



global environmental solutions

Hatfield Aerodrome

Land Quality Risk Assessment

SLR Ref: 403.01009.00132

January 2016

CONTENTS

1.0	INTRODUCTION.....	1
1.1	Background.....	1
1.2	Proposed Development.....	1
1.3	Objectives	1
1.4	Scope of Work.....	1
1.5	Data Sources.....	1
1.6	References and Historic Reports.....	2
2.0	SITE DETAILS, SETTING AND HISTORY	4
2.1	Site Vicinity Description.....	4
2.2	Regional Site Setting	4
2.2.1	Regional Geology	4
2.2.2	Regional Hydrogeology.....	8
2.2.3	Regional Hydrology	10
2.2.4	Regional Contamination.....	11
2.3	Physical Site Setting.....	11
2.4	Site History.....	13
2.5	Environmental Search Data	15
2.6	Previous Investigations.....	16
3.0	CONCEPTUAL MODEL & PRELIMINARY LAND QUALITY RISK ASSESSMENT ..	17
3.1	Regulatory Context and Conceptual Model	17
3.2	Preliminary Land Quality Risk Assessment.....	17
4.0	SITE INVESTIGATIONS	22
4.1	Context and Overview	22
4.2	Geology	23
4.3	Hydrogeology.....	23
4.3.1	UMH Aquifer	23
4.3.2	LMH Aquifer	24
4.3.3	Groundwater Quality	24
5.0	RESIDUAL POTENTIAL POLLUTANT LINKAGES	27
5.1	Land Quality Risk Assessment.....	27
6.0	POTENTIAL FUTURE REQUIREMENTS	30
6.1	Potential Future Voluntary Actions and Validation	30
6.1.1	Action to Avoid PPL 3(a-b).....	30
6.1.2	Action to Break PPL 4: Unidentified Sources	30
6.2	Land Quality / Remedial Works Validation Report	30
7.0	CLOSURE.....	32

TABLES

Table 1-1	Information Sources.....	1
Table 2-1	Site Details	4
Table 2-2	Summary of Physical Site Features	11
Table 2-3	Site History Summary.....	13
Table 3-1	Conceptual Site Model	18
Table 5-1	Residual Risks	28

FIGURES

Figure 1 Regional Solid Geology (Shand P, 2003)	5
Figure 2 Regional Geology Cross Section - Solid and Superficial (Shand P, 2003)	6
Figure 3 Southern England Chalk (Bristow et al 1998)	6
Figure 4 Regional Drift Geology (Shand P, 2003)	7
Figure 5 Site Geological Sequence	8
Figure 6 Regional Geology and Piezometric Surface – Chalk Aquifer (Shand P, 2003) ..	9
Figure 7 Major Surface Water Catchments	10
Figure 8 Site Geology and Hydrogeology	23

DRAWINGS

Drawing 1	Site Location Plan
Drawing 2	Regional Chalk Surface and Subcrop with Mineral Deposits
Drawing 3	Regional Geological Cross Section
Drawing 4	Regional Bromate Plume – July 2014
Drawing 5	LMH Piezometric Surface and Bromate Concentrations (2013-2015)

APPENDICES

Appendix A	GroundSure Historical Map Extracts & Site Photographs
Appendix B	GroundSure EnviroInsight Report
Appendix C	GroundSure GeoInsight Report
Appendix D	Groundwater Quality Summary Data Tables

1.0 INTRODUCTION

1.1 Background

SLR Consulting (SLR) has been commissioned by Brett Aggregates Limited (Brett) to undertake this land quality risk assessment (LQRA) in support of a planning application for a proposed sand and gravel quarry, new access onto the A1057, aggregate processing plant, concrete batching plant and other ancillary facilities on land at the former Hatfield aerodrome, Hertfordshire (the Site).

1.2 Proposed Development

The proposed development is an 8Mt sand and gravel quarry to be worked in phases over 30 years with processing facilities to the north of the Site. Inert material would be used to infill the void as work progresses. The proposed development and method of working is described in detail in Section 3 of the Environmental Statement¹.

1.3 Objectives

The primary objective of this LQRA is to establish if there is any evidence of significant subsurface contamination from past or present activities on or adjacent to the Site which could give rise to abnormal development costs (e.g. expenditure on remedial works to address unacceptable risks to the environment or Brett employees / contractors visiting any future developments on the Site).

1.4 Scope of Work

The scope of work for the LQRA included:

- a review of site data to identify and record on and off site land uses, potential areas of concern with respect to soil and groundwater contamination and potential contaminants of concern;
- a review of geological and hydrogeological data for the Site;
- analysis of historical maps and aerial photographs to establish the history of the Site as well as past on and off site potentially contaminative activities;
- a review of relevant information held by Brett and other parties;
- collection and analysis of environmental data from a proprietary database; and
- reporting.

1.5 Data Sources

This report has been produced following consultation with the sources of information summarised in Table 1-1.

**Table 1-1
Information Sources**

Information Type	Source
General topography and site setting	Google Earth Bing Maps Ordnance Survey 1:25,000 mapping

¹ SLR Hatfield Aerodrome Environmental Statement 403-01009-00132.

Information Type	Source
Site and background information	GroundSure Historical Map Extracts purchased 27 th January 2014, and historical aerial photographs sourced from Historic England (Appendix A). GroundSure EnvirolInsight Report purchased 16 th October 2015 (Appendix B).
Hydrogeology and Geology	Environment Agency (EA) (Website and personal contact with EA Hatfield). British Geological Society GroundSure GeolInsight Report purchased 16 th October 2015 (Appendix C).

1.6 References and Historic Reports

SLR previously undertook site investigations and a desk based review² of published literature relevant to contamination at the Site and in the surrounding area. Several references are included below which have been reviewed as a background source of data, although they are not specifically referenced within this or the previous report. Affinity plc³ and the Agency have provided borehole and groundwater sample data for the wider site area.

- Affinity Water plc 2013 & 2014: Hatfield Boreholes construction details and abstraction rates in 2013 and 2014, hydrographs for Sleafshyde OBH, precipitation data
- Butler R M 2005: Remediation of Bromate Contaminated Groundwater. PhD Thesis, School of Industrial and Manufacturing Science, Cranfield University
- Butler R M et al, 2005: Bromate Environmental Contamination: Review of Impact and Possible Treatment. Critical Reviews in Environmental Science and Technology, 35:193-217
- Cook S J, 2010: The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Incorporating Karst in Predictive Models. PhD Thesis, Dept. of Earth Sciences, UCL
- Cook, S. et al 2007: Geological Controls on Hydrodynamics and Contaminant Transport in the Hertfordshire Chalk Aquifer. Poster Series
- Environment Agency 2013-14: Groundwater monitoring data from selected wells in the Hatfield/Sandridge area.
- Fitzpatrick, C. M. 2007: The Evolution of Bromate Contamination in the Hertfordshire Chalk Aquifer. Poster Series
- BGS Mineral Assessment Reports: 67 Hatfield & Cheshunt, 69 Welyn Garden City, 71 St Albans and Watford, and 112 Hertford
- Shand P et al, 2003: Baseline Report Series; 6. The Chalk of the Colne and Lee River Catchments. Environment Agency Science Group, Solihull, BGS Keyworth, Nottingham
- Symes D K, 1994: Sand & Gravel Assessment, Hatfield Aerodrome. Land & Mineral Resource Consultants Ltd., on behalf of Hertfordshire County Council

SLR field engineers discovered 10 pre-existing monitoring wells across the Site during site works completed in 2013 and 2014. SLR developed and monitored water levels and has sampled groundwater quality in all of these wells and has used this data in the development of the Site Conceptual site Model (CSM). SLR was able to determine which geological zones were being monitored based on depth and water level but we did not have borehole logs or understand their origin or context.

² SLR (November 2014) Hatfield Mineral Development Site Hatfield Hertfordshire. Site Investigation. Ref: 402.01009.00064.

³ Operator of several PWS wells in the area

In January 2016 we learnt that investigations were undertaken in 2001 by Stanger and in 2009/10 by BAE on behalf of Arlington Properties and that the 10 pre-existing boreholes incorporated into our own sampling regime are likely to be part of these investigations. However, we have not managed to locate all the reports relating to these investigations which we will continue to pursue over the coming months to incorporate relevant data into our site data base. Data will be used in furthering our understanding of the Site and therefore any development strategy going forward.

2.0 SITE DETAILS, SETTING AND HISTORY

2.1 Site Vicinity Description

Table 2-1 summarises the Site details. Information within the table has been derived from Ordnance Survey (OS) mapping and site visits over the past year.

**Table 2-1
Site Details**

Address	Former Hatfield Aerodrome north of A1057.	
Site Location	This site of approximately 87.1 hectares is located to the west of Hatfield, north of A1057 (Drawing 1). It is situated at the edge of a mixed agricultural, industrial and residential area and former sand and gravel quarrying has taken place to the north and west of the Site.	
Recent Site Activities	The current use of the Site is public open space and grazing. A concrete roadway extended west into the centre of the Site from Albatross Way and a number of earth bunds and banks are present on site from the earlier airfield.	
Site Description	<p>The Site is irregularly shaped, with the southern boundary running parallel to the A1057, with sides broadly perpendicular to this. Access to the Site is currently off Albatross Way.</p> <p>The northern boundary is irregular and follows the field boundaries with old sand and gravel lakes (Hatfield Quarry) and a wooded area (Home Covert) outside of the Site. The Site is currently vegetated by grass with some scrub/trees predominantly along the old field boundaries.</p> <p>There is an ephemeral watercourse (River Nast) which originates northwest of the Site and flows east before joining with an ephemeral ditch flowing south along the boundary with Home Covert. This combined water course is then culverted southeast beneath the former runway area and reemerges at the A1057. Whilst no other surface water features are shown on the current Ordnance Survey map, site visits indicate there are a few shallow ponds to the north of the centre of the Site.</p>	
Surrounding Land Use	North	To the north of the Site is old sand and gravel quarry workings and silt lagoons (Hatfield Quarry) which have been restored to agricultural land via landfill or left as lakes.
	West	To the west of the Site the following are located: radio station, garden centre, nurseries, agricultural land and residential premises.
	South	To the south of the Site is the A1057, beyond which is agricultural land and residential properties.
	East	To the east, immediately adjacent to the boundary is more open land of the former Hatfield Aerodrome and a small playing field. Beyond these are a business park, residential area and part of the campus of the University of Hertfordshire.

