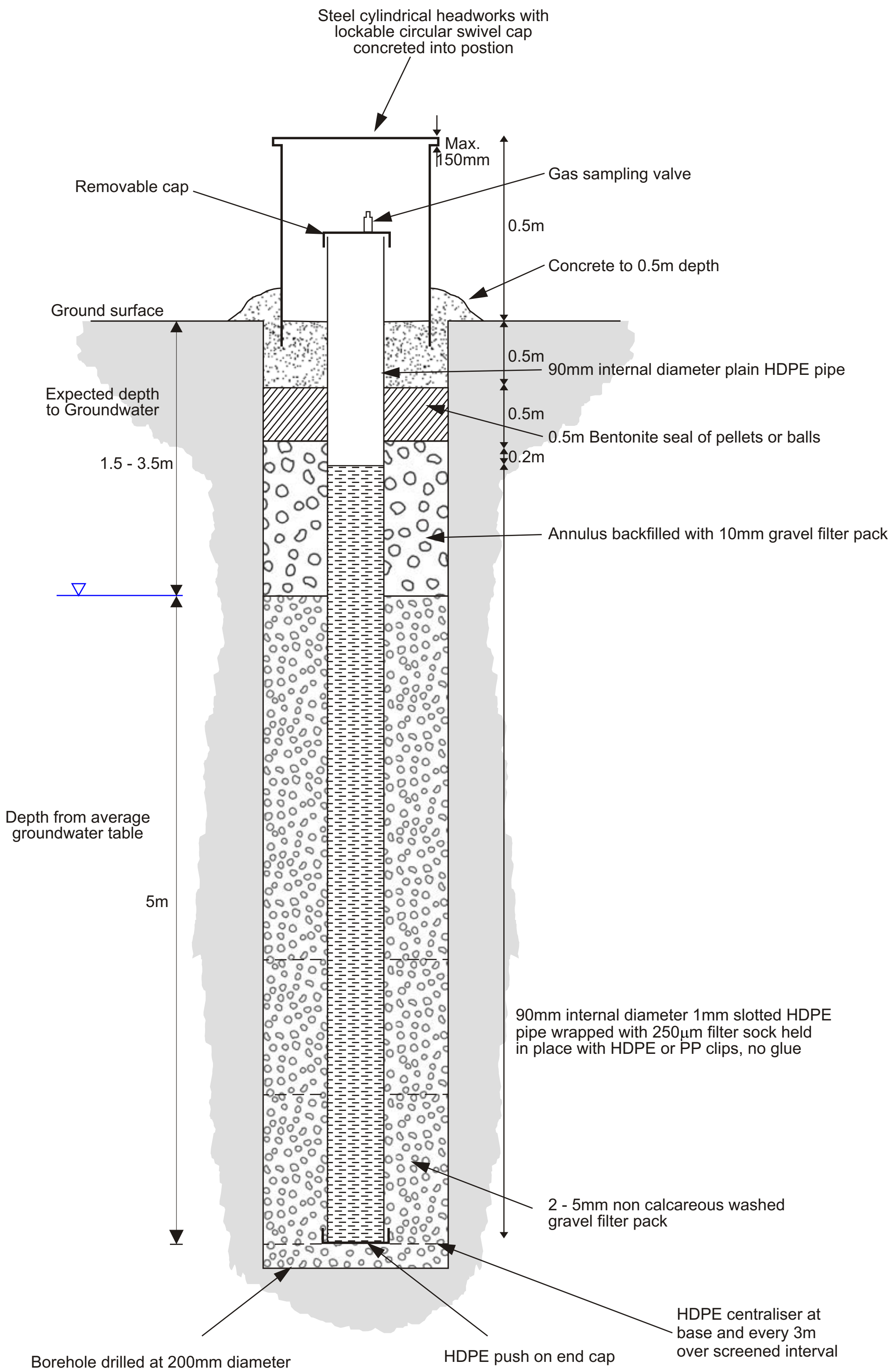
Project
PPC Permit Application

Location
Withyhedge Landfill Site Extension

Title
Proposed Separation Between Phase 1 Landfill and Proposed Phase 2 Landfill

Project No.	04529421	Engineer	RL
File No.	5225304	Reviewed by	DRJ
Created by	A.B.	Drawing No.	S4R1
Scale	Not to scale	Date	31st January 2006

Golder Associates



Not to Scale

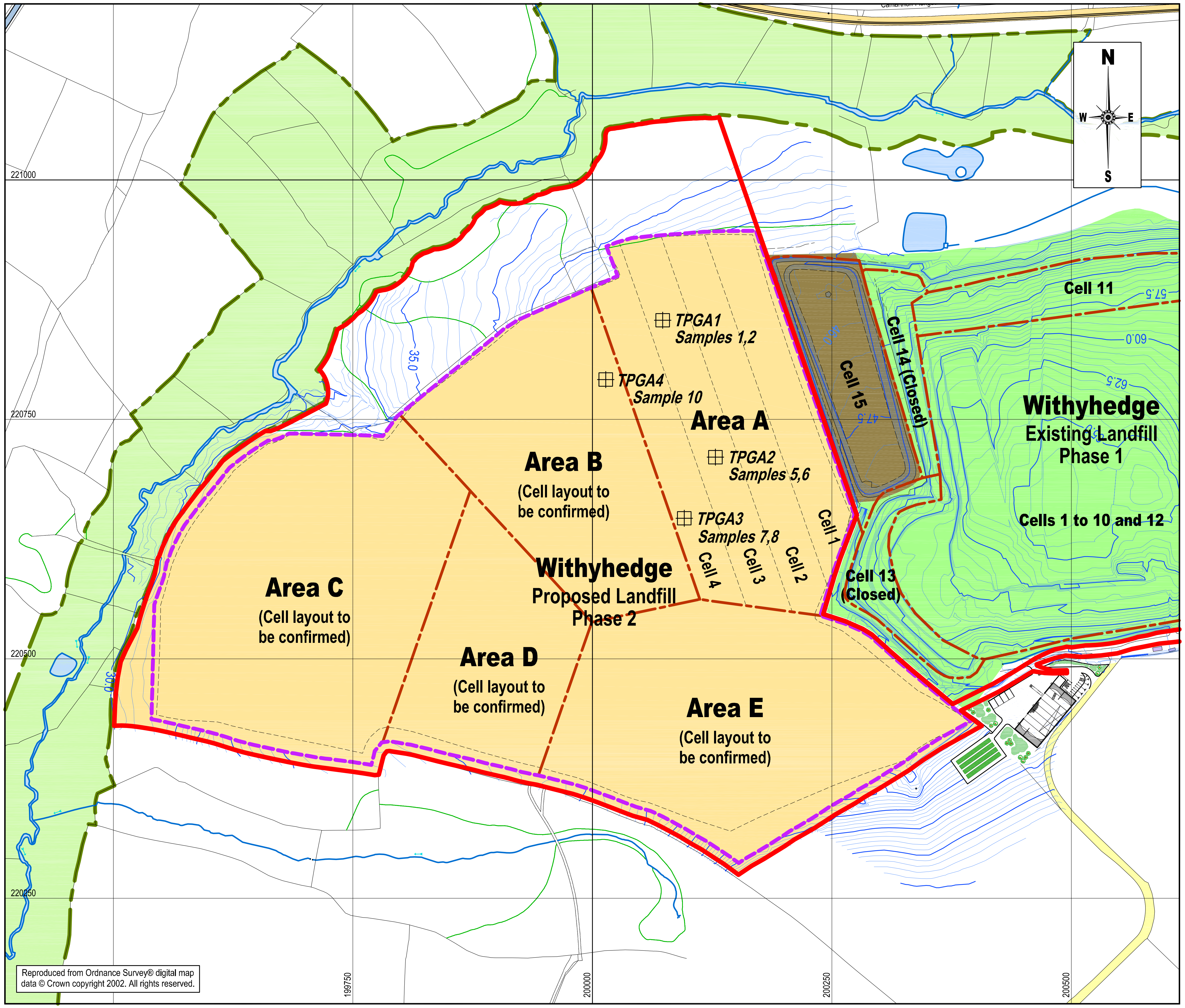
Date	19th January 2006	
Project No.	04529421	
Created by	A.B.	
File No.	5225277r1	

