Providing Ground Solutions

Waverley Borough Council

Weydon Lane Landfill, Farnham

Updated Land Development Feasibility Report

September, 2014

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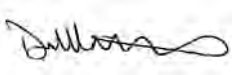
Author	Dan Matthews, Associate Director *BEng CSci CEnv MIEnvSc*			
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1. INTRODUCTION

1.1 General

Card Geotechnics Limited (CGL) was commissioned by Waverley Borough Council (WBC) to assess the feasibility of a number of potential development options for the former landfill located off Weydon Lane. The assessment has considered the following three development options:

(a) Formal public open space;

(b) Sports ground; and

(c) Sports ground and pavilion (as evaluated previously).

This report assesses the engineering feasibility of each option and provides an indication of the associated abnormal ground-related requirements. The report includes:

- Consideration of the engineering feasibility of developing the site, including outline requirements for ground gas and human health protection measures, building foundation and infrastructure (including drainage) requirements and potential landscaping requirements;
- Recommendations for additional investigation/survey work; and
- On-going management and maintenance requirements.

This report should be read in conjunction with the updated site maintenance and management plan[1], which presents the short, medium and long term requirements for on-going use as an informal public open space. In addition, an updated preliminary summary report[2] has been produced for the site, which presents a review of the various investigations and reports that have been completed for the site

1.2 Previous assessment

This assessment follows a previous feasibility assessment undertaken by CGL in 2012, which considered the feasibility and development potential for the site as sports pitches

[1] Card Geotechnics Limited (2014) *Updated site maintenance and management plan, Weydon Lane Landfill, Farnham, CG/5934C, August 2014.*

[2] Card Geotechnics Limited (2014). *Updated preliminary summary report review and site walkover, Weydon Lane Landfill, Farnham.* CG/5934C. July 2014.

including a pavilion[3]. Part of the 2012 commission included a preliminary summary report[4] and provision of a site maintenance and management plan[5] for on-going use as an informal public open space (which have since been updated as described above).

1.3 Limitations

Although WBC is considering developing the site into the options outlined above, the development plans have not been defined/confirmed and therefore, it was not possible to provide costs for the abnormals. Once development plans have been confirmed, costs associated with the abnormals can be better defined by a qualified Quantity Surveyor.

[3] Card Geotechnics Limited (2012). *Land development feasibility report, Weydon Lane Landfill, Farnham.* CG/5934. April 2012.
[4] Card Geotechnics Limited (2012). *Preliminary summary report on report review and site walkover, Weydon Lane Landfill, Farnham.* CG/5934. March 2012.
[5] Card Geotechnics Limited (2012). *Landfill maintenance and management plan, Weydon Lane Landfill, Farnham.* CG/5934. March 2012.

2. SITE CONTEXT

2.1 General

Various investigations and reports have previously been completed for the site including the following:

- Card Geotechnics Limited, 2013 Ground Gas Monitoring Report, Weydon Lane Landfill, Farnham. CG/5934A. July 2013
- Card Geotechnics Limited, Land development feasibility report, Weydon Land Landfill, Farnham. CG/5934. April 2012[6]
- Card Geotechnics Limited, Preliminary summary report on report review and site walkover, Weydon Land Landfill, Farnham. CG/5934. March 2012
- Card Geotechnics Limited, Site maintenance and management plan, Weydon Land Landfill, Farnham. CG/5934. March 2012
- Ground-Gas Solutions Ltd, GGS DataPack, Weydon Lane Landfill, Farnham. GGS187/DP. October 2011
- Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Further Gas Monitoring. 0001-UA003194-GDR-01. March 2011
- Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Further Gas Monitoring. 0110-GD00720-GDR-AO. May 2009
- Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Further Gas Monitoring. 0106-GD00720-GDR-AO-2. February 2009
- Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Groundwater and Human Health Assessment, Ground Investigation and Interpretation. 0001-GD00720-GDR-02. August 2008.

[6] Card Geotechnics Limited (2012). *Land development feasibility report, Weydon Lane Landfill, Farnham*. CG5934. March 2012.

- Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Landfill Gas Assessment of Adjacent Residential Properties, Landfill Gas Assessment Report. 0001-GD00720-GDR-02. March 2007
- Hyder Consulting (UK) Ltd. RPS Report Non-Technical Summary, October 2006
- RPS Planning Transport and Environment. Final Environmental Site and Risk Assessment Report at Weydon Lane, Farnham, Surrey. JER2963. August 2006
- Card Geotechnics Ltd. Weydon Lane, Review of construction options for recreational facilities. CG/4053. May 2005.
- RPS Planning Transport and Environment. Environmental Site Report, Weydon Lane, Farnham, Surrey. Revision 1. JER 2963. February 2005[7].
- Environmental Safety Group. An investigation of methane concentrations in and around a landfill site at Weydon Lane, Farnham, Surrey. May 1982.[8]

The full reports should be reviewed for detailed information; however, a summary of the reports is provided in the CGL preliminary summary report[2] and pertinent information is provided below.

2.2 Site location and description

A site walkover was conducted by CGL on 25 June 2014. At that time, the site was used as an informal public open space, which the surrounding residents used primarily for dog walking and jogging. The site was generally overgrown with tall grass and a variety of trees/shrubs, with a footpath around the perimeter of the site.

The ground level at the site dropped from south to north and the surface of the site was undulating. In some areas, generally within the centre and south of the site, several depressions were noted, which have previously been observed to contain ponded water. It is understood from WBC that during wetter weather conditions a large area of surface ponding occurs. Reeds were noted within these areas indicating that wetter ground conditions have occurred previously and over an extended period of time.

A gravel trench approximately 1m wide was located along the boundaries of the site. The

[7] A copy of the RPS 2005 report was not available for review, however it is understood that information from this report has been incorporated into the 2006 RPS report.
[8] Text unclear.

majority of the trench was covered at the surface by overgrown vegetation including brambles and nettles. The trench was only visible where footpaths crossed it along the eastern and south western boundaries.

The site appeared to be generally free of fly tipping; however, grass cuttings (likely to be from the adjacent residential properties) were noted along the eastern boundary.