2.2 Regional Site Setting

This section presents the regional geology, hydrogeology and hydrology and is based upon literature sources and site data. This data was used to develop the Conceptual Site Model (CSM) upon which the subsequent phases of investigation work were based.

2.2.1 Regional Geology

London Basin

The Site is located on the northern limb of the London Basin which forms an asymmetrical syncline with its axis trending southwest-northeast and plunging east. The boundary of the

synclinal basin is formed by the Chilterns to the north and the North Downs to the south where the Chalk forms the predominant hard geology.

The Chalk is subdivided into Lower, Middle and Upper and is overlain in the centre of the London Basin by Paleogene rocks (Thanet Sands, Reading Beds), and the Eocene London Clay. Figure 1 illustrates the solid geology of the region with the area of the Site circled in red. A northwest to southeast cross section depicting the southeast dipping strata in the London Basin is shown as Figure 2.

Figure 1
Regional Solid Geology (Shand P, 2003)

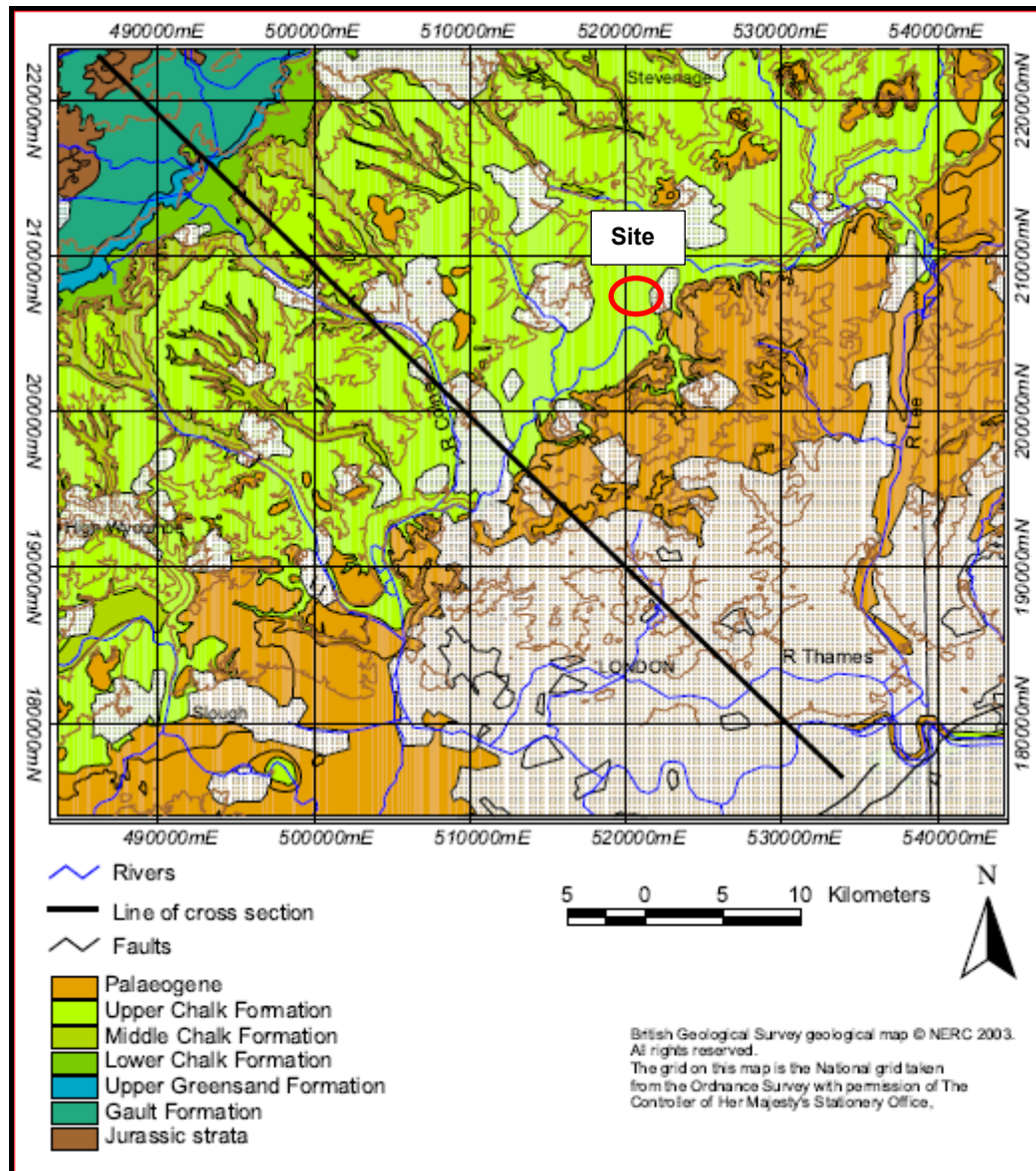
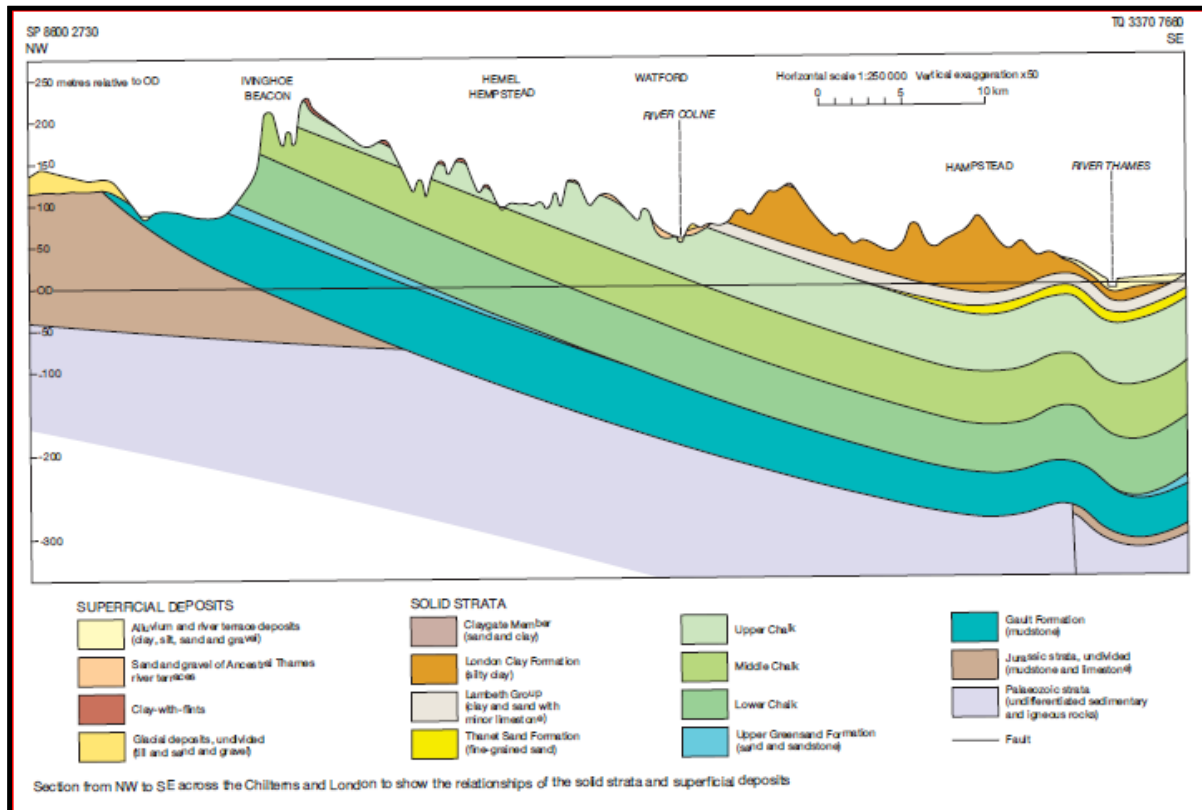


Figure 2
Regional Geology Cross Section - Solid and Superficial (Shand P, 2003)