Title

Details of Monitoring Boreholes
Withyhedge Landfill Site

Drawing

S4R2



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LEGEND

- Installation boundary
- Limit of waste disposal
- Afonydd Cleddau cSAC boundary
- Phase boundary
- 62.5 Ground level contour (mAOD)
- Break of slope
- Approximate Location of Trial Pits
- Completed landfill area
- Current landfill area
- Future landfill area

RML

Resources Management UK Limited
Withyhedge Landfill, Bowling Farm
Rudbaxton, Haverfordwest SA62 4DB

Project
Schedule 4 Response

Location
Withyhedge Landfill Phase 2

Title
Trial pit Locations for Samples Taken for Partition Coefficient Testing

Project No. 04529421	Engineer AH	Drawing No.	
File No. 5223653r2	Reviewed by DJ	**S4R3**	
Created by A.B.			
Scale 1:4,000		Date 31st January 2006	

Golder Associates

APPENDICES

APPENDIX S4R1

GROUNDWATER MONITORING RESULTS
(MAY 2005 TO JANUARY 2006)

Withyhedge Landfill groundwater level monitoring data May 2005 to January 2006

	2005								2006				
Location	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**No.**	**Min**	**Max**	**Seasonal Variation**
TP9			41.01	41.68		42.11	41.95	41.73		5	41.01	42.11	1.1
TP10		44.79	47.05	47.03				47.1		4	44.79	47.1	2.31
TP12			41.08	42.08		42.3	41.65	41.45		5	41.08	42.3	1.22
AIGBH101	36.79	36.94	36.75	36.82	36.72	37.65		37.8		7	36.72	37.8	1.08
AIGBH102	38.57	38.28	37.88	37.87	37.95	38.94		38.67		7	37.87	38.94	1.07
AIGBH103	39.89	39.35	39.02	39.08	39.14	41.45	41.42	40.42		8	39.02	41.45	2.43
AIGBH104	42.01	41.6	41.18	41.35	41.3	41.85	43	42.67		8	41.18	43	1.82
AIGBH105	39.79	39.25	38.97	39.33	39.45	39.9		39.69		7	38.97	39.9	0.93
GA1					43.14	43.45	45.38	44.87	45.35	5	43.14	45.38	2.24
GA2					43	43.18	45.09	44.79	45.09	5	43	45.09	2.09

Note: All values given in m AOD

APPENDIX S4R2

PARTITION COEFFICIENT LABORATORY TESTING RESULTS

ALcontrol Geochem

Chester Street,
Chester CH4 8RD
tel: (01244) 671121
fax: (01244) 683306
email: mkt@alcontrol.co.uk

01 NOV 2004

Golder Associates (UK) Limited
Attenborough House
Browns Lane Business Park
Stanton on the Wolds
Nottinghamshire
NG12 5BN ATTN: Richard Lansley

CERTIFICATE OF ANALYSIS

Date: 27 October, 2004

Our Reference: 04/13353/02/01

Your Reference:

Location: Withyhedge

A total of 10 samples was received for analysis on Wednesday, 25 August 2004 and completed on Friday, 22 October 2004. Accredited laboratory tests are defined in the log sheet, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation. We are pleased to enclose our final report, it was a pleasure to be of service to you, and we look forward to our continuing association.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Signed

Hazel Davidson
Operations Manager
Analytical Services

Compiled By ....
Jane Seymour

UKAS TESTING
1291
GROUP

ALcontrol Geochem is a trading division of ALcontrol UK Limited.
Registered Office: Templeborough House, Mill Close, Rotherham, S60 1BZ. Registered in England and Wales No. 4057291

ALcontrol Geochem
TEST SCHEDULE

Numeric values indicate additional scheduling
* Indicates test subcontracted

JOB NUMBER : 04/13353/02
CLIENT : Golder Associates (UK) Limited
CONTACT : Richard Lansley
DATE OF RECEIPT : 25/08/04
LOCATION : Withyhedge

BATCH NUMBER : 1
CLIENT REF/CODE :
ORDER NUMBER :
TURNAROUND : 20 days

Sample Number	Sample Identity	P / V	Depth (m)	Sample Type	Fraction Org Carbon	Part. Coeff.	Ammoniacal Nitrogen (S)	Cadmium
		ISO 17025 Accredited ?			✓			✓
1	TPGA01	BAG	1.00	ROCK	X			
2	TPGA01	BAG	1.80	ROCK	X	X		X
3	TPGA01	BAG	2.50	ROCK	Sample on hold			
4	TPGA01	BAG	3.50	ROCK	Sample on hold			
5	TPGAO2	BAG	1.50-1.80	ROCK	X	X	X	
6	TPGAO2	BAG	2.20	ROCK	X	X	X	X
7	TPGAO3	BAG	1.50	ROCK	X	X	X	X
8	TPGAO3	BAG	2.60	ROCK	X			
9	TPGAO4	BAG	2.50	ROCK	Sample on hold			
10	TPGAO4	BAG	3.90	ROCK	X	X	X	
				Total Number of Tests	7	5	4	3