The site was bounded by Weydon Lane to the north, residential properties to the west and east and Upper Way to the south. Residential properties were located beyond the roads to the north and south of the site.

The site location plan and site layout plan are presented in Figures 1 and 2, respectively. Photographs taken at the time of the walkover survey are provided within the July 2014 summary report[2].

2.3 Ground conditions – Geology, hydrogeology and hydrology

The previous investigations within the site boundary identified the following ground conditions:

- Topsoil/capping – 0.8m to 3m thick (mix of granular and cohesive soils)
- Landfill material – Proven to between 7.2mbgl and 14.7mbgl
- Folkestone Formation – Thickness not proven (silty slightly gravelly sand/sandstone; occasional pockets of silt and clay)
- Groundwater – level at approximately 16mbgl within the Folkestone Formation. Leachate and perched groundwater was also encountered within the landfill material.

The Folkestone Formation is classified as a Principal Aquifer; however, the site is not located within a groundwater source protection zone. The closest groundwater abstraction point is at the Bourne Pumping Station approximately 1km to the south east of the southern site boundary. The closest surface water receptor is the River Wey, which is located approximately 200m to the north of the site.

2.4 Historical development

The site lies in an area where historically gravel pits have been worked. Gravel extraction at the site started in the mid-1930s. It is understood that landfilling commenced at the site

in 1972 and was completed in 1981. A mixture of waste was landfilled including commercial, inert and domestic waste; including putrescible waste. The site was restored to grass land in about 1986 and has been under the management of Waverley Borough Council since then.

2.5 Previous investigations and reports

2.5.1 RPS, Hyder Consulting and GGS reports

Various phases of ground investigations have been completed at the site and in the surrounding area since the landfill was closed in the 1980s.

In the early 1980s investigations and monitoring identified elevated ground gas concentrations in the back gardens of residential properties at Pilgrim Close (western boundary). A trial venting trench was installed along the western boundary, which appeared to be successful in reducing ground gas concentrations. As a result, in 1984 a venting trench was installed around the entire site perimeter. Construction details are unclear for the full trench but they are likely to have been similar to the details for the trial trench, which included a 1m wide trench 5m in depth filled with uniformly graded stone with a perforated pipe in the base.

The investigations and assessments completed by RPS and Hyder Consulting (Hyder) indicated that soil, leachate and groundwater concentrations pose a low risk to human health (based on the end use as open space) and a low risk to controlled waters. A hotspot of lead was recorded in shallow soils (<0.2m bgl) in one location. It is understood from the Hyder 2008 report that some large assumptions were used in the detailed quantitative risk assessment for controlled waters, particularly the groundwater flow direction. However, according to the report (and supported by discussions with WBC), the Environment Agency considered further investigations to reduce the uncertainties would be desirable but not essential.

Elevated methane and carbon dioxide concentrations were encountered within the landfill. Monitoring undertaken by Hyder in March 2011 indicated: maximum carbon dioxide = 17.9%, maximum methane = 38.5%, maximum flow = 0.1l/hr. Monitoring of boreholes within the gardens of the residential properties in November 2008 recorded lower ground gas concentrations and flow rates (maximum carbon dioxide = 4.8%, maximum methane = 0.2%, maximum flow = 1.3 l/hr). Based on the off-site monitoring at the adjacent residential properties, the risk to residents from ground gas migrating from the landfill was

considered to be low and no retrospective gas protection measures are considered necessary.

Figures 3a and 3b present the exploratory hole locations from the RPS and Hyder investigations, respectively.

In addition to works within the site, monitoring was completed by Hyder at 29 standpipes within the gardens of the adjacent residential properties at weekly basis, for 6 weeks, between November 2006 and January 2007. Further monitoring rounds were undertaken in August 2007 and November 2008. These monitoring rounds indicated that generally near normal oxygen concentrations were detected off-site, with low carbon dioxide (<5%) and methane concentrations (<1%), and the risk to occupants was considered to be low. Therefore, it was agreed with WBC at the time that no further monitoring would be required as sufficient data was available from boreholes outside the gas venting trench.

2.5.2 CGL reports

Monitoring by CGL at selected boreholes at the site in March 2012, July 2013 and June 2014 recorded generally similar elevated ground gas concentrations within the landfill (maximum methane: 71.1%; maximum carbon dioxide: 26.6%) and relatively low flow rates (maximum 4 l/hr). It was noted during the June 2014 monitoring visit that only two of the monitoring wells outside of the vent trench could be found due to overgrown vegetation.

CGL has previously undertaken feasibility assessments for potential development options for the site in 2005 and 2012. The reports concluded that the two options considered (tennis courts, bowling greens and pavilion buildings in 2005 and sports pitches with pavilion in 2012) were feasible and provided recommendations to address potential risks associated with settlement, ground gas and to protection human health and controlled waters. It was also recommended that the existing cap be augmented to a depth of 1m with suitable cohesive material and a growth medium.

2.5.3 CGL updated site maintenance and management plan (August 2014)

An updated site maintenance and management plan was compiled by CGL in August 2014[1]. The plan identified the requirements recommended in the short, medium and long term should the site remain as informal public open space. In summary the requirements included:

1. Additional gas and groundwater monitoring;

2. Surface emission monitoring;
3. Inspections, re-levelling and augmentation of the clay cap, as required;
4. Managing and maintenance of the vegetation to ensure that the vent trench is not further covered/blocked;
5. Ecology surveys;
6. Drainage/control of surface run-off; and
7. Producing a DSEAR (Dangerous Substance and Explosive Atmospheres Regulations) assessment.

3. FEASIBILITY ASSESSMENT AND IDENTIFICATION OF ABNORMAL DEVELOPMENT REQUIREMENTS

3.1 Introduction

The CGL updated site maintenance and management plan (2014)[1] concluded that it was feasible for the site to remain as informal public open space, subject to a number of measures being put in place, as discussed in Section 2 above. The assessment presented below has assumed that the short term measures presented within the updated site maintenance and management plan will be undertaken and therefore these measures have not been included below.

This assessment has considered the feasibility of the following three potential options for development of the site:

Option a – Formal public open space;

Option b – Sports ground; and

Option c – Sports ground and pavilion.