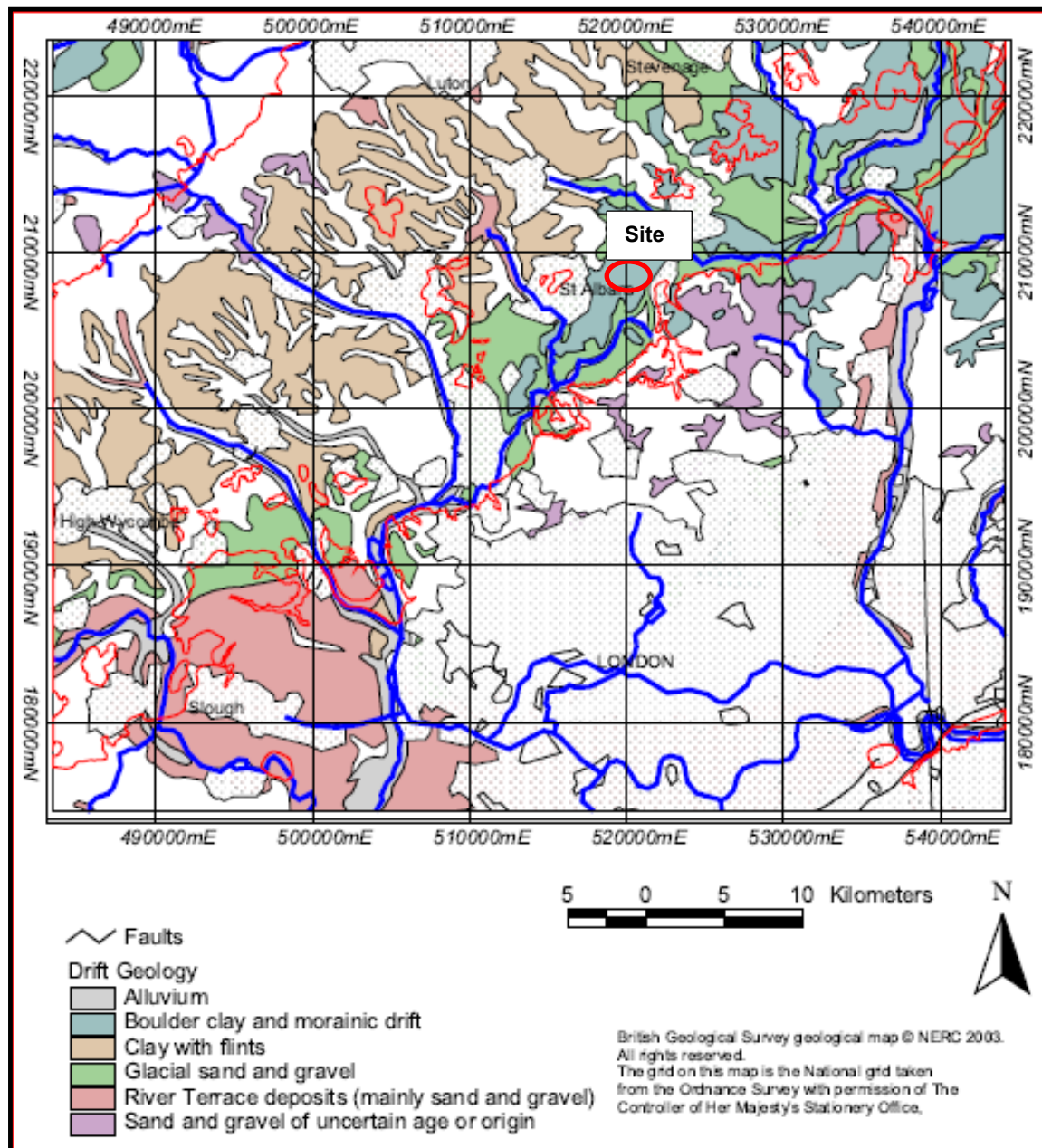
The solid geology beneath the Site comprises the Lewes Nodular Chalk (Bristow et al., 1997) being the lowermost part of the Upper Chalk, with a characteristic hard band close to the Chalk sub crop. Middle and Lower Chalk underlies the Lewes Nodular Chalk.

Figure 3
Southern England Chalk (Bristow et al 1998)

Formation Member		
Erosional bedrock surface beneath the Site	Chalk	Upper Chalk
		Middle Chalk
	Chalk	Lower Chalk
		West Melbury Marly Chalk

The solid geology is overlain by Quaternary superficial deposits comprising glacial gravels infilling valleys cut into the Lewes Nodular Chalk, with boulder clay and clay with flints across higher ground. Figure 4 illustrates the distribution of superficial deposits across the area with the study site circled in red.

Figure 4
Regional Drift Geology (Shand P, 2003)



Vale of St Albans

The Site lies within the Vale of St Albans; a broad northeast to southwest orientated plain between higher land to the northwest and southeast. The higher land to the west comprises Upper Chalk solid geology at outcrop locally with a cover of superficial drift (Clay with Flints). In contrast the higher land to southeast comprises Upper Chalk overlain by the feathering margins of the Lower London Tertiaries and some superficial drift.

The Vale of St Albans corresponds with the route of a pre-glacial water course (Proto-Thames) that is understood to have flowed northeast into East Anglia⁴. Tertiary period strata

⁴ Catt J. Hertfordshire Geology and Landscape. 2010.

are absent beneath the Site and the Vale of St Albans and the chalk solid geology is shown sub cropping⁵ beneath a sequence of glacial deposits comprising boulder clay and gravels.

Within the Vale of St Albans a number of previous studies^{6,7} have identified three broad superficial drift units comprising upper and lower granular formations (sands, gravels) separated by a relatively thin but laterally continuous boulder clay. The following geological sequence is indicated to be present beneath the Site area.

Figure 5
Site Geological Sequence

Drift/Solid	Geological Unit
Superficial Drift	Upper Mineral Horizon (UMH)
	Boulder Clay (BC)
	Lower Mineral Horizon (LMH)
Solid Geology	Upper Chalk (Lewes Nodular Chalk)

SLR has gathered borehole data from the Site area and beyond from the BGS Mineral Sheets and has used this data to prepare a contour plan of the chalk surface which in places is at outcrop and in others subcrops beneath the drift deposits. The areas shaded pink on Drawing 2 identify where chalk is overlain by mineral deposits.

The chalk erosional surface contours illustrates that the Site sits within a trough or paleo-valley with the chalk surface rising up to the northwest and southeast but also falling towards the northeast and the south. The point at which the chalk erosional surface falls from northeast to south coincides with the watershed between the River Colne and the River Lea surface water catchments.

2.2.2 Regional Hydrogeology

Groundwater in the general area of the Site is dominated by the Chalk aquifer which is designated by the Agency as a Principal Aquifer.

The area shaded green on Figure 6 is where the Chalk bedrock outcrops or where it is overlain locally by Quaternary drift deposits. The Chalk aquifer is typically unconfined where it outcrops to the northwest, although where incised valleys cut into the Chalk it can be filled with Quaternary drift in which case the Chalk can be locally confined beneath cohesive drift deposits. The Chalk becomes confined by Tertiary sediments to the southeast (Figure 6) although the lowermost Tertiary sediments (Thanet Sands and the Reading Beds) are generally considered part of the Chalk hydrostratigraphic system, with the London Clay acting as the confining aquitard unit.

The Chalk is a dual porosity aquifer with high matrix porosity but low matrix permeability, but is also highly fractured, typically within 10m - 30m of the water table due to dissolution which widens the fractures. The Chalk also contains hard bands that are layers of higher fracture permeability due to lithological differences in the lithology, which can be traced across the region, and which may exist close to the Chalk subcrop beneath the Site⁵.

⁵ British Geological Survey Sheet 239 Drift. Hertford. 1978.

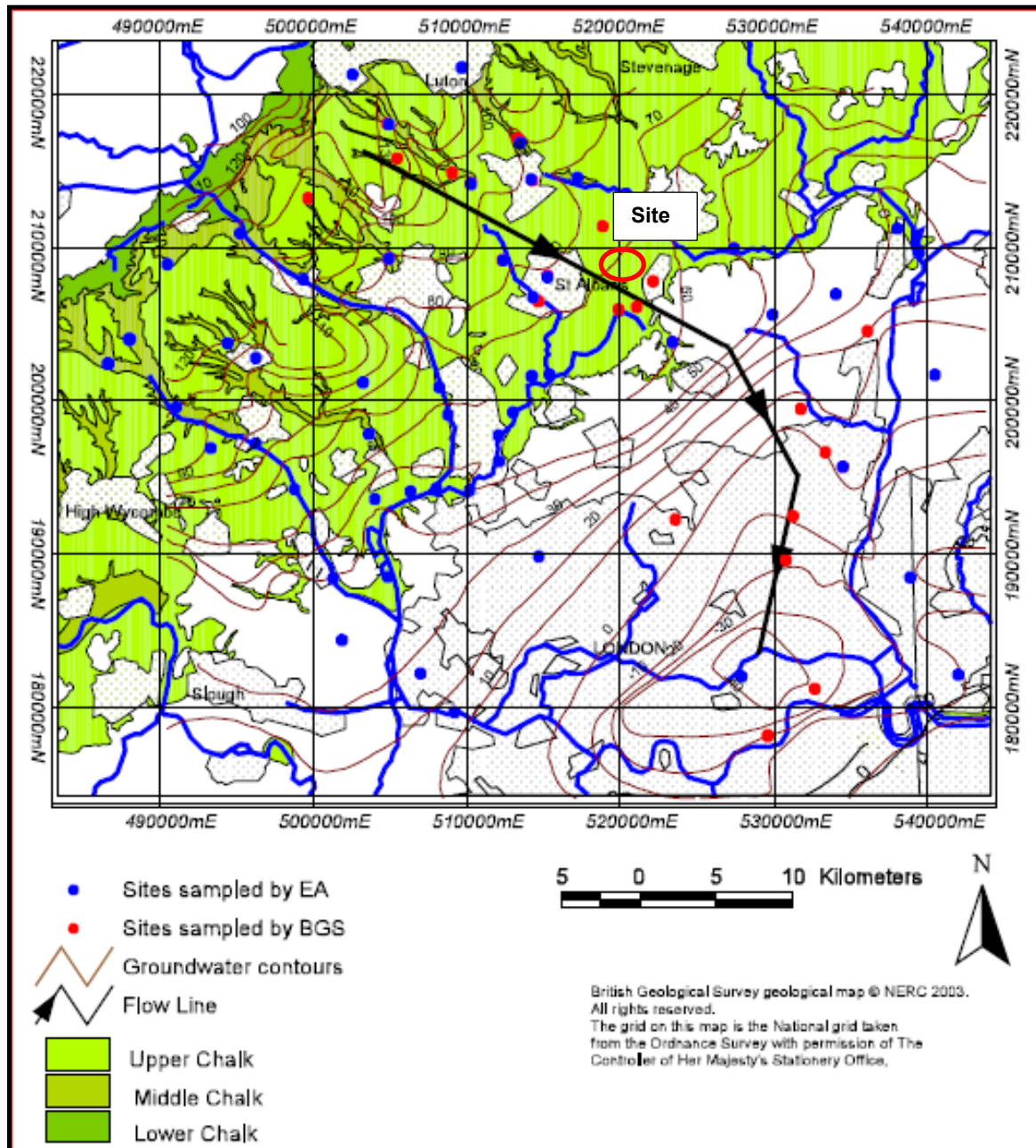
⁶ Symes D K, 1998: Sand & Gravel Assessment, Hatfield Aerodrome. On behalf of Hertfordshire County Council

⁷ Cook S J. The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Incorporating Karst in Predictive Models. EngD Thesis UCL. April 2011.