ALcontrol Geochem Analytical Services
Sample Descriptions

Job Number: 04/13353/02/01
Client: Golder Associates (UK) Limited
Client Ref :

Grain sizes

<0.063mm	Very Fine
0.1mm - 0.063mm	Fine
0.1mm - 2mm	Medium
2mm - 10mm	Coarse
>10mm	Very Coarse

Sample Identity	Depth (m)	Colour	Grain Size	Description	Batch
TPGA01	1.0	Brown	<0.063mm	Silt with some Stones	1
TPGA01	1.8	Brown	<0.063mm	Silty Clay with some Stones	1
TPGAO2	1.5-1.8	Brown	<0.063mm	Silty Clay with some Stones	1
TPGAO2	2.2	Brown	>10mm	Gravel	1
TPGAO3	1.5	Light Grey	<0.063mm	Silty Clay with some Stones	1
TPGAO3	2.6	Brown	>10mm	Gravel	1
TPGAO4	3.9	Dark Grey	<0.063mm	Silty Clay with some Stones	1

Validated ☑
Preliminary ☐

ALcontrol Geochem Analytical Services
Table Of Results

ISO 17025 accredited
M MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 04/13353/02/01 **Matrix:** SOLID
Client: Golder Associates (UK) Limited **Location:** Withyhedge
Client Ref. No.: **Client Contact:** R[illegible]rd Lansley

Sample Identity	TPGA01	TPGA01	TPGAO2	TPGAO2	TPGAO3	TPGAO3	TPGAO4			Method Code	LoD/Units
Depth (m)	1.0	1.8	1.5-1.8	2.2	1.5	2.6	3.9				
Sample Type	ROCK	ROCK	ROCK	ROCK	ROCK	ROCK	ROCK				
Sampled Date											
Sample Received Date	25.08.04	25.08.04	25.08.04	25.08.04	25.08.04	25.08.04	25.08.04				
Batch	1	1	1	1	1	1	1				
Sample Number(s)	1	2	5	6	7	8	10				
Cadmium	-	<1	-	<1	<1	-	-			TM129#	<1 mg/kg
Ammoniacal Nitrogen as N	-	-	10.1	9.3	10.0	-	9.4			TM024	<0.3 mg/kg
Fraction of Organic Carbon	0.004	0.001	0.001	0.002	0.002	0.005	0.019			TM050#	<0.001 NONE

All results expressed on a dry weight basis.

Date 22.10.2004

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 04/13353/02/01
Client: Golder Associates (UK) Limited
Client Ref. No.:

Report Key :

NDP	No Determination Possible	*	Subcontracted test
NFD	No Fibres Detected	»	Result previously reported (Incremental reports only)
#	ISO 17025 accredited	M	MCERTS Accredited
		EC	Equivalent Carbon (Aromatics C8-C35)

Note: Method detection limits are not always achievable due to various circumstances beyond our control.

Summary of Method Codes contained within report :

Method No.	Reference	Description	ISO 17025 Accredited	MCERTS Accredited	Wet/Dry Sample [1]
TM024	Method 4500A & B, AWWA/APHA, 20th Ed., 1999	Determination of Exchangeable Ammonium in soil samples	N	N	WET
TM050	Method 5310B, AWWA/APHA, 20th Ed., 1999 / DIN EN 13137	Total Organic Carbon determination by combustion method	Y	N	DRY
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer	Y	N	DRY

[1] Applies to Solid samples only. **DRY** indicates samples have been dried at 35°C. **NA** = not applicable.

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 04/13353/02/01
Client: Golder Associates (UK) Limited
Client Ref. No.:

Summary of Coolbox temperatures

Batch No.	Coolbox Temperature (°C)
1	NA

PARTITION COEFFICIENTS

ANALYTE	Cadmium	Cd
DATE STARTED	22/09/04	
DATE FINISHED	22/10/04	

	A1	A2	B1	B2	C1	C2	D1	D2
CONCENTRATION DAY 0 ug/L								
Conc. mg/l spike	0.00	0.00	50.00	50.00	250.00	250.00	500.00	500.00
Actual Conc. mg/l	<0.001	<0.001	50	50	250.00	250.00	500.00	500.00
pH	6.4	6.5	4.5	4.5	3.7	3.7	3.4	3.4
Weight taken in grams	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Volume of spike (mls)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
CONCENTRATION DAY 7								
JOB No./SAMPLE No.								
13353/2	<0.001	<0.001	0.08	0.25	5.05	5.79	34.80	36.59
13353/7	<0.001	<0.001	0.03	0.08	0.23	0.23	0.46	0.38
13353/10	<0.001	<0.001	0.48	0.71	1.22	0.69	1.36	1.27
CONTROL NO SOIL	<0.001	<0.001	6.43	4.50	172.10	182.90	432.20	436.30
pH after filtering on Day 7								
JOB No./SAMPLE No.	A1	A2	B1	B2	C1	C2	D1	D2
13353/2	4.59	4.49	4.86	4.98	4.47	4.49	4.47	4.47
13353/7	4.71	4.62	4.57	4.63	4.67	4.63	4.83	4.85
13353/10	3.64	3.66	3.72	3.73	3.85	3.74	3.75	3.79
CONTROL NO SOIL	6.2	6.3	4.5	4.5	3.7	3.7	3.4	3.4
Calculated Kd								
	A1	A2	B1	B2	C1	C2	D1	D2
JOB No./SAMPLE No.								
13353/2	-	-	6240	2023	485	422	134	127
13353/7	-	-	16657	6484	10860	10813	10813	13218
13353/10	-	-	1025	691	2034	3592	3672	3921
TEMP READINGS °C	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	
TEMP READINGS °C	20	20	19	18	20	19	19	

$$Kd = [(I-F)/F] \times (V/M)$$

I = Initial Concentration (mg/l)
F = Final Concentration (mg/l)
V = Volume of liquid (g)
M = Mass of solid (g)