In order to evaluate the feasibility of each option, the assessment has considered the potential abnormal development requirements associated with the following aspects:

- Remedial measures required for the protection of human health (Options a, b and c);
- Pitch construction (Options b and c);
- Pavilion foundations and associated infrastructure (Option c only);
- Underground Services (Options b and c);
- Ecological implication of landscaping (Options a, b and c); and
- Future monitoring and maintenance (Options a, b and c).

The abnormal requirements associated with these aspects for each of the potential development options are described in the following sections.

3.2 Human health protection measures

3.2.1 Capping layer (Options a, b and c)

The cap currently present across the site is inconsistent in thickness and composition (granular and cohesive). However, the risk assessments undertaken to date indicate that, based on current conditions, the potential risk presented to human health from contaminants in shallow soils is low. This is with the exception of a localised hotspot of lead that has been identified in shallow soils, which presents a potential risk to human health. The updated site maintenance and management plan recommended that further assessment and/or remedial works should be undertaken to address this potential risk.

In the event that long term use of the site becomes formal open space (Option a), it is anticipated that re-levelling works will be required. This should be carried out in combination with upgrading the cap to allow continued protection to site users by providing a consistent cohesive layer above the landfill material.

Should sports pitches with or without a pavilion be selected (Options c or b), then it is anticipated that the construction of the pitches (and pavilion) will mitigate potential risks to site users in these areas. The clay cap should be upgraded in the areas outside of the pitches and pavilion as outlined above.

3.2.2 Ground gas protection measures for buildings (Option c only)

Over a 10 year period (although not at regular intervals and not consistently at the same locations) 18 rounds of gas monitoring have been conducted at boreholes across the site, the findings of which are summarised within the updated preliminary summary report[2]. Monitoring has typically indicated the site to be Characteristic Situation (CS) 3, although the monitoring in 2013 indicated that the potential worst case condition may be CS4. It is recommended that a gas risk assessment be undertaken to confirm the appropriate gas regime and enable ground gas protection measures to be designed. This should include generation of representative gas screening values and consideration of the appropriate building type (i.e. public or commercial building). The assessment should also take into account the location and design of the pavilion building.

As a reasonable worst case, assuming a site classification of CS4 and the building type being a public building, this would require a gas protection score of 5 based on the British

Standard[9]. This could be achieved through the following measures:

- ***Ventilation:***
    - Passive subfloor ventilation with very good performance *(score = 2.5 points).*
- ***Barriers (Floor slabs):***
    - Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into the slab *(score = 1.5 points)*; or
    - Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints *(score = 1.5 points)*.
- ***Membranes:***
    - Proprietary gas resistance membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) *(score = 1 point)*.

3.3 Pitch construction (Options b and c)

There are four Options available for the construction of the sports pitches. These include:

1. Re-grading and compaction of the existing capping material;
2. Re-grading and compaction of the existing capping material and provision of a geogrid layer beneath to provide additional support;
3. Replacement of the existing capping material with a suitably compacted granular sub-base layer with a geotextile and geogrid layer beneath to prevent fines from entering the granular layer and to provide additional support;
4. Replacement of the existing capping material with a reinforced concrete raft of limited size.

[9] British Standards (2007). Code of practice for the characterisation and remediation from ground gas in affected developments. BS 8485:2007

The upfront capital cost for the above pitch options may typically increase from pitch option 1 to pitch option 4. Although pitch option 1 may result in lower capital cost, it would need to be accepted by WBC that significantly more on-going maintenance of sport playing surfaces will be required, compared to the other options, if settlement of the landfill waste affects the playing surface's serviceability.

Another option could be to reuse the existing capping at the site and provide the required support from settlement by provision of a geogrid layer (pitch option 2). However, given the variability of the capping materials at the site this may not be appropriate.

A more costly (in capital outlay) approach would be to construct the sports pitches on a compacted and geo-reinforced granular sub-base layer (pitch option 3). In addition, a geotextile layer should be placed as a separating layer to act as a barrier and prevent upward migration of fines. The additional costs associated with this option would include: import of suitable granular materials, provision of the geotextile and geogrid, disposal of soils excavated to allow construction of the sub-base (unless final finished levels allows for this material to be retained on site). Pitch option 3 would however reduce on-going maintenance costs when compared to pitch options 1 and 2 although periodic general sport pitch maintenance or resurfacing may still be required to adjust levels. This option is considered the most suitable and cost effective solution for the site as it offers the greatest possibility of stability to the final surface and it is a practice accepted by Sport England and Sports and Play Construction Association[10].

The adoption of discrete reinforced concrete rafts was recommended by CGL in 2005 (pitch option 4) when the development plans included tennis courts and bowling greens (which are relatively small areas very sensitive to a flat playing surface requirement). Although this could still be an option this would not be cost effective if football/cricket pitches are part of the proposed development.

Drainage beneath sport pitches is standard practice and therefore not considered to be abnormal. However, consideration should be given to where the drainage system is placed, as surface run-off should not be allowed to migrate into landfill material as this may generate leachate.

[10] Sport England and Sports and Play Construction Association. *A Guide to the Design, Specification and Construction of Multi Use Games Areas including Multi-Sport Synthetic Turf Pitches. Part 1 (of 3) – General Guidance and Design Considerations; Dimensions and Layouts.*

Regardless of the pitch option chosen, prior to construction of the pitches a cohesive cap should be maintained across the site, particularly in the landscaped areas. The cap currently present is inconsistent in thickness and composition (granular and cohesive). Therefore, a cohesive layer a minimum thickness of 600mm should be maintained above the landfill material. This may need to be completed inside and outside the alignment of the venting trench as some landfill material was encountered at some locations outside the venting trench including boreholes HS303, HS301 and HS304. However, this material may not be truly representative of the landfill material based on its description in the logs (not as much miscellaneous waste present) and the low ground gas concentrations encountered at these locations.

Where possible, the topsoil and capping at the site should be re-used. This could be accomplished through waste exemptions, environment permits or through the Development Industry Code of Practice[11]. The latter has been developed to enable earthworks on site using site won material and this is within the Site Waste Management Plan.

However, depending on finished levels and the suitability of the existing soils, additional materials may need to be imported, which would increase development costs.

