CONTENTS

Introduction **6-1**
Assessment Methodology **6-1**
Approach 6-1
Policy Context 6-1
Good Practice Guidance 6-2
Information Sources 6-3
Scoping and Consultations 6-4
Significance Criteria 6-4
Baseline Conditions 6-6
Geology 6-7
Hydrogeology 6-9
Hydrology 6-22
Designated Ecological Site 6-30
Proposed development **6-31**
Assessment of Potential Impacts **6-33**
Groundwater 6-33
Surface Water 6-35
Ecological Sites 6-36
Proposed Mitigation Measures **6-40**
Groundwater and Surface Water Quality 6-40
Groundwater Levels and Surface Water Flow 6-42
Residual Effect **6-43**
Conclusions **6-47**

INTRODUCTION

6.1 This chapter of the ES details the local hydrology and hydrogeology of the application site and the surrounding area. It also identifies possible hydrogeological and hydrological impacts associated with the proposed development, details of which have been set out in Chapter 3 above.

6.2 The assessment is based on the hydrological and hydrogeological regimes and the specific mitigation measures which have been incorporated into the design of the scheme.

ASSESSMENT METHODOLOGY

Approach

6.3 The assessment has involved the following:

- detailed desk study to establish current baseline hydrological and hydrogeological conditions.
- identification of possible measures to avoid and mitigate any adverse impacts resulting from the proposed development; and
- evaluation of the residual significance of these impacts by consideration of the sensitivity of the baseline features of the application site and the potential magnitude, following mitigation.

6.4 The desk top study was undertaken in order to:

- describe the geological, hydrological and hydrogeological setting.
- identify flooding risks; and
- identify sensitive hydrogeological and hydrological features which may potentially be impacted by the proposed development.

6.5 The extent of the desk top study was based on professional judgment.

Policy Context

6.6 The proposals for the development of the application site have had regard to technical guidance, relevant Guidance for Pollution Prevention, and other codes of best practice in order to limit the potential for contamination of ground and surface waters, the potential for flooding to be caused by the development, and other potential impacts on the water environment. The development of the application site would therefore be in accordance with the following:

European Legislation

6.7 The key piece of European Legislation that protects the UK's water environment is the Water Framework Directive (2000/60/EC). This Directive protects all elements of the water cycle and seeks to enhance the quality of groundwaters, surface waters, estuaries and coastal waters.

National Legislation and Policy

6.8 Key national legislation and policy relevant to this proposed development includes:

- Environmental Permitting (England and Wales) Regulations 2016
- Environment Act 1995
- the Agency's (the Agency) statutory obligations over the management and control of pollution into water
- the Agency's Groundwater Protection Policy, March 2017 (https://www.gov.uk/government/collections/groundwater-protection)
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 in England and Wales
- Flood and Water Management Act, 2010
- National Planning Policy Framework, Published by Department for Communities and Local Government, 19 February 2019; and
- National Planning Policy Framework and Relevant Planning Guidance29th November 2016 (Planning practice guidance - GOV.UK (www.gov.uk).

Local Planning Policy and Strategy

6.9 As noted from Chapter 4 above, the main local planning policy documents include:

- Hertfordshire County Council (2007). Hertfordshire Minerals Local Plan Review 2002- 2016; and
- Hertfordshire County Council (2012). Hertfordshire Waste Development Framework: Waste Core Strategy & Development Management Policies Development Plan Document 2011-2026.

6.10 Details of the relevant planning policies that relate to the water environment are set out in Chapter 4.

Good Practice Guidance

6.11 Relevant UK guidance on good practice for construction projects is detailed in the following documents:

- Control of Water Pollution from Construction Sites - Guide to Good Practice, CIRIA 2002; and
- Environmental Good Practice on Site C650, CIRIA 2005.

6.12 The Pollution Prevention Guidelines (PPG), which were officially withdrawn on the 17th of December 2015, and their replacement guidance series Guidance for Pollution Prevention (GPPs) identified below, provide environmental good practice guidance for England that are related to the site activities:

- GGP1 1: Understanding your environmental responsibilities - good environmental practices (October 2020)
- GPP 2: Above Ground Oil Storage Tanks (January 2018)
- GPP 3: Use and Design of Oil Separators in Surface Water Drainage Systems (April 2006)
- GPP 4: Treatment and disposal of wastewater where there is no connection to the public foul sewer (November 2017)
- GPP 5: Works and maintenance in or near water (February 2018)
- GPP 13: Vehicle washing and cleaning (April 2017)
- GPP 21: Pollution incident response planning (July 2017)
- GPP 22: Dealing with spills (October 2018)
- GPP 26: Safe storage - drums and intermediate bulk containers (February 2019)