Ref: CEC and kD Determination in Landfill Performance Evaluation
Research and Development
Project Record P1/254/01 (page 13)

PARTITION COEFFICIENTS

ANALYTE	**Ammonium**	**NH4**
DATE STARTED	22/09/04	
DATE FINISHED	22/10/04	

CONCENTRATION DAY 0								
	A1	A2	B1	B2	C1	C2	D1	D2
Conc. mg/l spike	**0.00**	**0.00**	**250.00**	**250.00**	**500.00**	**500.00**	**1000.00**	**1000.00**
Actual Conc. mg/l	<0.03	<0.03	250.00	249.32	499.78	500.02	1000.00	1000.00
pH	6.18	6.23	5.78	6.01	5.64	5.67	5.87	5.46
Weight taken in grams	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
Volume of spike (mls)	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**
	CONCENTRATION DAY 7							
JOB No./SAMPLE No.								
13353/5	<0.03	<0.03	221.0	225.30	476.80	472.60	961.24	919.67
13353/6	<0.03	<0.03	233.8	235.30	497.30	495.32	997.36	995.34
13353/7	<0.03	<0.03	208.1	201.60	446.10	438.60	984.51	987.69
13353/10	<0.03	<0.03	240.1	242.50	488.30	487.32	988.23	950.15
CONTROL NO SOIL	<0.03	<0.03	260.00	262.00	499.00	505.10	1001.22	1003.00
	pH after filtering on Day 7							
JOB No./SAMPLE No.	A1	A2	B1	B2	C1	C2	D1	D2
13353/5	4.59	4.49	4.86	4.98	4.47	4.49	4.47	4.47
13353/6	4.47	4.52	4.47	4.39	4.56	4.42	4.70	4.63
13353/7	4.49	4.94	4.37	4.33	4.38	4.34	4.39	4.47
13353/10	4.71	4.62	4.57	4.63	4.67	4.63	4.83	4.85
CONTROL NO SOIL	6.12	6.21	4.55	4.55	4.59	4.61	4.73	4.72
	Calculated Kd							
	A1	A2	B1	B2	C1	C2	D1	D2
JOB No./SAMPLE No.								
13353/5	-	-	1.31	1.07	0.48	0.58	0.40	0.87
13353/6	-	-	0.69	0.60	0.05	0.09	0.03	0.05
13353/7	-	-	2.01	2.37	1.20	1.40	0.16	0.12
13353/10	-	-	0.41	0.28	0.24	0.26	0.12	0.52
TEMP READINGS °C	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	
TEMP READINGS °C	20	20	19	18	20	19	19	

$$Kd = [(I-F)/F] \times (V/M)$$

I = Initial Concentration (mg/l)
F = Final Concentration (mg/l)
V = Volume of liquid (g)
M = Mass of solid (g)

Ref : CEC and kD Determination in Landfill Performance Evaluation
Research and Development
Project Record P1/254/01 (page 13)

APPENDIX

APPENDIX

1. Results are expressed on a dry weight basis (dried at 35°C) for all soil analyses except for the following:
   NRA Leach tests, flash point, ammoniacal N_2 by the BRE method, VOC TICS, SVOC TICS, TOF-MS SCAN/SEARCH and TOF-MS TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. A sub sample of all samples received will be retained free of charge for one month for both soils and waters (sample size permitting), but may then be discarded unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited be ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, an asbestos screen is done in-house on soils and if no fibres are found will be reported as NFD – no fibres detected. If asbestos is detected, then identification and quantification is carried out by ALcontrol Technichem. If a sample is suspected of containing asbestos, then drying and crushing will be suspended on that sample until the asbestos results is known. If asbestos is present, then no analysis requiring dry sample will be undertaken.

7. If no separate volatile sample is supplied be the client, the integrity of the data may be compromised if the laboratory is required to create a sub-sample from the bulk sample – similarly, if a headspace is present in the volatile sample.

8. NDP – No determination possible due to insufficient/unsuitable sample.

9. Metals in water are performed on a filtered sample, and therefore represent dissolved metals – total metals must be requested separately.

10. A table containing the date of analysis for each parameter is not routinely included with the report, but is available upon request.

Last updated June 2004

ALCONTROL GEOCHEM - MCERTS UPDATE (1st October 2004)

Annex A (normative)

Table 1 - Performance characteristics (metals and organometallics)	UKAS	MCERTS
Antimony	yes	p
Arsenic	yes	p
Barium	yes	p
Beryllium	yes	p
Boron (water soluble)	yes	p
Cadmium	yes	p
Cobalt	yes	p
Copper	yes	p
Chromium	yes	p
Iron	yes	p
Lead	yes	p
Manganese	yes	p
Mercury	yes	p
Molybdenum	yes	p
Nickel	yes	p
Organolead compounds	no	no
Organotin compounds	no	no
Selenium	yes	p
Thallium	yes	p
Vanadium	yes	p
Zinc	yes	p

Table 2 - Performance characteristics (inorganics)	UKAS	MCERTS
Easily liberated cyanide	yes	yes
Complex cyanide	yes	yes
Sulphide	yes	no - p
Sulphate	yes	p
Sulphur	yes	no - p
Thiocyanate	yes	yes

Tabel 3 - Performance characteristics (organics)	UKAS	MCERTS
Benzene	yes	yes
Benzo[a]pyrene	yes	p
Chlorobenzene	yes	yes
Chloromethane	yes	p
Chlorophenol	yes	p
Chlorotoluene	yes	p
1,2-dichloroethane	yes	p
Dichloromethane	yes	p
"Dioxins"	no	no
Ethylbenzene	yes	p
"Furans"	no	no
Hexachloro-1,3-butadiene	yes	p
"Hydrocarbons"	yes	yes
"Nitroaromatics"	yes	p
Pentachlorophenol	p	no - p
"Phenols"	yes	p
"Phthalate esters"	p	no - p
"Polyaromatic hydrocarbons" - 16	yes	13
"Polychlorinated biphenyls"	yes	no - p
Tetrachloroethane	yes	p
Tetrachloroethene	yes	yes
Tetrachloromethane (carbon tetrachloride)	yes	yes
Toluene	yes	yes
Trichloroethane	yes	p
Trichloroethene	yes	yes
Trichloromethane (chloroform)	yes	p
Vinyl chloride	yes	yes
Xylene	yes	p

yes - accreditation awarded
p = pending - data meeting MCERTS criteria submitted to UKAS - awaiting certification
no - p = data not yet submitted - will be in next few weeks
no = not being submitted in the near future