3.4 Foundations for pavilion construction (Option c)

Should the proposed development include the construction of the pavilion, a reinforced concrete raft solution remains the most viable foundation solution for the pavilion as this would be less sensitive to differential and overall settlement across the building footprint. A raft would also be more cost effective than pile foundations (when considering both installation and drilling arisings that would require disposal if piles were used). In addition, before pile foundations could be used at the site a Foundation Risk Assessment[12] would need to be completed and submitted to the Environment Agency for approval.

Settlement of the structure is likely, however this can be alleviated either by designing the structure to be re-levelled across the raft by jacking at the short column positions or excavation of formation and replacing with compacted granular material reinforced with a geogrid (and a geotextile separator). The latter option may be more cost effective,

[11] CL:AIRE. *The Definition of Waste: Development Industry Code of Practice*. Contaminated Land: Application in Real Environments. Version 2. March 2011.
[12] Environment Agency (2001). *Piling and Penetration Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution and Prevention*. NC/99/73.

mitigating the need to design the structure as above and reducing the maintenance requirement.

The previous investigations completed at the site have been focused on confirming the suitability of the current use (open space). However, the investigations have not obtained information needed to confirm requirements for future developments that include buildings. In-situ testing to determine the state of compaction of the landfill material (a combination of dynamic probing and window sampling with in-situ Standard Penetration Tests; nominally to 10m is recommended) and the percentage of organic or putrescent material present is required to provide an indication of the amount of settlement that might occur throughout the design life of the development. This additional information will allow the foundations to be appropriately designed. In addition, Atterberg Limit testing should be conducted to determine the shrink/heave potential of the shallow soils, which might impact the foundations. Chemical analysis (pH and water soluble sulphate) is required to allow the appropriate design of buried concrete.

Once the development plans have been confirmed, loadings are known and additional ground information obtained, an assessment of the potential settlement of the raft foundation will be required. This can be completed through programmes such as PDISP[13].

3.5 Installation of underground services (Options b and c)

It is anticipated that it would not be necessary to install underground services should formal open space be selected. However, underground services will be required for the pavilion, and also potentially for the sports pitches for irrigation and drainage.

Underground services should be protected from deeper underlying contamination. In accordance with UKWIR guidance[14] without development plans and targeted sampling and testing it is not possible to accurately assess what pipework may be necessary on a site. In the absence of detailed data a default of 'barrier pipe' should be assumed as acceptable to the water company (which is likely given the site's history). Pipework for water supply pipes and other underground services should be agreed with the relevant statutory authorities.

Services should be placed in oversized, geotextile lined trenches that have been backfilled

[13] Oasys software.
[14] UK Water Industry Research. *Guidance for the selection of water supply pipes to be used in brownfield sites*. Report Ref No. 10/WM/03/21. 2010.

with clean granular material to protect the pipes and also maintenance workers from coming into contact with possible contaminated soil.

Services and manhole chambers should be designed and constructed allowing for potential on-going settlement by adopting appropriate falls in drains and with articulated joints and flexible pipework. The natural topography should also be considered for the layout of the final development as the drop in ground level from south to north could be used to accommodate the required fall for the drains. In addition, ventilated manhole chambers will be required to prevent the build-up of ground gases within these enclosed areas.

3.6 Ecological implications of landscaping (Options a, b and c)

It is assumed that some form of landscaping will be incorporated into the final development. There are currently trees and vegetation present along the boundaries of the site and development of the site may result in an ecological impact. An ecological appraisal was completed by RPS in 2004, which stated that the site was likely to be of local ecological significance and the ecological value of the site was largely restricted to the periphery.

CGL also obtained a preliminary ecological assessment (by Remenham Associates) based on the photographs taken during the site walkover in March 2012. A summary of this assessment is provided below:

The site generally - and in particular the gas trench and its vegetation - present suitable habitat for nesting birds around the edge of the site and in the vegetation, amphibians and reptiles (although only the common species and at relatively low density). There is some standing water on the site shown in the photographs, but this looks as though it may be seasonal and so the potential for Great Crested Newts (GCN) is limited from the site itself.

However, the risk of GCN living in ponds around the site's perimeter can't be ruled out and the vegetation does provide suitable terrestrial habitat for them. There MAY be bats in the trees which are shown the photographs - an inspection would be needed to confirm presence / absence as the quality of the trees as suitable habitat is unclear.

The updated site maintenance and management plan[1] recommended that a Constraints Survey (factual report and recommendations for further works, if necessary) be undertaken for the site prior to clearing vegetation. In addition, a data search is recommended to confirm if a Great Crested Newt survey is required. These surveys would be required to identify the potential constraints associated with clearing vegetation within

the vent trench and to locate the missing boreholes, and enable mitigation measures to be defined.

In addition, prior to the development of the site (Options a, b or c) it is recommended that an Extended Phase 1 Habitat Survey is completed to confirm the ecological issues, if any, at the site and the mitigation measures required prior to development and clearance of vegetation. The Extended Phase 1 Habitat Survey will include identifying the potential for relevant protected species (including bats) and set out recommendations for the procedures to follow during site clearance. This survey would be suitable for submission as part of a planning application for near future development, if required. However, it should be noted that there is a 'shelf-life' attached to these surveys as site circumstance change.

3.7 Monitoring and maintenance

3.7.1 Pitches (Options b and c)

Should the development include the construction of sports pitches, the surfaces of the sports pitches generally need to be maintained on a regular basis. Increased maintenance may be required for development options b and c due to increased sensitivity to potential settlement. The frequency of this maintenance will depend on the pitch construction used. However, the preferable pitch construction described above, i.e. pitch option 3, would reduce the amount of additional maintenance require due to settlement.

3.7.2 Landscaped areas (Options a, b and c)

Typically, for landfills, most settlement takes place over 30 years with the majority occurring in the initial 5 year period. Therefore, self-settlement of this landfill should be largely complete. It is recommended that the cap is inspected after re-levelling and augmentation, should this be undertaken, to confirm if settlement is still occurring and if differential settlement has resulted in cracks/undulations. Such cracks/undulations could provide a pathway for ground gases to migrate to the surface, allow infiltration of water or permit ponding of water at the surface.