⁸ Little J A & Atkinson J H. Some Engineering Properties of Anglian Tills in the Vale of St Albans. QJEG. 21. Pp183-199. 1988.

Figure 6 also illustrates the regional groundwater head in the Chalk Aquifer with a maximum elevation of about 120mAOD on strike with the outcrop approximately 15km northwest of the Site and approximately -30mAOD in Central London, 30km to the southeast. Regional groundwater flow is therefore towards the southeast.

Figure 6
Regional Geology and Piezometric Surface – Chalk Aquifer (Shand P, 2003)



The Upper Chalk is a Principal Aquifer⁹ and the granular superficial drift deposits are classified as Secondary aquifers¹⁰.

⁹ Rock or drift deposits that have high inter-granular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale (Environment Agency (EA)).

¹⁰ Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers (EA).

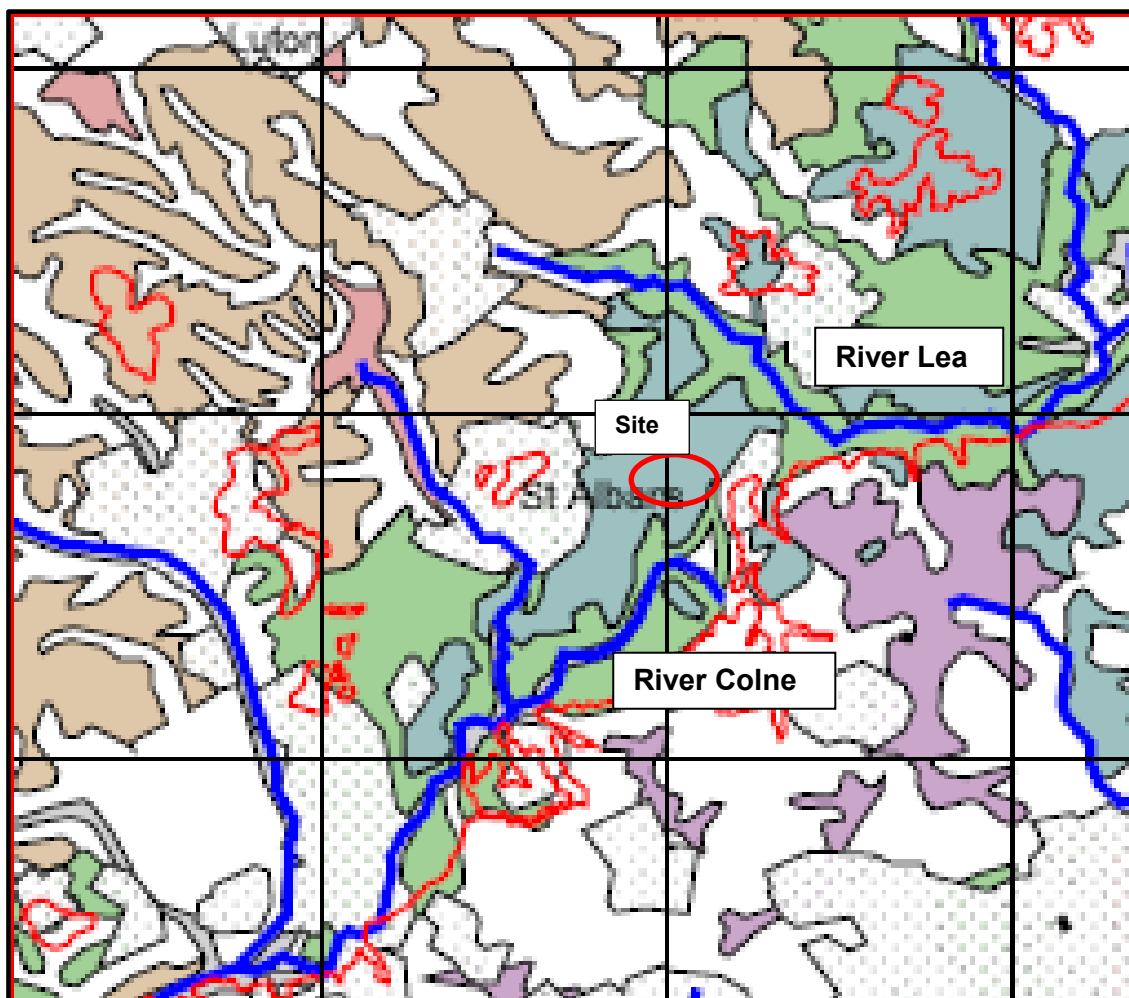
The BGS¹¹ indicates that the elevation of groundwater table (piezometric surface) in the Chalk in the area of the Site is approximately 60 to 70mAOD (i.e. 8m to 14m below ground level) with a southeast flow direction. This may vary locally due to seasonal fluctuations and local abstractions.

Drawing 3 is an East to West cross section through the Site (line of section shown on Drawing 2) illustrating the location of the Site within the drift filled erosional surface of the Chalk. Of note is the regional piezometric surface of the Chalk aquifer crossing into the drift from the Chalk and saturating the LMH which is then confined by the intermediate boulder clay.

2.2.3 Regional Hydrology

As illustrated on Figure 7, the Hatfield Aerodrome Site lies on or near what is considered to be the watershed between the River Colne catchment to the south-southwest and the River Lea to the northeast. More description and discussion of the nearby surface water features are presented in Section 2.3.

Figure 7
Major Surface Water Catchments



Key: As Figure 4

¹¹ Institute of Geological Sciences Hydrogeological Map of the area between Cambridge and Maidstone. BGS.

2.2.4 Regional Contamination

Regional groundwater has been impacted by a historical release of bromate into the Chalk aquifer at Sandridge located 3km to the northwest of the Site and a bromate plume extends east-southeast over a large part of Hertfordshire, so of primary importance was the need to assess the nature and extent of bromate impacted groundwater present beneath the Site, if any. The lateral extent of the bromate plume is illustrated on Drawing 4.

Bromate in the Chalk aquifer at Sandridge has migrated laterally with groundwater flow east-southeast from the source. However, although the bromate originally impacted the Chalk at its source (there is no saturated mineral present at Sandridge), the chalk aquifer piezometric surface crosses the Chalk/LMH geological boundary approximately 1 km east of the source which has resulted in the plume being present in both the Chalk and the LMH. It is at this location that the axis of the plume extends west to east towards the northern end of the Aerodrome plume before it turns again in an east-southeast direction.

The slightly unusual shape to the bromate plume described above could be due to the presence of low permeability material within Hatfield Quarry Landfills in place of more permeable mineral deposits hydraulically up-gradient of the former Hatfield Aerodrome. This would act as a barrier to flow causing the plume to migrate around the workings before it resumes its flow direction towards the southeast, which appears to be towards the Hatfield Boreholes operated by Affinity plc.

As shown on Drawing 4 the bromate plume does not appear to cross the northern boundary of the application site and exists principally beneath the northern half of the former undeveloped Aerodrome.

2.3 Physical Site Setting

A summary of the main physical features of the Site are given in Table 2-2. Information has been derived from the GroundSure EnviroInsight Report, previous SLR site investigations and other sources.

Table 2-2
Summary of Physical Site Features

Geography and Geology	Gradient	The Site is gently sloping and falls slightly from the western boundary of the Site to the north, east and south. The gradient is approximately 1 in 50.
	Elevation	The Site has the greatest elevation in the west (c.79-78mAOD) and lowest in the south east corner (c. 74mAOD). There are no permanent structures on site, however, demolition of the former aerodrome runway which ran south west to north east across the majority of the central part of the application site and crossed the eastern site boundary, causes localised high ground associated with this feature up to 83mAOD.
	Made Ground	The runway and race track area are reworked as well the mock film village which was offsite. There will probably be made ground with the associated aerodrome buildings and fire training area. Borehole logs have identified no other made ground on site but show an area around BH105 where the mock village for the 'Saving Private Ryan' and 'Band of Brothers' film set was located.
	Superficial Drift Geology	Site investigations and studies have identified four broad glacial superficial drift units comprising an upper and lower granular formation (sands, gravels known as the Upper Mineral Horizon and Lower Mineral Horizon respectively) separated by