APPENDIX S4R3

REVISED LANDSIM MODEL INPUT PARAMETERS

Calculation Settings

Number of iterations: 201

Results calculated using sampled PDFs

Full Calculation

Clay Liner:

Retarded values used for simulation

Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

Biodegradation

Saturated Vertical Pathway:

No Vertical Pathway

Aquifer Pathway:

Unretarded values used for simulation

No Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Mecoprop c (kg/l): 0.57	Non-Volatile m (kg/l): 0
Naphthalene Half life (years): 10	Volatile
Phenols Half life (years): 10	Volatile

Contaminant Half-lives (years)

Unsaturated Pathway:

Phenols	UNIFORM(0.14,0.82)

Background Concentrations of Contaminants

Justification for Contaminant Properties

No contaminant properties input for aquifer pathway

All units in milligrams per litre

Phase: Phase 2A

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268.7,26.81)
End of filling (years from start of waste deposit):	11
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Calculated using soil moisture budgeting equations to monthly average rainfall and poerntial evaporation data from 1961 - 1990. (Rainfall data: Aberporth Met Station, www.met-office.gov.uk) (Potential Evaporation data: South west wales region reported on http://www.ncl.ac.uk/wrincle) .

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	125.2
Cell length (m):	125.2
Cell top area (ha):	1.7242
Cell base area (ha):	1.5675
Number of cells:	4
Total base area (ha):	6.27
Total top area (ha):	6.8968
Head of Leachate when surface water breakout occurs (m)	SINGLE(4)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(6,24)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry

Measured from site design drawings. Dry density of waste taken from Beaven and Powrie (1995)

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Mecoprop	LOGTRIANGULAR(0.000253,0.011,0.14)
	Substance to be treated as List 1
Naphthalene	LOGTRIANGULAR(5e-005,0.00046,0.042)
	Substance to be treated as List 1
Phenols	LOGUNIFORM(5e-005,12)
	Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate

In the absence of leachate composition data for this phase of development the LandSim default leachate source term has been applied for Ammoniacal Nitrogen (with maximum conc increase to take account of max observed in existing site), Cadmium, Chloride and Nickel.

Range of concentrations of Mecoprop and Naphthalene have been taken from Knox et al. (2000).

Range of concentrations for Phenol have been based on values from Robinson and Gronow (1995) and site specific data. [CHANGED]

Drainage Information

Fixed Head.

Head on EBS is given as (m): SINGLE(1)

Justification for Specified Head

Specified Leachate head of 1 m

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Composite Liner with Leak Detection Survey Specified

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1.53,1.95)
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):

Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
FML installed under CQA supervision with a leak detection survey and defects repaired.

Hydraulic conductivity of mineral lower liner (m/s): LOGTRIANGULAR(3e-010,4.35e-010,1e-009)

Justification for Composite: Clay or BES Substrate Properties
Derived properties from Withyhedge (Phase 1) Cell 15

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.001,0.001,0.004)

Justification for Liner Kd Values by Species
Ammonium Kd obtained from site specific testing of glacial clay at the site.
Cadmium Kd obtained from site specific testing of glacial clay at the site.
foc obtained from site specific testing of glacial clay at the site.
Nickel Kd taken from ConSim help files for Glacial Till.
Naphthalene and Phenol Koc taken from ConSim help files.
Mecoprop Koc taken from Toxnet database.

pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
Site Engineered to ensure a 1 m thick unsaturated zone

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(1e-008,1e-005)

Justification for Unsat Zone Hydraulics Properties
Taken from testing data of the fluvio glacial deposits (AIGC, 2003)

Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
10% Pathway length

Retardation parameters for pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	LOGTRIANGULAR(0.001,0.002,0.019)

Justification for Kd Values by Species

Unsaturated material comprising weathered shale and glacial deposits characterised by Kd testing for ammonium and cadmium. In addition foc analysis has ben carried out for these geological units. Kd of other contaminant species has been obtained from the consim help files.

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(690,890)
Pathway width (m):	SINGLE(440)

Phase: Phase 2B

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268.7,26.87)
End of filling (years from start of waste deposit):	20
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Calculated using soil moisture budgeting equations to monthly average rainfall and poerntial evaporation data from 1961 - 1990. (Rainfall data: Aberporth Met Station, www.met-office.gov.uk) (Potential Evaporation data: South west wales region reported on http://www.ncl.ac.uk/wrincle)

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	88.8
Cell length (m):	88.8
Cell top area (ha):	0.8674
Cell base area (ha):	0.788544
Number of cells:	7
Total base area (ha):	5.51981
Total top area (ha):	6.0718
Head of Leachate when surface water breakout occurs (m)	SINGLE(6)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(2,24)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry

Measured from site design drawings. Dry density of waste taken from Beaven and Powrie (1995)

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Mecoprop	LOGTRIANGULAR(0.000253,0.011,0.14) *Substance to be treated as List 1*
Naphthalene	LOGTRIANGULAR(5e-005,0.00046,0.042) *Substance to be treated as List 1*
Phenols	LOGUNIFORM(5e-005,12) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate

In the absence of leachate composition data for this phase of development the LandSim default leachate source term has been applied for Ammoniacal Nitrogen (with maximum conc increase to take account of max observed in existing site), Cadmium, Chloride and Nickel.

Range of concentrations of Mecoprop and Naphthalene have been taken from Knox et al. (2000).

Range of concentrations for Phenol have been based on values from Robinson and Gronow (1995) and site specific data. [CHANGED]

Drainage Information

Fixed Head.