3.7.3 Ground gas (Options a, b and c)

Ground gas monitoring should be completed during the construction phase and for a period of time after construction to confirm that the ground gas regime beneath the site and outside the venting trench has not been adversely affected by the construction activities and changes to the capping layer.

Monitoring should be completed twice a month during construction and twice a month for 3 months after construction. Figure 4 shows the locations of the monitoring boreholes that should be maintained at the site. These are also highlighted below in Table 2. As highlighted in the updated site maintenance and management plan, it will be necessary to clear vegetation to allow access to the selected monitoring boreholes indicated below prior to monitoring visits.

Table 2. Suggested boreholes for long term monitoring

Borehole	Location
HS304, BH01	Northern boundary; outside venting trench
BH03, BH107	Eastern boundary; outside and inside venting trench
BH101, BH102	Eastern boundary; outside and inside venting trench
HS301, BH103	Southern boundary; outside and inside venting trench
BH02	Southern boundary; outside venting trench
BH114, BH105	Western boundary; outside and inside venting trench
HS302, BH104	Western boundary; outside and inside venting trench

Note: Where access is possible boreholes within the private gardens of surrounding residential properties should also be monitored.

3.7.4 Groundwater (Options a, b and c)

Prior to development, monitoring installations within the site are likely to be damaged or destroyed during construction, particularly during pitch and pavilion construction, but possibly also during re-profiling of the capping layer should formal open space be selected. Monitoring wells with response zones within the underlying Folkestone Formation should be decommissioned, in accordance with Environment Agency guidance[15], to prevent creation of a pathway to the Principal Aquifer. These include boreholes BH401, BH402 and BH303. After monitoring at the site has been completed the remaining wells with installations into the underlying Folkestone Formation should also be decommissioned.

[15] Environment Agency (2012). *Good practice for decommissioning redundant boreholes and wells*. Product Code GEHO0112BWAW-E-E. January 2012.

These include boreholes on-site (BH01, BH02, BH03, BH101, BH105, BH114, BH301 and BH302) and off-site (BH201, BH202, BH203).

4. CONCLUSIONS & RECOMMENDATIONS

4.1 Conclusions

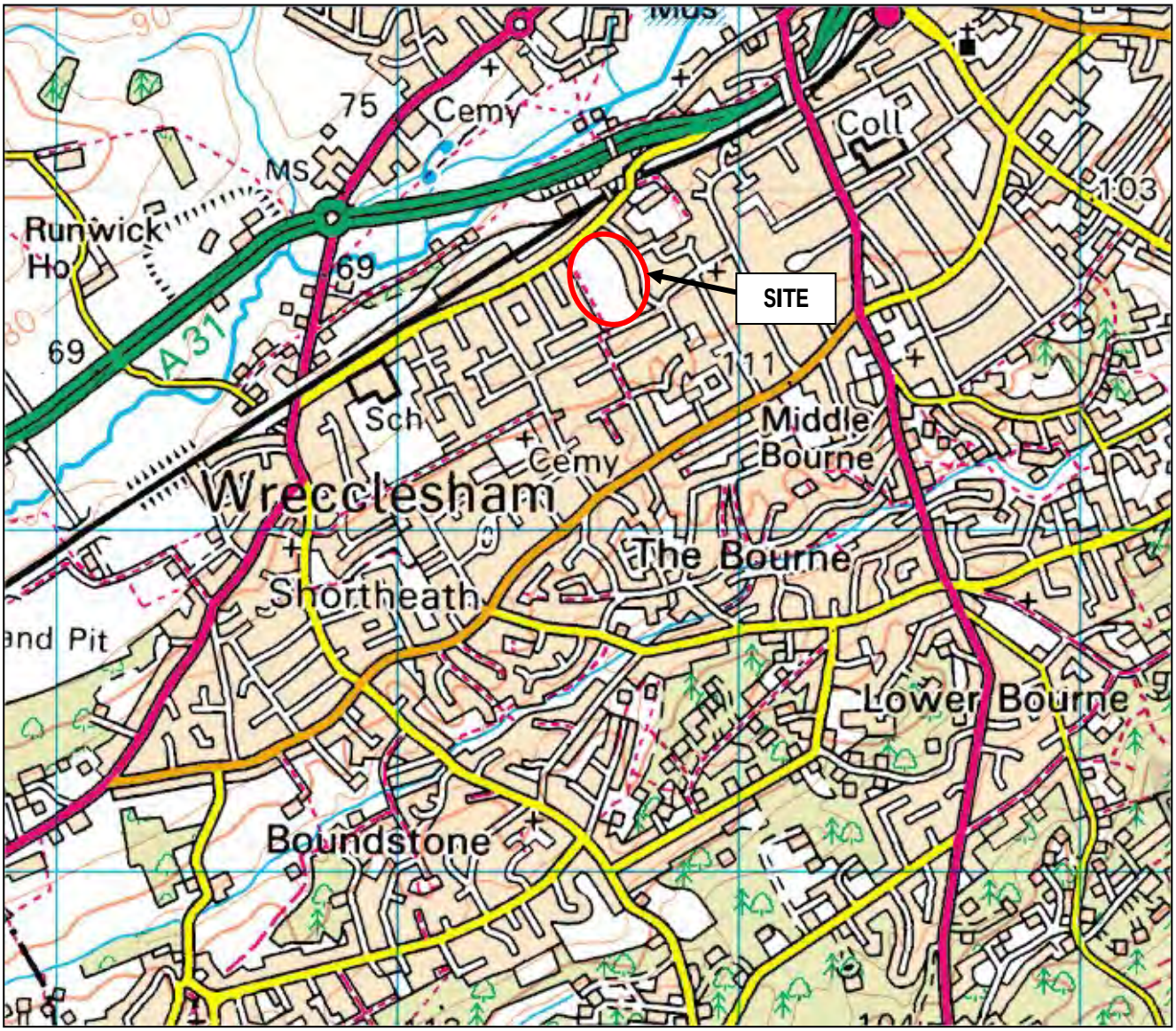
Based on the information provided in the reports available for the Weydon Lane Landfill the site can be redeveloped into a) a formal public open space, b) a sports ground or c) a sports ground and pavilion. Given the site history there will be abnormal development costs associated with each of the three development options. These are summarised in Table 1 below.