		boulder clay and all overlain by a gravelly clay overburden. An alluvium deposit is associated with the part of the Nast channel that is currently culverted beneath the majority of the Site. These superficial drift deposits are recorded to have a highly variable permeability from high to very low.
	Solid Geology	<p>The solid geology beneath the application site comprises undifferentiated Lewes Nodular Chalk Formation and Seaford Chalk Formation. This dips to the south-east and is underlain by undifferentiated Holywell Nodular Chalk Formation and New Pit Chalk Formation.</p> <p>Further details for geology and hydrogeology are provided in section 4 of this report.</p>
	Radon Gas	Brett's proposal does not include the development of dwellings, but in any case no radon protective measures are necessary.
	Mining, and Ground Stability Hazards	GroundSure shows numerous old sand and gravel pits to the immediate north and northwest of the Site and suggests there was a small area of sand and gravel extraction near the course of the Nast in the proposed processing area. The report also notes that some occasional minor mining for chalk may have occurred at the Site but no area is identified. There are very low to negligible ground stability hazards from shrinking / swelling clay, landslides, ground dissolution, collapsible ground, compressible ground and running sands. There is considered to be moderate compressible ground risk in the area of the alluvium channel, however, this will be removed as part of the proposed development.
Hydrology	Surface Water and River Network	<ul style="list-style-type: none"> The ephemeral River Nast originates in the northwest of the Site and flows east before joining with an ephemeral un-named water course in a ditch that flows south along the site boundary with the Home Covert wooded area. This combined water course is then culverted southeast under the old runway area and Hatfield University playing fields before eventually joining the Ellenbrook offsite. There are a few shallow small ponds onsite close to the course of the Nast. Lagoons from previous mineral workings exist to the immediate north of the Site. A tributary of the Ellenbrook is located c.200m east of the Site. There are also retention basins for the residential area which feed into the brook at this location. To the west of the Site is a small stream called Boggymead Spring which is c.500m at its closest point this flows south and joins the Ellenbrook. The Ellenbrook joins the River Colne which flows east to west and is approximately 2km south of the Site.
	Flood Risk	The majority of the Site lies within Zone 1 Floodplain; however, a small part of the Site near the playing fields relating to the culverted River Nast is designated as Zone 2. A Flood Risk Assessment has been undertaken and found there will be minimal impact due to the nature of the proposed development.
	Surface Water Abstractions	There are no surface water abstraction licences within 2km of the Site.
	Surface Water Safeguard Zones	The Site is within a Surface Water Drinking Water Safeguard Zone.

Hydrogeology	Aquifer	<p>The glacial drift deposits of sand, gravel and clay (Overburden, Upper Mineral Horizon (UMH), Interburden and Lower Mineral Horizon (LMH)) are designated as Secondary (undifferentiated) Aquifers whilst the alluvium is designated Secondary (A) Aquifer.</p> <p>The Chalk is classified as a Principal Aquifer. Groundwater within the chalk and LMH are in hydraulic continuity whilst the groundwater in the UMH is perched on the Interburden, this is described in more detail in section 3.</p>
	Groundwater Abstractions	There are 7 groundwater abstractions within 2km of the Site. One of which is for potable water. The others are for agricultural and mineral process water.
	Source Protection Zones	The Site is predominantly within a Source Protection Zone 3 – Total Catchment, with Zone 2 – Outer Catchment in the south east and south west corners of the Site. The SPZ3 and SPZ2's relate to public water supply boreholes (Hatfield and Colney Heath) located 1.5km southeast and 2.2km south southeast from the Site, respectively. The Hatfield boreholes no longer provide potable water but are part of a groundwater control system related to the bromate plume described earlier.
	Groundwater Safeguard Zones	The Site is classified as an "At Risk Area" under the Groundwater Drinking Water Protected Areas meaning that raw groundwater quality in the vicinity of the site requires improvement, to avoid the need for extra treatment at drinking water treatment plants. The majority of the Site is not within a Groundwater Safeguard Zone, meaning that specific actions are not being implemented. The far eastern part of the site is within a Groundwater Safeguard Zone however, this related to the Hatfield boreholes which will be discussed further later.

2.4 Site History

A review of OS map extracts and historical aerial photographs have been summarised in Table 2-3. Map extract and aerial photographs are included in Appendix A.

Whilst the age and general type of activity and land use can often be determined from the type and layout of structures depicted on OS maps specific elements of site operations cannot normally be determined. Large scale (1:10,000) historical map extracts and available aerial photos from google earth were reviewed for selected years between 1937 and 2011.

Table 2-3
Site History Summary

Year	Site	Wider Area
1937	<ul style="list-style-type: none"> The Site comprises fields and pasture. The Nast follows its current open water and culverted route. A Race Track occupies an area northwest of Popefield Farm. 	<ul style="list-style-type: none"> East: Fields and pasture. West: Fields and pasture. North: Astwick Manor, fields and woodland. South: Some housing, nursery/greenhouses and fields. The Ellenbrook is not recorded. Home Covert is as today with a small cottage, a pond and paths crossing through the woodland.
1960	<ul style="list-style-type: none"> The Site is completely within the former Hatfield Airfield with the runway extending northeast to southwest across 	<ul style="list-style-type: none"> East: Airfield and aircraft works to the northeast. West: Woodland and fields.

Year	Site	Wider Area
	<p>the centre of the Site, with part of the taxiway skirting the southern side of the development area.</p> <ul style="list-style-type: none"> • Remaining areas appear to be open and undeveloped. • The Nast is shown flowing onto site at the northwest site boundary before ending on the northern side of the runway where it enters a culvert (as today). 	<ul style="list-style-type: none"> • North: Astwick Manor, fields and woodland. • South: Housing, nursery/greenhouses and fields. • Home Covert is an area of woodland on the northwest boundary that appears to occupy the same area as today. • The Ellenbrook is not recorded.
1975	<ul style="list-style-type: none"> • As 1960 	<ul style="list-style-type: none"> • As 1960
1990	<ul style="list-style-type: none"> • As 1975 	<ul style="list-style-type: none"> • As 1975
1999	<ul style="list-style-type: none"> • As 1990 • A small area southwest of Home Covert is an aircraft parking stand with a fire training area. Further detail is shown on the historical aerial photographs. 	<ul style="list-style-type: none"> • The majority of the aerodrome works buildings have been removed and new commercial buildings are cover about 30% of the former aerodrome works. • The outline of a small rectangular industrial area north of Home Covert is suspected to be related to aerodrome operations in the 1990's.
2001	<ul style="list-style-type: none"> • The Site is being used for the Band of Brothers film set and various areas have been landscaped: • The open course of the Nast has been moved slightly and the area around it shows shallow depressions. • A mock base/barracks is visible to the south of the runway. • The fire training area remains. 	<ul style="list-style-type: none"> • The rectangular building northeast of Home Covert remains. • A few aerodrome work buildings such as hangers are still shown to the east. • To the east of the Site is a mock village, outlying farmhouses, a tree avenue, two large water features, cuts next to one of the taxiways and a raised hill from the Band of Brothers film set.
2006	<ul style="list-style-type: none"> • The Band of Brothers film set has been removed. • The runway hard standing has been broken up and removed. • The taxiway remains. • The open Nast channel has been reinstated to the pre 2000 route. • The fire training area has mostly been broken up with some hardstanding remaining. 	<ul style="list-style-type: none"> • The Band of Brothers set has been removed along with the associated water features and hill. • The runway has been removed and has been largely replaced with commercial warehouse-like buildings and some residential properties. • Aircraft works buildings southeast of the aerodrome taxi-way have been demolished and are in the process of being replaced with new commercial buildings. • The rectangular building northeast of Home Covert remains. • Hatfield University buildings/campus is in place. • Ellenbrook is present in its current form. • Ellenbrook balancing lagoons are in place adjacent to the Site.
2011	<ul style="list-style-type: none"> • The runway has been dismantled. • The taxiway remains. • The Nast remains culverted across the Site. 	<ul style="list-style-type: none"> • Northeast: The aerodrome buildings have been redeveloped with additional commercial buildings. • The rectangular building northeast of Home Covert remains. • The Ellenbrook is in place. • Residential property has been built east of Ellenbrook. • Hatfield University is built to the south of the residential buildings.

Year	Site	Wider Area
		<ul style="list-style-type: none"> Northwest: Mineral extraction and lagoons are present along the north-western site boundary.

In summary, the Site was predominately agricultural land until it was designated as an aerodrome, which occurred after 1937. The entire site was formerly part of Hatfield Aerodrome although the associated aircraft design, testing and manufacturing aspects of the de Havilland and subsequently Hawker Siddeley and BAe facilities were all located off site to the east (beyond Ellenbrook). With the exception of the former aircraft fire training area, there is little evidence for past potentially contaminative activities having taken place on site.

It is also known that parts of Saving Private Ryan (1998) were filmed at Hatfield Aerodrome in the late 1990's and that this included larger water features; however, aerial photos are not available of this time and it is only the later Band of Brothers (2001) film set that is seen on satellite images (Google Earth).

Off site, the land was largely agricultural until the 1990s, when significant industrial development started to the east, followed by residential development.

Mineral extraction to the north of the Site has been occurring throughout the 20th century. The various phases of the Hatfield Quarry and associated landfilling operations (closed and active) run parallel with the northwest site boundary. Given that the Site is hydraulically down gradient within the chalk/LMH aquifers of all these areas there is a possibility that they could impact upon groundwater beneath the Site.

Potentially contaminative off site land uses are limited to:

- aerodrome buildings/workshops (all hydraulically down gradient);
- surrounding industrial developments (all hydraulically down gradient);
- infilled sand and gravel quarries to the northwest, north and northeast; and
- the bromate plume is deemed to be a source of potential secondary contamination, with the source area being near Sandridge.