Head on EBS is given as (m):	SINGLE(1)

Justification for Specified Head

Specified leachate head

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Composite Liner

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1.53,1.95)
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):	
Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
FML installed under CQA supervision with a leak detection survey and defects repaired

Hydraulic conductivity of mineral lower liner (m/s): LOGTRIANGULAR(3e-010,4.35e-010,1e-009)

Justification for Composite: Clay or BES Substrate Properties
Values derived from data for Cell 15 CQA (Withyhedge Phase 1)

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)

Fraction of Organic Carbon (fraction) TRIANGULAR(0.001,0.001,0.004)

Justification for Liner Kd Values by Species
See Phase 2A

pathway parameters

Modelled as unsaturated pathway	
Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
Engineered to provide an unsaturated zone of 1m

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(1e-008,1e-005)

Justification for Unsat Zone Hydraulics Properties
Derived from testing of the glacial deposits

Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
10% Pathway length

Retardation parameters for pathway
Modelled as unsaturated pathway
Uncertainty in Kd (l/kg):

Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	LOGTRIANGULAR(0.001,0.002,0.019)

Justification for Kd Values by Species
See Phase 2A

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(390,690)
Pathway width (m):	SINGLE(350)

Phase: Phase 2C

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268.7,26.87)
End of filling (years from start of waste deposit):	27
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Calculated using soil moisture budgeting equations to monthly average rainfall and poerntial evaporation data from 1961 - 1990. (Rainfall data: Aberporth Met Station, www.met-office.gov.uk) (Potential Evaporation data: South west wales region reported on http://www.ncl.ac.uk/wrincle)

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	103.622
Cell length (m):	103.622
Cell top area (ha):	1.18113
Cell base area (ha):	1.07375
Number of cells:	8
Total base area (ha):	8.59
Total top area (ha):	9.449
Head of Leachate when surface water breakout occurs (m)	SINGLE(6)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(2,14)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry

Measured from site design drawings. Dry density of waste taken from Beaven and Powrie (1995)

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Mecoprop	LOGTRIANGULAR(0.000253,0.011,0.14) *Substance to be treated as List 1*
Naphthalene	LOGTRIANGULAR(5e-005,0.00046,0.042) *Substance to be treated as List 1*
Phenols	LOGUNIFORM(5e-005,12) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
In the absence of leachate composition data for this phase of development the LandSim default leachate source term has been applied for Ammoniacal Nitrogen (with maximum conc increase to take account of max observed in existing site), Cadmium, Chloride and Nickel.
Range of concentrations of Mecoprop and Naphthalene have been taken from Knox et al. (2000).
Range of concentrations for Phenol have been based on values from Robinson and Gronow (1995) and site specific data. [CHANGED]

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(1)

Justification for Specified Head
Specified leachate head

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Composite Liner

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1.53,1.95)
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):	
Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
FML installed under CQA supervision with a leak detection survey and defects repaired

Hydraulic conductivity of mineral lower liner (m/s):	LOGTRIANGULAR(3e-010,4.35e-010,1e-009)

Justification for Composite: Clay or BES Substrate Properties
Derived from CQA data for Cell 15 (Withyhedge Phase 1)

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.001,0.001,0.004)

Justification for Liner Kd Values by Species
see Phase 2A

pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
Engineered to provide UZ of 1 m

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(1e-008,1e-005)

Justification for Unsat Zone Hydraulics Properties
Derived propeties

Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
10% Pathway Lenth

Retardation parameters for pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	LOGTRIANGULAR(0.001,0.002,0.019)

Justification for Kd Values by Species
see Phase 2A

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(10,390)
Pathway width (m):	SINGLE(360)

Phase: Phase 2D

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268.7,26.87)
End of filling (years from start of waste deposit):	32
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Calculated using soil moisture budgeting equations to monthly average rainfall and poerntial evaporation data from 1961 - 1990. (Rainfall data: Aberporth Met Station, www.met-office.gov.uk) (Potential Evaporation data: South west wales region reported on http://www.ncl.ac.uk/wrincle)

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	76.59
Cell length (m):	76.59
Cell top area (ha):	0.645333
Cell base area (ha):	0.586603
Number of cells:	6
Total base area (ha):	3.51962
Total top area (ha):	3.872
Head of Leachate when surface water breakout occurs (m)	SINGLE(12)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(2,22)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry

Measured from site design drawings. Dry density of waste taken from Beaven and Powrie (1995)

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Mecoprop	LOGTRIANGULAR(0.000253,0.011,0.14) *Substance to be treated as List 1*
Naphthalene	LOGTRIANGULAR(5e-005,0.00046,0.042) *Substance to be treated as List 1*
Phenols	LOGUNIFORM(5e-005,12) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate

In the absence of leachate composition data for this phase of development the LandSim default leachate source term has been applied for Ammoniacal Nitrogen (with maximum conc increase to take account of max observed in existing site), Cadmium, Chloride and Nickel.

Range of concentrations of Mecoprop and Naphthalene have been taken from Knox et al. (2000).

Range of concentrations for Phenol have been based on values from Robinson and Gronow (1995) and site specific data. [CHANGED]

Drainage Information

Fixed Head.

Head on EBS is given as (m):	SINGLE(1)

Justification for Specified Head

Specified leachate head

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Composite Liner

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1.53,1.95)
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):	
Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
FML installed under CQA supervision with a leak detection survey and defects repaired

Hydraulic conductivity of mineral lower liner (m/s):	LOGTRIANGULAR(3e-010,4.35e-010,1e-009)

Justification for Composite: Clay or BES Substrate Properties
Derived from data for Cell 15 (Withyhedge Phase1)

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.001,0.001,0.004)

Justification for Liner Kd Values by Species
see Phase 2A

pathway parameters

Modelled as unsaturated pathway	
Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
Site engineered to allow for 1 m of unsaturated zone

Pathway hydraulic conductivity values (m/s):	LOGUNIFORM(1e-008,1e-005)

Justification for Unsat Zone Hydraulics Properties
Derived from site specific testing

Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
10% Pathway Length

Retardation parameters for pathway
Modelled as unsaturated pathway
Uncertainty in Kd (l/kg):

Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	LOGTRIANGULAR(0.001,0.002,0.019)

Justification for Kd Values by Species
see Phase 2A

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(390,590)
Pathway width (m):	SINGLE(280)

Phase: Phase 2E

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(30,3)
Infiltration to waste (mm/year):	NORMAL(338,33.8)
Infiltration to grassland (mm/year):	NORMAL(268.7,28.81)
End of filling (years from start of waste deposit):	44
Start of cap degradation (years from end of waste deposit):	250
End of cap degradation (years from end of waste deposit):	1000

Justification for Specified Infiltration

Calculated using soil moisture budgeting equations to monthly average rainfall and poerntial evaporation data from 1961 - 1990. (Rainfall data: Aberporth Met Station, www.met-office.gov.uk) (Potential Evaporation data: South west wales region reported on http://www.ncl.ac.uk/wrincle)

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	107.5
Cell length (m):	107.5
Cell top area (ha):	1.27142
Cell base area (ha):	1.15562
Number of cells:	6
Total base area (ha):	6.93375
Total top area (ha):	7.6285
Head of Leachate when surface water breakout occurs (m)	SINGLE(8)
Waste porosity (fraction)	UNIFORM(0.1,0.25)
Final waste thickness (m):	UNIFORM(6,24)
Field capacity (fraction):	UNIFORM(0.08,0.15)
Waste density (kg/l)	UNIFORM(0.29,0.53)

Justification for Landfill Geometry

Measured from site design drawings. Dry density of waste taken from Beaven and Powrie (1995)

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Mecoprop	LOGTRIANGULAR(0.000253,0.011,0.14) *Substance to be treated as List 1*
Naphthalene	LOGTRIANGULAR(5e-005,0.00046,0.042) *Substance to be treated as List 1*
Phenols	LOGUNIFORM(5e-005,12) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate

In the absence of leachate composition data for this phase of development the LandSim default leachate source term has been applied for Ammoniacal Nitrogen (with maximum conc increase to take account of max observed in existing site), Cadmium, Chloride and Nickel.