The assessment for the three development options outlined above has assumed that the short term measures presented within the updated site maintenance and management plan[2] will be undertaken and therefore these measures have therefore not been included within the abnormal requirements outlined in Table 1.

Table 1: Abnormal Requirements for Potential Developments

Potential Development Option	Human Health Protection Measures	Pitch Construction	Foundations	Underground services	Ecology	Monitoring & Maintenance
(a) Formal public space (*e.g.* park with planting)	Upgrading of the clay cap with cohesive soils to provide a barrier from contamination within the underlying soils.	N/A	N/A	N/A (No service installation anticipated)	Extended Habitat Survey to identify the mitigation measures required prior to development and clearance of vegetation.	Soil gas monitoring to confirm that the works have not changed the onsite and offsite soil gas regime. The cap and site levels should be inspected twice a year to determine if maintenance is required. Decommissioning of monitoring wells with response zones within the underlying Folkestone Formation
(b) Sports ground without pavilion	Pitch construction and upgrade of the existing clay cap to provide a barrier from contamination within the underlying soils.	Options for construction of the sports pitches in order of increasing cost and complexity are: 1. Re-grading and compaction of the existing capping material. 2. Re-grading and compaction of the existing capping material and provision of a geogrid layer beneath to provide additional support. 3. Replacement of the existing capping material with a suitably compacted granular sub-base layer with a geotextile and geogrid layer to prevent fines from entering the granular layer and to provide additional support. 4. Replacement of the existing capping material with a reinforced concrete raft of limited size.	N/A	'Barrier pipe' should be assumed for water supply pipes. Services should be placed in oversized, geotextile lined trenches that have been backfilled with clean granular material. Services and manhole chambers will have to allow for potential on-going settlement by adopting appropriate falls in drains and with articulated joints and flexible pipework. Ventilated manhole chambers required.		Soil gas monitoring to confirm that the works have not changed the onsite and offsite soil gas regime. Decommissioning of monitoring wells with response zones within the underlying Folkestone Formation The cap and site levels should be inspected twice a year to determine if maintenance is required. The surfaces of the sports pitches generally need to be maintained on a regular basis. Increased maintenance may be required due to potential settlement issues. The frequency of this maintenance will depend on the pitch construction used.
(c) Sports ground with pavilion	Ground gas risk assessment and design of ground gas protection measures, anticipated to include appropriate floor slab design, proprietary gas membrane and sub-floor ventilation. Pitch and pavilion construction and upgrade of the existing clay cap to provide a barrier from contamination within the underlying soils.		A reinforced concrete raft solution remains the most viable foundation solution for the pavilion as this would be less sensitive to differential and overall settlement across the building footprint. Settlement of the structure can be alleviated either by designing the structure to be re-levelled across the raft by jacking at the short column positions or excavation of formation and replacing with compacted granular material reinforced with a geogrid (and a geotextile separator). Further investigation and assessment required to design foundations.			

FIGURES



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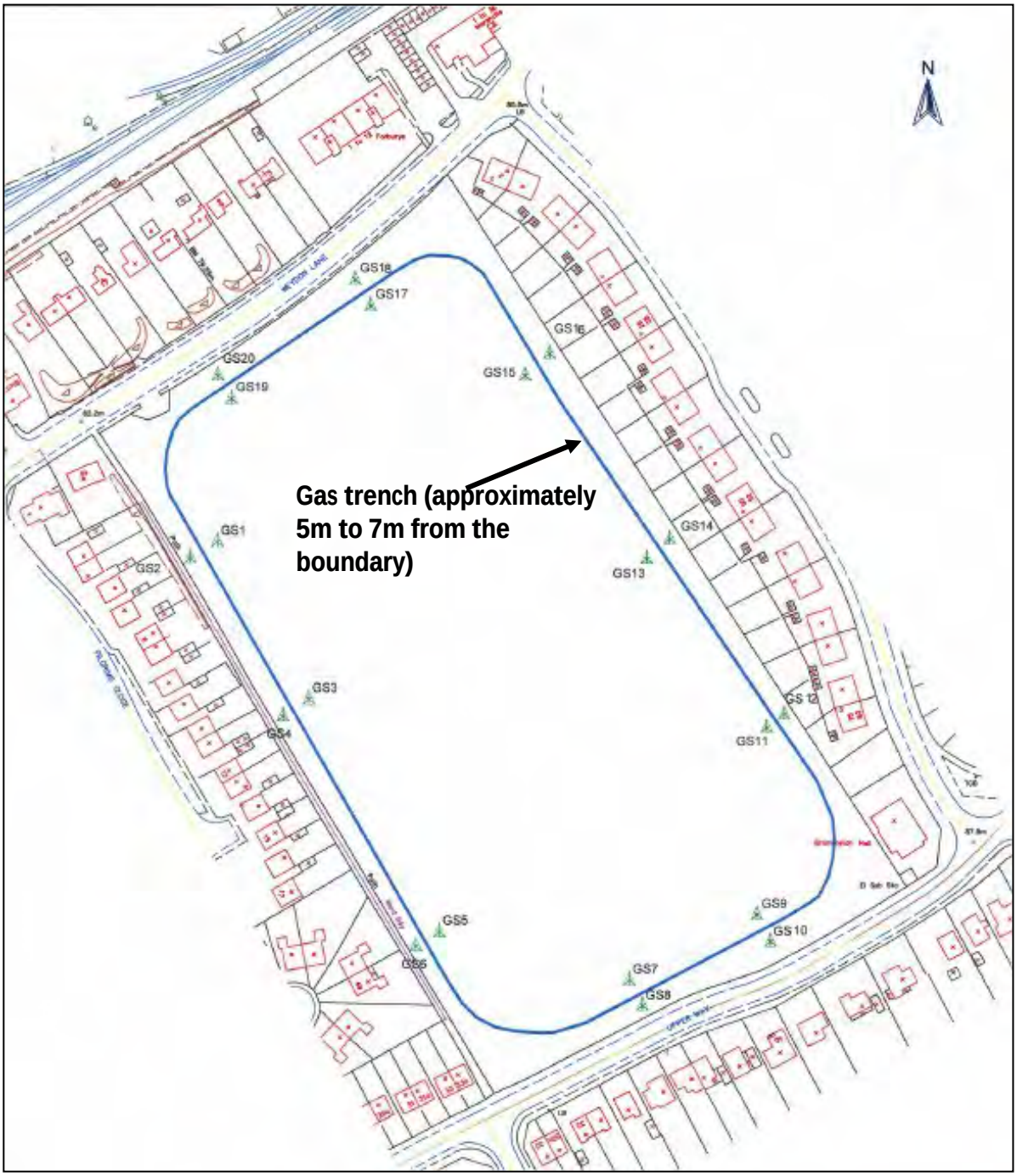
Client	Project	Job No
Waverley Borough Council	**Weydon Lane Landfill, Farnham**	**CG/5934C**
CGL	Title: **Site Location Plan**	**Figure 1**