2.5 Environmental Search Data

The EnviroInsight report, presented in Appendix B, was reviewed to gain commercially available environmental data for the Site and its immediate vicinity. A summary of the search information is provided below:

- Sites Determined as Contaminated Land – there are no sites within 500m determined as Contaminated Land under Part 2A EPA 1990;
- Discharge consents – there is one consent within 500m of the Site, which is treated effluent and 433m north west at Beech Farm;
- Integrated Pollution Prevention and Controls– none within 500m;
- Local Authority Prevention & Controls – 3 records are listed within 500m of the Site, Shell Service Station. Cemex UK Materials Ltd (cement and lime batching) and Smallford Motors;
- EA recorded pollution incidents – there are none recorded within 200m of the Site, However 3 minor incidences are recorded within 500m which are to the south of the A1057;
- Landfill sites – There is one active landfill within 1km of the site, located to the north of the site. However, this landfill has a closed status and is not receiving waste;
- Historic Landfills – There are 32 historic landfill licenses within 1.5km of the Site, however, it is noted that some of these cover the same areas but for different waste

types and/or times. The closest landfills are to the immediate north, northwest and northeast of the site. The historic landfills within 500m of the site are listed below:

- 0m north (Hatfield Quarry, which accepted industrial, commercial and household wastes, 1935-1977);
- 0m north (Hatfield Quarry, which accepted inert wastes 1977-1987);
- 1m northwest (Hatfield Quarry, which accepted industrial, commercial and household wastes 1935-1977);
- 143m southwest (Oak Farm, which accepted industrial, commercial and household wastes 1935-1977);
- 291m north (Hatfield Quarry, accepted unknown waste types 1993- 2014);and
- 451m southwest (Pollards Playing Fields, accepted unknown waste types).
- Ecological Designations – There are two areas of Ancient and Semi-Natural Woodland within a 1km radius, both are to the northwest of the Site c. 750m and c.900m. There are no National Nature Reserves, RAMSAR, Special Areas of Conservation, Special Protection Areas or Sites of Special Scientific Interest within 2km of the Site.

2.6 Previous Investigations

See notes in Section 1.6.

3.0 CONCEPTUAL MODEL & PRELIMINARY LAND QUALITY RISK ASSESSMENT

3.1 Regulatory Context and Conceptual Model

The normal procedure for assessing land dictates that potential contaminants, pathways and receptors should be considered within the context of contaminant and pollutant linkages. An evaluation of the risks associated with each linkage should drive decisions regarding the status of the land as potentially contaminated and requiring remediation, uncontaminated or requiring further investigation.

The information summarised in the previous sections has been used to identify the potential for contaminant sources, receptors and pathways present at the Site. The elements of the conceptual model built into Table 3-1 (overleaf) have been used to consider the **potential pollutant linkages (PPL)** and their significance.

3.2 Preliminary Land Quality Risk Assessment

The following conclusions have been drawn from the desk study and considered in development of the LQRA:

- the land use of the Site area has remained largely undeveloped as either agricultural land or aerodrome runway;
- there are no indicators from historic mapping that made ground other than that related to the runway, fire training area and film set is likely to be present on site as there have been no other structures present;
- the ground has been reworked in the runway and fire training areas when the majority of the made ground was broken and largely removed from areas. SLR borehole records indicate there is no made ground at their location;
- the development under consideration for the Site will be mineral extraction, not residential;
- the bromate plume is an off-site source of secondary potential contamination. Natural attenuation (e.g. dispersion) of the bromate within the groundwater could cause some bromate to spread beneath the site boundaries albeit at lesser concentrations; and
- other off-site contamination sources include the landfills to the north and west which are hydraulically up-gradient in the Chalk/LMH aquifer.

Given the proposed industrial use the most significant PPL's appear to be:

- **PPL1a:** Potential Harm to Human Health from Exposure to Contaminants within Soils via Ingestion, Dermal Contact and Inhalation.
- **PPL1b:** Potential Damage to Buildings from Exposure to Aggressive Ground.
- **PPL1c&d:** Potential impact to Controlled Waters by Contaminants in Soil / Natural Geology.
- **PPL2a:** Potential Harm to Human Health from Potential Landfill Contaminants in Groundwater.
- **PPL2b:** Potential Damage to Buildings from Exposure to Aggressive Groundwater
- **PPL2c&d:** Potential Harm to the Environment from Potential Landfill Contaminants in Groundwater.
- **PPL3a-c:** Potential Harm to Human Health and the Environment from Potential Spreading of the Bromate Plume.
- **PPL4:** Potential Risks to Health or the Environment from Unidentified Sources.

Table 3-1
Conceptual Site Model

Source / Area of Concern	Contaminant(s)	Receptors	Likelihood of PPL Forming & Comment on Consequence	Next Step in Procedure
Source 1 – Possible Made Ground on site <i>Made Ground is likely to be limited to the fire training area and the course of the runway. Both areas have had the majority of the Made Ground broken and dismantled (e.g. hardstanding).</i>	Potential remnants of asbestos, metals, organics related to fuels and solvents in made ground soils	Humans – Indoors: Future workers & visitors	Unlikely	-
		Humans – Outdoors: Future workers & visitors	PPL 1a: Low potential harm to human health from ingestion, inhalation and dermal contact with contaminants within the made ground (i.e. asbestos, metals, PAHs and TPH).	PPL 1a: Further Investigation & Assessment – see Section4
		Humans - Neighbours	Unlikely that any site derived contamination would impact humans working on or visiting neighbouring sites.	-
		Property – Built Environment: Future buildings	PPL 1b: Possible that exposure to contaminants in Made Ground could result in deterioration of buried concrete due to sulphate or acid attack. However, this is unlikely.	PPL 1b: Further Investigation & Assessment – see Section4
		Property – Scheduled Ancient Monuments	Unlikely - none on site	-
		Property - Flora / Fauna: Crops or ornamental planting	Unlikely - none on site	-
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.	PPL1c: Possible contamination of the watercourses and ponds through surface water run-off and particulate matter.	PPL 1c: Further Investigation & Assessment – see Section4
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	PPL1d: The pathway is through contaminants potentially leaching from the soil. Impacts to the perched Secondary Aquifer are possible but impacts to the underlying Principle Aquifer are far less likely due to the presence of the Boulder Clay beneath the Secondary Aquifer.	PPL 1d: Further Investigation & Assessment – see Section4
		Ecosystems: Two areas of Ancient and semi-natural woodland c.800m north-west of the Site.	Unlikely	-

Source / Area of Concern	Contaminant(s)	Receptors	Likelihood of PPL Forming & Comment on Consequence	Next Step in Procedure
Source 2 – Possible methane, other hazardous gases and contaminated groundwater emanating from the adjacent landfill sites. <i>The surrounding landfills accepted a range of wastes from inert, industrial, commercial, household and special waste.</i>	Hazardous gasses (e.g. methane and carbon dioxide)	Humans – Indoors: Future workers & visitors	Gas: Unlikely – future buildings will be associated with the processing plant. Groundwater: Unlikely.	-
		Humans – Outdoors: Future workers & visitors	Gas: Unlikely given diffusion to atmosphere Groundwater: PPL2a : Possible contamination via ingestion and dermal contact with contaminant in groundwater	PPL 2a : Further Investigation & Assessment – see Section 4
	Elevated ammoniacal nitrogen, metals and hazardous substances in groundwater	Humans - Neighbours	Unlikely to be significantly impacted by on site sources	-
		Property – Built Environment: Future buildings	Gas: Unlikely explosion risk from build-up of gases / vapours under / within the building due to nature of well-ventilated buildings. Groundwater: PPL 2b : Possible that exposure to contaminants in groundwater could result in deterioration of buried concrete due to sulphate or acid attack. However, this is unlikely.	PPL 2b : Further Investigation & Assessment – see Section 4
		Property – Scheduled Ancient Monuments	Unlikely - none on site	-
		Property - Flora / Fauna: Crops or ornamental planting	Unlikely – crops will not be grown on the Site.	-
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.	Gas: Unlikely Groundwater: PPL2c : The watercourses are ephemeral and groundwater fed from the UMH superficial aquifer. If groundwater is impacted then contamination of surface water is possible during high groundwater levels with a potential impact upon ecology.	PPL 2c : Further Investigation & Assessment – see Section 4
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	Gas: Unlikely Groundwater: PPL2d : Groundwater in the UMH and Chalk/LMH is hydraulically down-gradient of the historic landfills so there is a potential for groundwater to be impacted on site.	PPL 2d : Further Investigation & Assessment – see Section 4
		Ecosystems: Two areas of Ancient and semi-natural woodland c.800m north-west of the Site.	Unlikely given distance	-

Source / Area of Concern	Contaminant(s)	Receptors	Likelihood of PPL Forming & Comment on Consequence	Next Step in Procedure
Source 3 – Bromate plume within the Chalk/LMH aquifer. <i>Whilst the source of the bromate is 3km to the northwest of the Site. The edge of the current plume within the groundwater is just within the site boundary. Remediation for the plume is occurring further down-gradient from the Site at the Hatfield boreholes owned by Affinity and natural attenuation will continue to dilute and disperse the plume, however, the possibility of contamination from the plume must be considered.</i>	Bromate/bromide above the UK Drinking Water Standard (DWS)	Humans – Indoors: Future workers & visitors	Unlikely	-
		Humans – Outdoors: Future workers & visitors	PPL3a: Possible contamination via ingestion and dermal contact with bromate in groundwater	PPL 3a: Further Investigation & Assessment – see Section 4
		Humans - Neighbours	Unlikely	
		Property – Built Environment: Future buildings	Unlikely	-
		Property – Scheduled Ancient Monuments	Unlikely - none on site.	-
		Property - Flora / Fauna: Crops or ornamental planting	Unlikely – crops will not be grown on site.	-
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.	Unlikely – there is no bromate in the UMH nor has bromate been detected in surface water. Site operations will extend down into both the upper and lower mineral aquifers, so the potential for groundwater mixing exists with the potential for impacting surface water. Operational proposals mitigate this risk and will be a topic of the operational permit.	-
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	PPL3b: Possible contamination of the LMH and Chalk groundwater beneath the Site via the contaminated groundwater off-site. PPL3c: This linkage applies to the LMH and the UMH aquifers	PPL 3b: As for PPL 3a. PPL3c: As for PPL 3a
Source 4 - Unidentified Contaminant Source(s) on site	Various common contaminants	Ecosystems: Two areas of Ancient and semi-natural woodland c.800m north-west of the Site.	Unlikely	-
		Humans – Indoors: Future workers & visitors	PPL 4: Potential Harm to Health or the Environment from Unidentified Contaminant Sources – Exposure Mechanism Unknown.	PPL4: If Needed – Voluntary Remedial Action – see Section 6
		Humans – Outdoors: Future workers & visitors		
		Humans - Neighbours		
		Property – Built Environment: Future buildings		
		Property – Scheduled Ancient Monuments		

Source / Area of Concern	Contaminant(s)	Receptors	Likelihood of PPL Forming & Comment on Consequence	Next Step in Procedure
		Property - Flora / Fauna: Crops or ornamental planting		
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.		
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.		
		Ecosystems: Two areas of Ancient and semi-natural woodland c.800m north-west of the Site.		