Range of concentrations of Mecoprop and Naphthalene have been taken from Knox et al. (2000).

Range of concentrations for Phenol have been based on values from Robinson and Gronow (1995) and site specific data. [CHANGED]

Drainage Information

Fixed Head.

Head on EBS is given as (m): SINGLE(1)

Justification for Specified Head

Specified leachate head

Barrier Information

There is a composite barrier

Justification for Engineered Barrier Type
Composite Liner

Liner installed under CQA	
Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1.53,1.95)
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Onset of FML degradation (years since filling commenced)	150
Pathway longitudinal dispersivity (m):	SINGLE(0.1)
Time for area of defects to double (years)	100

Membrane defects (number per hectare):	
Pin holes:	Minimum 0, Maximum 5
Holes:	Minimum 0, Maximum 2
Tears:	Minimum 0, Most Likely 0, Maximum 0

The most likely value for the PDFs representing the density of pinholes and holes will move from the minimum value selected above to the maximum value selected above over the time period before FML degradation commences

Justification for Composite: Flexible Membrane Liner
FML installed under CQA supervision with a leak detection survey and defects repaired

Hydraulic conductivity of mineral lower liner (m/s):	LOGTRIANGULAR(3e-010,4.35e-010,1e-009)

Justification for Composite: Clay or BES Substrate Properties
Derived from CQA data for Cell 15 (Withyhedge Phase1).

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)
Fraction of Organic Carbon (fraction)	TRIANGULAR(0.001,0.001,0.004)

Justification for Liner Kd Values by Species
see Phase 2A

pathway parameters

Modelled as unsaturated pathway	
Pathway length (m):	SINGLE(1)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.16,0.18)
Pathway Density (kg/l):	UNIFORM(1.53,1.95)

Justification for Unsat Zone Geometry
see Phase 2A

Pathway hydraulic conductivity values (m/s): LOGUNIFORM(1e-008,1e-005)

Justification for Unsat Zone Hydraulics Properties
see Phase 2A

Pathway longitudinal dispersivity (m): SINGLE(0.1)

Justification for Unsat Zone Dispersion Properties
10% Pathway

Retardation parameters for pathway

Modelled as unsaturated pathway	
Uncertainty in Kd (l/kg):	
Mecoprop: Calculated kd	
Partition to Organic Carbon ml/g	UNIFORM(5.3,13.3)
Naphthalene: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(1288)
Phenols: Calculated kd	
Partition to Organic Carbon ml/g	SINGLE(27)

Fraction of Organic Carbon (fraction) LOGTRIANGULAR(0.001,0.002,0.019)

Justification for Kd Values by Species
see Phase 2A

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(595,1045)
Pathway width (m):	SINGLE(280)

pathway parameters

No Vertical Pathway

pathway parameters

Modelled as aquifer pathway.

Mixing zone (m):

Calculated. Aquifer Thickness: SINGLE(20)

Justification for Aquifer Geometry
Measured from Local Hydrogeology Drawing

Darcy flux (m/s): LOGNORMAL(8.57e-007,8.57e-008)

Pathway porosity (fraction): LOGUNIFORM(0.01,0.1)

Justification for Aquifer Hydraulics Properties
Darcy Flux calculated by estimating the recharge volume to the catchment.

Pathway longitudinal dispersivity (m): UNIFORM(1,60)

Pathway transverse dispersivity (m): UNIFORM(0.3,20)

Justification for Aquifer Dispersion Details
Mixing Zone thickness calculated based on an effective aquifer thickness of 20m and vertical dispersivity of 1% of the range of potential pathway lengths.

Retardation parameters for pathway

Modelled as aquifer pathway.
No retardation values used in this simulation.
Check 'Unretarded Contaminant Transport' setting under simulation preferences.

APPENDIX S4R4

SURFACE EMISSIONS MONITORING AND ACTION PLAN

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REPORT ON

SURFACE EMISSIONS MONITORING AND ACTION PLAN WITHYHEDGE PHASE 2

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REPORT ISSUE FORM

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A. Applied to reports after external/client review.
The version number starts at '0' and is raised by '1' at each re-type.

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1.0 REPORT CONTEXT

This report details the surface monitoring to be implemented at Withyhedge Landfill Site. The site is operated by Resources Management UK Ltd (PPC application number BP3131SG). The future gas compound will be operated by Ener.G Natural Power Ltd. This report has been produced in response to Question 17 of the Schedule 4 Notice dated 20 December 2005, which states:

"Please provide information on the proposal for surface gas emissions monitoring in accordance with the Agency guidance."

2.0 REPORT METHODOLOGY

This report details a site-specific monitoring plan for surface emissions at Withyhedge Landfill Site. The methodology has been produced in accordance with Environment Agency guidance including “Guidance on the Management of Landfill Gas” (Environment Agency, 2004a) and “Guidance on Monitoring Landfill Gas Surface Emissions” (Environment Agency, 2004b).

3.0 MONITORING SURFACE EMISSIONS

The forthcoming section details how, in accordance with Environment Agency guidance, surface emissions monitoring will be undertaken, including the frequency and location of the monitoring.

3.1 Monitoring Methodology

The monitoring of surface emissions at the Site will be undertaken in accordance with the "Guidance on Monitoring Landfill Gas Surface Emissions" (Environment Agency, 2004b) and will be undertaken in two stages:

1. **Survey of site;** to demonstrate whether there are inadequacies in the gas containment and collection system. Only when deficiencies have been located and remediated such that the concentration of gas above the surface is low is it appropriate to begin the second stage comprising a quantitative survey of surface flux.