6.13 Guidelines for surface water management and flood risk assessment are as follows:

- The SuDS Manual (Report C753). CIRIA, 2015
- National Planning Policy Framework, department for Communities and Local Government (last updated June 2019)
- CIRIA Report C624, Development and flood risk – guidance for the construction industry (October 2004)
- BS8533:2017, Assessing and managing flood risk in development – Code of Practice (December 2017)
- Department for Environment, Food & Rural Affairs and Agency (2015). Flood risk assessment: local planning authorities (at https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities); and
- Planning Policy Guidance, Ministry of Housing, Communities & Local Government, Flood Risk and Coastal Change (2014) (https://www.gov.uk/guidance/flood-risk-and-coastal-change).

Information Sources

6.14 The following sources of information have been consulted in order to characterise the geology, hydrogeology, and hydrology of the area within and surrounding the application site:

- BGS online maps (www.bgs.ac.uk/data/mapViewers/home.html) for details of geology and borehole logs
- British Geological Survey / the Agency (1997) The Physical Properties of Major Aquifers in England and Wales, Technical Report WD/97/34
- The Agency Website (www.environment-agency.gov.uk) for details on aquifer classification, source protection zones, groundwater vulnerability, flood risk and Water Framework Directive classifications for groundwater and rivers

- Institute of Hydrology Flood Estimation Handbook Webservice, Map - FEH Web Service (ceh.ac.uk)
- Ordnance Survey website for 1:25,000 scale explorer map (https://www.ordnancesurvey.co.uk)
- Emap Groundsure reports of application site including FloodInsight, GeoInsight and Enviroinsight reports
- C Fitzpatrick, 2010, The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Double-Porosity Effects on Catchment-Scale Evolution;
- SLR Consulting Ltd (November 2014) Hatfield Aerodrome Mineral Development Site - Site Investigation, Ref 406.01009.00064; and
- SLR Consulting Ltd (2013 through May 2021) Baseline Groundwater Quality Data Tables
- SLR Consulting Ltd (September 2018) Pumping Test Assessment Report, as incorporated into the abstraction licences applications (July 2018 422.01009.00211)
- SLR Consulting Ltd (January 2020) Groundwater and Water Management Plan v5, subsequently varied August 2021 (v.6)

Scoping and Consultations

6.15 As noted from Chapter 1 above, a scoping opinion was requested from the MPA and issued on the 19 November 2015. Discussions have been held with the Agency over a period of 5 years to help develop a working plan that would be acceptable to the EA. There have been ongoing discussions with the Agency and Affinity dating from the original submission of the application until 2020. A further scoping opinion was sought in May 2021, which was issued by Hertfordshire County Council on 14 July 2021.

Significance Criteria

6.16 A qualitative risk assessment methodology has been used to assess the significance of the potential effects associated with the proposed development. Two factors have been considered using this approach: the sensitivity of the receiving environment and the potential magnitude of impact, should that potential impact occur.

6.17 This approach provides a mechanism for identifying the areas where mitigation measures are required and for identifying mitigation measures appropriate to the risk presented by the scheme. This approach also allows effort to be focused on reducing risk where the greatest benefit may result.

6.18 Criteria for determining the significance of effects are provided in Table 6-1, Table 6-2 and Table 6-3 below. Effects of ‘major’ and ‘moderate’ significance are considered to be ‘significant’ in terms of the EIA Regulations.

6.19 The sensitivity of the receiving environment (i.e., the baseline quality of the receiving environment as well as its ability to absorb the impact without perceptible change) is defined in Table 6-1.

Table 6-1
Sensitivity Criteria for Water Environment Receptors

Sensitivity	Definition
Very High	• International importance. • Receptor with a high quality and rarity, regional or national scale and limited potential for substitution / replacement.
High	• National importance. • Receptor with a high quality, local scale, and limited potential for substitution / replacement; or • Receptor with a medium quality and rarity, regional or national scale and limited potential for substitution / replacement.
Medium	• Regional importance. • Receptor with a medium quality and rarity, local scale and limited potential for substitution / replacement; or • Receptor with a low quality and rarity, regional or national scale and limited potential for substitution / replacement.
Low	• Local importance. • Receptor with a low quality and rarity, local scale. • Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.