4.0 SITE INVESTIGATIONS

4.1 Context and Overview

SLR site work started in July 2013 with subsequent groundwater and surface water monitoring being carried out regularly up to October 2015. Additional drilling was undertaken in May 2014 in response to findings from the initial set of boreholes and permeability testing was undertaken in January 2015. The site work included:

- borehole drilling and collection of bulk and undisturbed soil samples:
 - particle size distribution analyses of mineral horizon soil samples;
- hydraulic conductivity testing of the Interburden clay (laboratory analysis of U100 sample in a triaxial permeameter);
- 29 monitoring well installations in 20 boreholes (UMH, LMH & Chalk aquifer intervals):
 - BH101 to BH108, BH201; and
 - FT101 to FT103
- development and sampling of selected pre-existing monitoring wells (10 No.);
- groundwater and surface water level monitoring from all SLR wells and subsequently from a network of pre-existing “old” wells identified by SLR;
 - monthly (08/13 - 07/14), and quarterly (10/14 – 10/15)
- continuous groundwater level monitoring in 6 wells using transducers and data loggers (08/13 – current);
- groundwater and surface water quality sampling of SLR monitoring wells (quarterly schedule as per water level monitoring, amended to monthly if bromate was detected);
- additional water level monitoring and groundwater analysis of 10 pre-existing monitoring wells discovered during site works (added to the monitoring schedule from time of discovery);
- laboratory analysis of groundwater and surface water samples:
 - baseline – bromate/bromide, total petroleum hydrocarbons (TPHCWG), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, metals, inorganic compounds, major ions;
 - quarterly – bromate/bromide, metals, inorganic compounds, major ions; and
 - monthly – bromate/bromide from selected monitoring wells.
- tracer dye testing of the Nast and Ellenbrook; and
- purchase of additional groundwater quality data from the Environment Agency for the wider Hatfield area.

Details of the site work and sampling are described in a previous SLR report², whereas this report provides a brief summary of groundwater quality and assesses the data in relation to the PPL’s identified in Section 3.

4.2 Geology

Figure 8 schematically shows the geology and hydrogeology identified on site.

Figure 8
Site Geology and Hydrogeology

Drift/Solid	Depth (mbgl)	Geological Unit	Aquifer and Depth (mbgl)
Superficial Drift	0.1 – 5.7	Overburden – Clay, Sand, Gravel	0.49 -8.39
	2.2 – 11.8	Upper Mineral Horizon (UMH)	
	6.2 – 14.2	Interburden - Boulder Clay (BC)	5.39 – 13.63
	8 – 18.3	Lower Mineral Horizon (LMH)	
Solid Geology		Upper Chalk	

The boreholes installed by SLR provide the following information:

- the overburden comprises a variable mixture of clay, sand and gravel, mixed and in discrete lenses;
- the UMH comprises of slightly gravelly sand, whilst the LMH comprises sand and sandy gravel;
- the Interburden is a typical over-consolidated glacial boulder clay. Its permeability has been measured in laboratory tests at 5×10^{-11} m/s; and
- the LMH comprises sandy gravel and gravel, with less sand than the UMH.

The upper surface of the chalk is an erosional surface with clay like texture at its surface thought to be caused by weathering processes.

Drawing HQ 6/3 of the Environmental Statement¹ (ES) depicts a SW – NE trending geological cross section that extends beyond the site boundary across and beyond the Ellenbrook. The site boundary is shown and illustrates the two mineral zones and boulder clay Interburden separating the two horizons and dipping towards the northeast.

4.3 Hydrogeology

4.3.1 UMH Aquifer

Groundwater has been recorded in the UMH at depths below ground level between 0.495m (BH101 U) and 8.6m (BH105X U), representing groundwater elevations between 77.28 to 71.86mAOD. Groundwater flow within the UMH is west south west to north east across the application site and the hydraulic gradient ranges between 0.0004 and 0.01. The piezometric surface is illustrated on Drawing HQ 6/6 of the ES¹.

The UMH groundwater is perched upon the surface of the boulder clay Interburden so flow direction is principally controlled by the dip of this surface together with local areas of recharge and surface water discharge.

4.3.2 LMH Aquifer

Groundwater has been recorded in the LMH at depths below ground level between 5.32m (BH104 L) and 13.63m (BHB L), representing groundwater elevations between 70.256 to 64.27mAOD. Groundwater flow within the LMH and Chalk is north-west to south east across the application site; the hydraulic gradient is approximately 0.001. The piezometric surface is illustrated on Drawing HQ 6/7 of the ES¹.

The LMH aquifer is in hydraulic connection with the regional Chalk aquifer used for potable water supply and as base flow to regional river systems.

4.3.3 Groundwater Quality

Groundwater quality has been monitored on and next to the application site since August 2013 with the latest monitoring event being October 2015. The groundwater monitoring locations are shown on Drawing HQ6/5 of the ES¹.

Data and key characteristics from water quality analyses for monitoring boreholes screened within the UMH, LMH and Chalk are included within Appendix D.

Quality within the UMH, LMH and Chalk is typically good with minor occasional exceedances of the relevant standards. A summary of the quality results relevant to the identified PPL's in Section 3 is detailed below.

PPL1: Made Ground

- within the UMH the groundwater quality is typically good with a few single exceedances of certain metals across the boreholes;
- metal concentrations are typically low across the application site, however, manganese exceeds the UK Drinking Water Standard (DWS) of 0.05mg/l in the UMH, LMH and Chalk aquifers in the majority of the perimeter boreholes at least once, whilst zinc and nickel have been detected over the respective freshwater Environmental Quality Standard (EQS) and UK DWS in UMH and Chalk in boreholes BH102 (southwest) and BH106 (southeast);
- sulphate slightly exceeds the DWS of 250mg/l with 260mg/l in BH107U which is located next to an area of made ground which included crushed concrete;
- no elevated concentrations of potential contaminants of concern were detected at the boreholes around the fire training area; and
- no hazardous substances have been detected within the Site with the exception of BHA to the north east which has detected trace amounts of volatile organic compounds. This is unlikely to be related to made ground and is discussed further as part of PPL4.

PPL2: Landfill Contaminants

- ammoniacal nitrogen concentrations are generally below the DWS of 0.39mg/l across the Site. Single exceedances are recorded at BH101 (in both Chalk 2.1mg/l, and UMH 0.51mg/l) and BH102 (in both LMH 1.7mg/l and Chalk 0.76mg/l). BH103 exceeds the DWS in the LMH and Chalk. Maximum concentrations recorded are 11mg/l and 0.7mg/l respectively;
- nickel has exceeded the DWS of 0.02mg/l more than once in LMH and Chalk boreholes BH102L, BH103L and BH103C with a maximum concentration of 0.083mg/l in BH103L;
- arsenic has been detected twice above the DWS of 0.01mg/l once in BH101L and once in BH102L with a concentration of 0.012mg/l in both boreholes.

- cadmium has not been detected at concentrations exceeding the DWS; and
- it is noted that BH103 which is located to the north west is hydraulically down-gradient of some of the offsite landfills and generally exhibits higher concentrations of key determinands than in other wells.

PPL3: Bromate

- bromate has not been detected over the DWS of 0.01mg/l across the Site, however, LMH boreholes BHG L, BH101 L, BH106 L and BH104 (both L & C) have all detected bromate at trace levels at least once
- groundwater from BH106 U has detected bromate twice at trace concentrations below the DWS;
- off-site boreholes BHB, BH201, BH105 and BH108 within the LMH and Chalk (where screened) have all detected bromate at concentrations above the DWS. There have been multiple detections in all these boreholes which are situated to the northeast of the application site. The maximum recorded concentration is 0.33mg/l in BH105L which is the furthest monitored borehole from the Site; and
- bromate has been detected once in groundwater from BH108U when it marginally exceeded the DWS.

Boreholes detecting bromate are identified on Drawing 5 with all bromate concentrations recorded between 2013 and October 2015.

PPL4: Unconfirmed Sources

- BH102 to the southwest of the Site has detected nitrate in all three of the aquifers over the DWS of 50mg/l, whilst the LMH and Chalk aquifers have concentrations of ammoniacal nitrogen which has exceeded the DWS of 0.39mg/l at least once over the monitoring period;
- the only borehole to detect hazardous substances on site is BHA to the north of the Site which is screened in the UMH. The following substances have been detected: 1,1 dichloroethene 0.006mg/l (no standard), 1,1 dichloroethane 0.015mg/l (0.03mg/l DWS for 1,2 dichloroethane) and 1,1,1 trichloroethane 0.033mg/l (0.05mg/l WHO DWS guidelines) which are all below the relevant standards; and
- the following hazardous substances have been detected in the off-site boreholes:
 - trichloroethene has been detected within the LMH in BH201, BH108L and BH105L.
 - trichloroethene has also been detected within the UMH and Chalk within BH105. The maximum concentration recorded is 0.17mg/l in BH105C;
 - vinyl chloride has been detected at elevated concentrations in BH108L, BH105L and BH105C with a maximum concentration of 0.0048mg/l in BH105C; and
 - 1,2 Dichloroethene has been detected at elevated concentrations in BH105 across all three horizons with a maximum concentration of 0.22mg/l in BH105C.
- It is not possible to confirm the source of impacts in the offsite monitoring wells. However, given that the higher impacts are in the LMH and Chalk (not the UMH), it would seem to indicate a source hydraulically up gradient towards the northeast, and where the boulder clay separating the two aquifers is absent.