2. **Flux box survey;** the flux of methane emitted through the intact cap is measured at a number of representative points using an array of flux boxes. From these individual measurements, the average flux from the capped zones will be calculated and compared to the Agency's standards.

3.1.1 Survey of site

1. Background data relating to the site will be gathered from Resources Management UK Ltd who control and have responsibility for gas utilisation and flaring at the Site.

2. The site's major characteristics will be identified at the outset and recorded on a suitable form similar to the example contained within Appendix B of the "Guidance on Monitoring Landfill Surface Emissions" (Environment Agency, 2004b).

3. Based on a site plan the landfill will be divided into a number of zones dependant on the cap properties.

4. Prior to the walkover survey any major faults in the gas management system will be identified and rectified.

5. Prior to the walkover survey the general weather conditions will be noted including barometric pressure, recent precipitation, wind speed and direction. Also the nature of areas adjacent to the survey will be noted e.g. activities that may emit gas or lead to gas migration.

6. The site walkover survey will be conducted with a flame ionisation detector (FID) or similar. The sample probe will be held as close to the surface (<5 cm) as possible. The air at head height will periodically be sampled (to enable distinction of surface emissions from the landfill from other potential upwind sources). Zones identified in the desk study will be traversed in a systematic manner, typically along regular lines 50 m apart on a permanent cap and 25 m apart on a temporary cap. These distances will be reduced where failures in the containment of gas are more likely. In addition

the walkover survey will be directed by observations of the surface, methane emissions measured and secondary factors such as odour. Where high concentrations of methane are detected, the survey will deviate to locate the likely source of the emission. Care will be undertaken when taking measurements in the vicinity of heavy plant, as the unburnt hydrocarbons in diesel exhausts will register on the FID and give potentially misleading results.

7. The survey will also identify:

- Surface cracking or fissures;
- Stressed vegetation;
- Interfaces between capped zones;
- Landfill edges and side slopes;
- Gas wells and monitoring points;
- Junctions in gas collection pipework;
- Pathways where pipework may be buried in trenches; and
- Leachate sumps, towers, risers and other monitoring points.

8. Where the survey identifies locations with particularly high emissions, these will be marked with paint or poles for attention during subsequent remedial work. It is noted that many fluorescent survey paints are very high in VOCs and will give misleading results for several days if sprayed directly on the landfill surface.

9. If the survey demonstrates the cap is not consistent and there are discrete features emitting substantial amounts of landfill gas, remedial action is required as soon as possible.

10. The Site survey and subsequent remedial action will continue until the concentration of methane in air is:

- Less than 100 ppmv immediately above the surface on the main zones of the cap; and
- Less than 1000 ppmv close to any discrete features.

3.1.2 Flux box survey

If deemed necessary, through the initial site walkover phase, and in agreement with the Environment Agency, a flux box survey will be carried out at the Site. The flux box survey will be carried out in line with the methodology contained within "Guidance on Monitoring Landfill Gas Surface Emissions" (Environment Agency, 2004b). The methodology that will be adopted is outlined below:

1. The most recent site walkover and desk study results will be used to define emission zones and features at the Site, where a zone is an extensive area of the landfill surface over which the average emissions can be calculated and a feature is a discrete area or installation within a zone where abnormal emissions might be found;

2. An appropriate number of samples points and average spacing will be determined using the methodology outlined in Section 5.6 of the "Guidance on Monitoring Landfill Gas Surface Emissions" (Environment Agency, 2004b);

3. The survey will be carried out when the emissions are representative of normal operation of the gas management system.

The survey will be carried out under appropriate meteorological conditions as summarised below:

- During periods of falling or low pressure;
- Not during and following periods of heavy rainfall; and
- Not during periods of frost.

The flux box survey will be designed based on information gathered during walkover surveys already conducted. The flux box survey will be designed in line with Chapter 5, ‘design of flux box surveys’ contained within “Guidance on Monitoring Landfill Surface Emissions”, (Environment Agency, 2004b).

Any flux box survey undertaken at the Site will be carried out following the methodology outlined in Chapter 6, ‘measuring emissions using a flux box’ contained within “Guidance on Monitoring Landfill Gas Surface Emissions”, (Environment Agency, 2004b).

Monitoring data from any flux box surveys undertaken at the Site will be processed following the methodology outlined in Chapter 7, ‘data processing’ contained within “Guidance on Monitoring Landfill Gas Surface Emissions”, (Environment Agency, 2004b). Data will be processed and a mass emission rate for each zone or feature calculated.

Emissions data from any flux box survey will be assessed and the average flux of methane from the surface of the cap in each zone will be compared to the following emissions standards set by the Environment Agency:

- Permanently capped zone: 0.001 mg CH_4/m^2/second; and
- Temporarily capped zone: 0.1 mg CH_4/m^2/second.

3.2 Monitoring Frequency

In line with the Agency’s “Guidance on the Management of Landfill Gas” – Table 5.4 (Environment Agency, 2004a) and “Guidance on Monitoring Landfill Gas Surface Emissions” (Environment Agency, 2004b), we propose that an annual walk over FID survey for surface emissions is appropriate for this site. A more detailed flux box survey may be carried out at a frequency of 1 to 5 years based on the results of the walk over survey and subsequent discussions with the Agency.

3.3 Reporting of Results

Monitoring data from any flux box surveys undertaken at the Site will be processed following the methodology outlined in Chapter 9, ‘reporting’ contained within “Guidance on

Monitoring Landfill Gas Surface Emissions", (Environment Agency, 2004b). Data will be processed and a mass emission rate reported for each zone or feature.

The results of any walkover survey, flux box survey or remediation plan developed subsequent to a flux box survey conducted will be presented to the Environment Agency.

3.4 Remediation

If any zone is found to be non-compliant, the results of the survey will be used to review the overall gas management plan.

Remediation measures will be carried out as soon as reasonably practicable and within timescales agreed with the Environment Agency.

3.5 Summary

In line with the Environment Agency Guidance document, "Guidance on Monitoring Landfill Gas Surface Emissions" (Environment Agency, 2004b), surface emissions monitoring at the Site will initially comprise an annual walkover survey of the site. The walkover survey will be followed by a flux box survey if deemed necessary.

4.0 REFERENCES

1. Environment Agency (2004a), Guidance on the Management of Landfill Gas.

2. Environment Agency (2004b), Guidance on Monitoring Landfill Gas Surface Emissions.