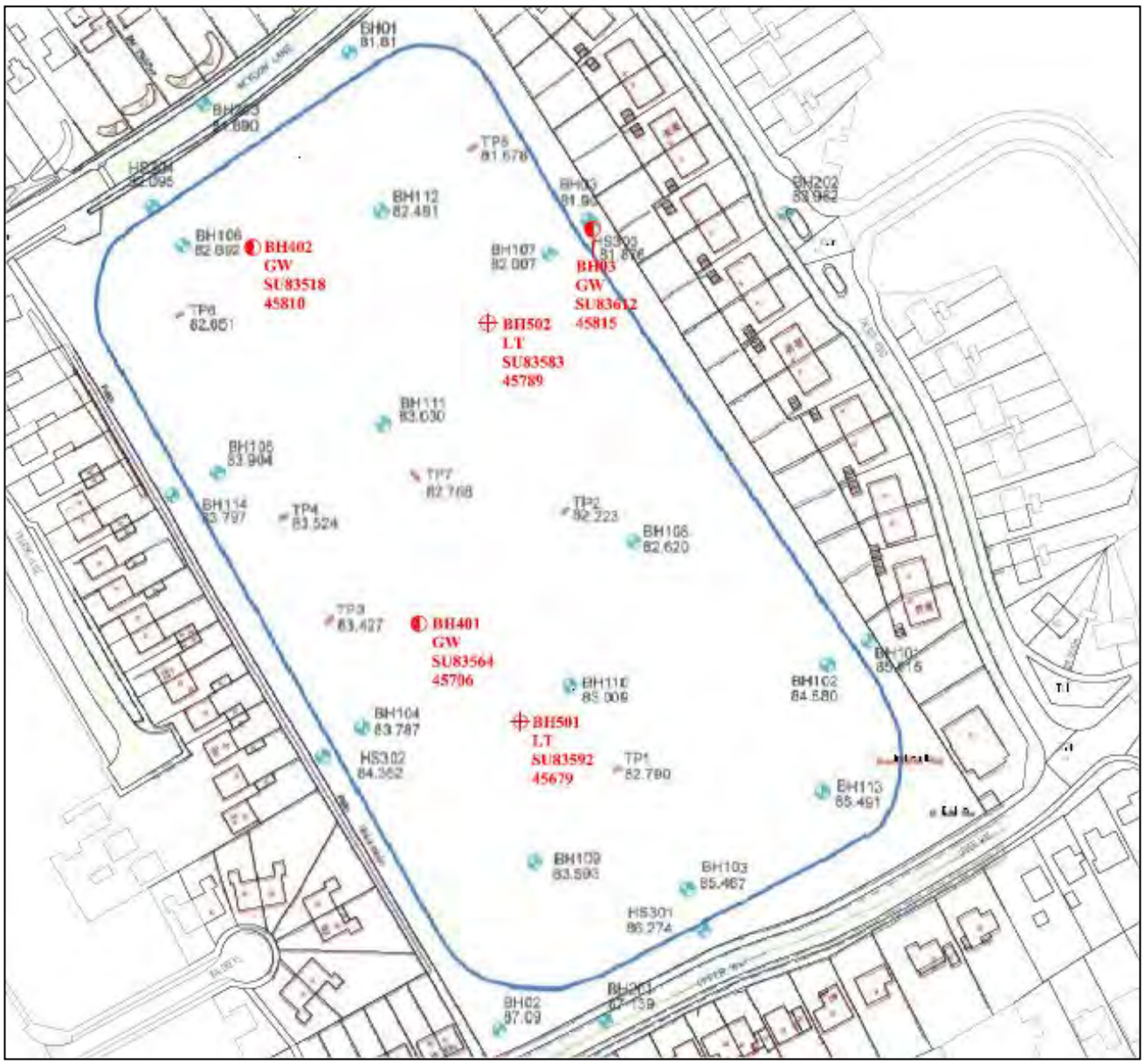


Reference: RPS Planning Transport and Environment. Final Environmental Site and Risk Assessment Report at Weydon Lane, Farnham, Surrey. JER2963. August 2006

Client	Project	Job No
Waverley Borough Council	**Weydon Lane Landfill, Farnham**	**CG/5934C**
CGL	Title: **Site Layout Plan**	**Figure 2**

Reference: RPS Planning Transport and Environment. Final Environmental Site and Risk Assessment Report at Weydon Lane, Farnham, Surrey. JER2963. August 2006