5.0 RESIDUAL POTENTIAL POLLUTANT LINKAGES

5.1 Land Quality Risk Assessment

The potential pollutant linkages (PPL's) identified in Section 3 have been reassessed following the conclusions of the site investigation and subsequent monitoring detailed in Section 4. Details are shown in Table 5-1 and discussed further in Section 6.

The PPL's previously identified are:

- **PPL1a:** Potential Harm to Human Health from Exposure to Contaminants within Soils via Ingestion, Dermal Contact and Inhalation.
- **PPL1b:** Potential Damage to Buildings from Exposure to Aggressive Ground.
- **PPL1c&d:** Potential impact to Controlled Waters by Contaminants in Soil / Natural Geology.
- **PPL2a:** Potential Harm to Human Health from Potential Landfill Contaminants in Groundwater.
- **PPL2b:** Potential Damage to Buildings from Exposure to Aggressive Groundwater
- **PPL2c&d:** Potential Harm to the Environment from Potential Landfill Contaminants in Groundwater.
- **PPL3a-c:** Potential Harm to Human Health and the Environment from Potential Spreading of the Bromate Plume.
- **PPL4:** Potential Risks to Health or the Environment from Unidentified Sources.

**Table 5-1
Residual Risks**

Source / Area of Concern	Contaminant(s)	Receptors	PPL	Investigation and Conclusion
Source 1 – Possible Made Ground <i>Made Ground is likely to be limited to the fire training area and the course of the runway. Both areas have had the majority of the Made Ground broken and dismantled (e.g. hardstanding).</i>	Various common contaminants	Humans – Outdoors: Future workers & visitors	PPL 1a	Manganese is commonly found in soils and rocks and due to the wide spread nature across the Site the source of the manganese on site is thought to be natural. There is nothing elevated in the UMH that suggests the reworked ground is contaminated with the exception of a single slightly elevated sulphate concentration at BH107U (260mg/l). It is known that this area formerly had crushed concrete on the surface and is the most likely cause. Sulphate can impact upon infants and the elderly if ingested at high concentrations. It is thought that any remaining sources will be removed during excavation and best work practices will protect the work force from ingestion.
		Property – Built Environment: Future buildings	PPL 1b	
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.	PPL1c	
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	PPL1d	
Source 2 – Possible contaminated groundwater emanating from the adjacent landfill sites. <i>The surrounding landfills accepted a range of wastes from inert, industrial, commercial, household and special waste.</i>	Elevated ammoniacal nitrogen, metals and hazardous substances in groundwater	Humans – Outdoors: Future workers & visitors	PPL2a	Ammoniacal nitrogen concentrations are higher at BH103L (max recorded 11mg/l) and are also elevated in the chalk aquifer. BH103 is located down-gradient of the landfills to the immediate northwest and due to the other key determinands showing slightly higher concentrations at this borehole (but still typically below the relevant standards) it is thought this impact is due to the landfills. Due to the low concentrations it is considered to be of minor threat to future workers, property and environment, however, it is recommended that perimeter monitoring is continued to monitor trends.
		Property – Built Environment: Future buildings	PPL 2b	
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.	PPL2c	
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	PPL2d	
Source 3 – Bromate plume within the Chalk/LMH aquifer. <i>Whilst the source of the bromate is 3km to the northwest of the Site. The edge of the dissolved plume borders the northern site boundary. Plume capture is occurring</i>	Bromate/bromide over the proposed UK Drinking Water Standard (DWS)	Humans – Outdoors: Future workers & visitors	PPL3a	The site investigation has proven that the edge of the bromate plume is close to the north eastern boundary. Although it is currently within UK DWS beneath the Site, the proposed mineral workings have been designed with practicable methods to keep the bromate plume from being pulled towards the Site or excavation area during operation and restoration and for isolating UMH groundwater from groundwater in the LMH. This will protect the future work force, public water supplies c. 2.2km to the south east of the Site and mitigate risk of
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.	PPL3b and PPL3c	

Source / Area of Concern	Contaminant(s)	Receptors	PPL	Investigation and Conclusion
<i>further down-gradient from the Site at the former Hatfield PWS boreholes owned by Affinity. Remedial action at the source is being planned and could reduce plume concentrations at the Site in the medium to long term. The potential for exposure to bromate must be considered.</i>				impact to surface water Further information is given in section 6
Source 4 - Unidentified Contaminant Source(s) on site	Ammoniacal nitrogen and VOCs	Humans – Indoors: Future workers & visitors	PPL 4	The site investigation identified a slightly elevated concentration of nitrate in BH102 in the UMH, LMH and Chalk aquifers and occasional ammoniacal nitrogen exceedances in the LMH and Chalk. The source of these impacts is unproven but could be the nurseries to the west of the Site although it is noted that the LMH and chalk aquifers at this location are also hydraulically down-gradient of offsite landfills albeit at a distance. Trace concentrations of volatile organic compounds (VOCs) have been detected at BHA U to the north of the Site. This area has undergone previous investigation by others (see section 1.6) and we are awaiting further details before further comment can be made. The negligible concentrations detected do not exceed human health exposure criteria, plus mineral excavation will cause the rapid dispersal of VOC vapours further reducing the potential for exposure. PPL4: If Needed – Voluntary Remedial Action – see section 6 .
		Humans – Outdoors: Future workers & visitors		
		Humans - Neighbours		
		Property – Built Environment: Future buildings		
		Property – Scheduled Ancient Monuments		
		Property - Flora / Fauna: Crops or ornamental planting		
		Surface Water: Ponds and watercourses onsite. No surface water abstraction within 2km.		
		Groundwater: Principle bedrock aquifer and Secondary aquifer in the superficial deposits. Site is in Source Protection Zone 3/2 and is an “at risk” Groundwater Drinking Water Protected Area for the principle aquifer. Potable groundwater abstraction 2.2km.		
		Ecosystems: Two areas of Ancient and semi-natural woodland c.800m north-west of the Site.		

6.0 POTENTIAL FUTURE REQUIREMENTS

6.1 Potential Future Voluntary Actions and Validation

6.1.1 Action to Avoid PPL 3(a-b)

Potential Harm to Human Health and the Environment from Potential Spreading of the Bromate Plume

The proposed development has been designed to minimise the potential for bromate plume expansion during mineral extraction. The safeguards include:

- the LMH will be worked wet and pumping to reduce water levels kept to minimum and only where water levels are above the base of the Interburden;
- Phases A and B, located between the plume and the Site, will be worked first, will not require lowering of water levels in the LMH and will provide a barrier to flow from the bromate and VOC impacted groundwater towards the Site during the working of other phases;
- pumped groundwater from the LMH and potentially from the UMH depending upon volumes, will be recharged to the LMH/Chalk via a recharge lagoon between the mineral extraction phases and the bromate contaminated groundwater which will lead to the creation of a hydraulic barrier to flow from the plume beyond the site boundary;
- mineral working that require lowering of the groundwater will be limited, as best practicable, to seasons where groundwater levels are lower to reduce the amount of water removed from the working area; and
- a water management plan will be agreed with the Environment Agency prior to works commencing and this will include a monitoring programme to confirm the mitigation measures described above are effective and to agree contingency actions as necessary.

The impacts of temporarily lowering groundwater levels on the bromate plume have been considered in the Water Environment Section 6 of the Environmental Statement¹ and have been found to be minor with suitable practicable mitigation measures as briefly mentioned above.

6.1.2 Action to Break PPL 4: Unidentified Sources

Whilst two areas of unknown potential contamination have been identified and assessed (PPL4: VOCs offsite and ammoniacal nitrogen), there is the potential for further undiscovered contamination to exist. Should any unidentified contamination be encountered as part of the redevelopment, the developer may be required to implement additional voluntary measures to investigate and identify/manage risks.

In practise, should anybody encounter potentially hazardous materials work should cease and the matter be referred to an appropriate environmental consultant.

Any remedial actions should be agreed with the local authority and recorded in a Land Quality Validation Report (see Section 6.2).

6.2 Land Quality / Remedial Works Validation Report

Given the site's history the potential for additional contamination is considered to be low. However, should any contamination be discovered either as a result of additional investigation or through any other means, then remedial work may be required. Any remedial works should follow a period of liaison with the local authority in which final details of the

remedial scheme would be agreed. The local authority may or may not want to be informed of progress during any remedial works, but the regulator will require a report shortly after the remedial works are complete. The Land Quality Validation Report should be submitted to the local authority and should:

- set out which organisations have been responsible for implementing and supervising the remedial works (any environmental consultant used should be suitably experienced and operate under an externally accredited quality assurance scheme e.g. ISO9001);
- present the results of any additional testing;
- demonstrate that quality assurance procedures relevant to soil sampling, storage and testing were complied with (including the use of accredited laboratories and, where possible, the use of MCERTS testing methods);
- form a record of the remedial activities (and any changes to any pre-agreed remedial design) using as-built drawings, progress photographs, etc.; and
- set out any additional remedial measures volunteered to deal with contamination (beyond that previously identified) encountered as part of the proposed development.

7.0 CLOSURE

This report has been prepared by SLR Consulting Limited with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client.

Information reported herein is based on the interpretation of data collected from various sources which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Brett Aggregates Limited; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.