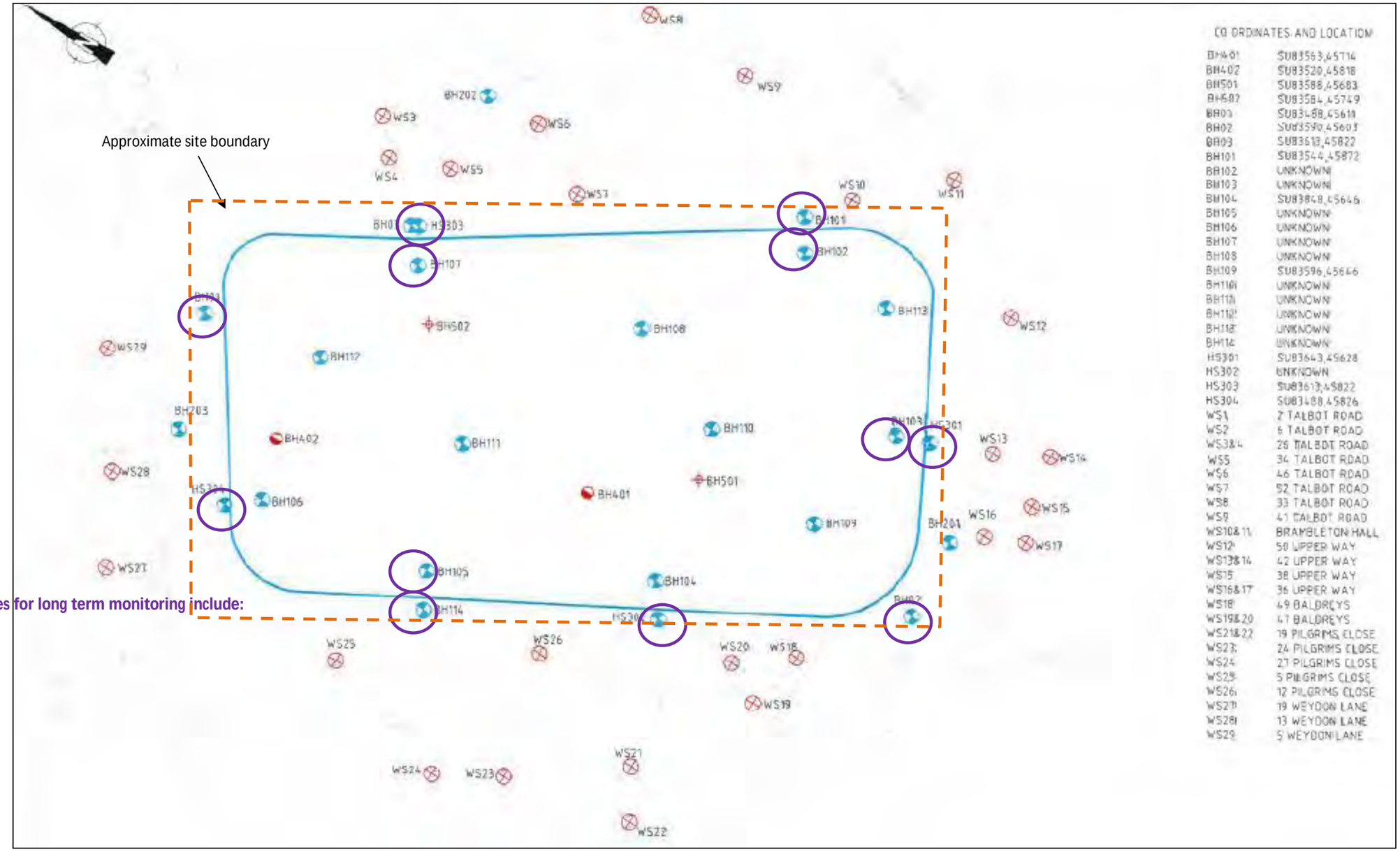
Client	Project	Job No
Waverley Borough Council	**Weydon Lane Landfill, Farnham**	**CG/5934C**
CGL	Title **Exploratory hole location plan - RPS**	**Figure 3a**



Reference: Hyder Consulting (UK) Ltd. Weydon Lane Landfill. Groundwater and Human Health Assessment, Ground Investigation and Interpretation. 0001-GD00720-GDR-02. August 2008.

(75 hand dug trial pits also excavated across the site based on a herringbone pattern and a grid size of 16.6m by 16,6m)

Client	Project	Job No
Waverley Borough Council	**Weydon Lane Landfill, Farnham**	**CG/5934C**
CGL	Title **Exploratory hole location plan π Hyder**	**Figure 3b**



CO ORDINATES AND LOCATION

BH401	SU83563,45714
BH402	SU83520,45818
BH501	SU83588,45683
BH502	SU83584,45749
BH03	SU83488,45618
BH02	SU83590,45603
BH03	SU83613,45822
BH101	SU83544,45872
BH102	UNKNOWN
BH103	UNKNOWN
BH104	SU83848,45646
BH105	UNKNOWN
BH106	UNKNOWN
BH107	UNKNOWN
BH108	UNKNOWN
BH109	SU83596,45646
BH110	UNKNOWN
BH111	UNKNOWN
BH112	UNKNOWN
BH113	UNKNOWN
BH114	UNKNOWN
HS301	SU83643,45628
HS302	UNKNOWN
HS303	SU83613,45822
HS304	SU83488,45826
WS1	2 TALBOT ROAD
WS2	6 TALBOT ROAD
WS3&4	26 TALBOT ROAD
WS5	34 TALBOT ROAD
WS6	46 TALBOT ROAD
WS7	52 TALBOT ROAD
WS8	33 TALBOT ROAD
WS9	41 TALBOT ROAD
WS10&11	BRAMBLETON HALL
WS12	50 UPPER WAY
WS13&14	42 UPPER WAY
WS15	38 UPPER WAY
WS16&17	36 UPPER WAY
WS18	49 BALDREYS
WS19&20	47 BALDREYS
WS21&22	19 PILGRIMS CLOSE
WS23	24 PILGRIMS CLOSE
WS24	27 PILGRIMS CLOSE
WS25	5 PILGRIMS CLOSE
WS26	12 PILGRIMS CLOSE
WS27	19 WEYDON LANE
WS28	13 WEYDON LANE
WS29	5 WEYDON LANE

NOTE:

Proposed boreholes for long term monitoring include:

- **HS304**
- **BH01**
- **BH03**
- **BH107**
- **BH101**
- **BH102**
- **HS301**
- **BH103**
- **BH02**
- **BH114**
- **BH105**
- **HS302**
- **BH104**

If access is available installations within the private gardens of surrounding properties should also be monitored.

Client	Project	Job No
Waverley Borough Council	**Weydon Lane Landfill, Farnham**	**CG/5934C**
CGL	Title: **Long term monitoring points**	**Figure 4**