6.20 The criteria that have been used to assess the magnitude of the impacts are defined in
6.21 Table 6-2.

Table 6-2
Magnitude of Impact Criteria and Definitions

Magnitude	Criteria	Definition
Major	Results in loss of attribute.	Fundamental (long term or permanent) changes to hydrology, hydrogeology, and water quality, such as: • Wholesale changes to watercourse channel, route, hydrology, or hydrodynamics. • Changes to the application site resulting in an increase in runoff with flood potential and also significant changes to erosion and sedimentation patterns. • Major changes to the water chemistry or hydro-ecology. • Major changes to groundwater levels, flow regime and risk of groundwater flooding.
Moderate	Results in impact on integrity of attribute or loss of part of attribute.	Material but non-fundamental and short to medium term changes to hydrology, hydrogeology and water quality, such as: • Some fundamental changes to watercourses, hydrology or hydrodynamics. Changes to application site resulting in an increase in runoff within system capacity. • Moderate changes to erosion and sedimentation patterns. • Moderate changes to the water chemistry of surface runoff and groundwater. • Moderate changes to groundwater levels, flow regime and risk of groundwater flooding.
Minor	Results in minor impact on attribute.	Detectable but non-material and transitory changes to hydrology, hydrogeology, and water quality, such as:

Magnitude	Criteria	Definition
		• Minor or slight changes to the watercourse, hydrology, or hydrodynamics. • Changes to application site resulting in slight increase in runoff well within the drainage system capacity. • Minor changes to erosion and sedimentation patterns. • Minor changes to the water chemistry of surface runoff and groundwater. • Minor changes to groundwater levels, flow regime and risk of groundwater flooding.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use/integrity.	No perceptible changes to geology, hydrology, hydrogeology and water quality, such as: • No impact or alteration to existing important geological environs. • No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns. • No pollution or change in water chemistry to either groundwater or surface water. • No alteration to groundwater recharge or flow mechanisms.

6.22 The sensitivity of the receiving environment together with the magnitude of the impact defines the significance of the potential effect, as identified in

6.23

6.24 Table 6-3.

Table 6-3
Significance of Potential Effect

Magnitude of Impact	Sensitivity			
	Very High	High	Medium	Low
Major	Major	Major	Moderate	Minor
Moderate	Moderate	Moderate	Moderate	Minor
Minor	Minor	Minor	Minor	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

6.25 The characteristics of the impacts are described in terms of direct/indirect, temporary (reversible)/permanent (irreversible), together with timescales (short, medium, long term). These terms are defined within Chapter 1 of this Volume.

Baseline Conditions

6.26 The following hydrogeological and hydrological regime is considered below:

- Regional geology;
- Local geology;
- Aquifer characteristics;
- Recharge mechanisms;

- Groundwater levels and flow,
- Water abstraction and use;
- Groundwater quality;
- Catchment overview;
- Surface water flows;
- Surface water quality; and
- Flood risk.

6.27 The hydrogeological and hydrological data have been used to develop a conceptual site model.

Geology

Regional Geology

6.28 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.

6.29 The application site lays within the Vale of St Alban's, a broad northeast to southwest orientated plain between higher land to the north-west and south-east. The chalk on the higher land to the west is overlain by superficial drift Clay with Flints deposits. In contrast the chalk on the higher land to the south-east is overlain by the Lambeth Group and London Clay, and other drift.

6.30 The Vale of St Albans corresponds with the route of a peri-glacial water course (Proto-Thames) that is understood to have flowed northeast into East Anglia. Overlying the chalk in this area and at the site is the Lowestoft Formation, comprising a sequence of glacial deposits including boulder clays and sands and gravels. A thin tract of alluvium associated with the former alignment of a surface water course known as the Nast also crosses the site.

6.31 Extracts of the geological maps are shown on Drawing HQ 6/1 and HQ 6/2.

Local geology

6.32 A number of site investigations and studies have been undertaken at the site between c. 1994 and present. Drawing 6/3 is a site plan with the location of previous and current boreholes and groundwater monitoring wells, and the alignment of a geological cross section.

6.33 Four broad superficial drift units above the chalk comprise an upper and lower granular formation (sands, gravels referred to as the UMH and LMH respectively), separated by boulder clay, referred to as Interburden (IB), all overlain by a gravelly clay overburden. This corresponds to the Lowestoft Formation described in the regional geology of the area.

6.34 The geological sequence including depths are summarised in

6.35 Table 6-4.

Table 6-4
Application Site Geology

Drift/Solid	Depth (m)	Geological Unit	Description
Superficial Drift	0.1 – 5.7	Overburden – Clay, Sand, Gravel	Variable mixture of clay, sand and gravel, sometimes in discrete lenses
	2.2 – 11.8	Upper Mineral Horizon (UMH)	Slightly gravelly sand.
	6.2 – 14.2	Interburden - Boulder Clay (BC)	Stiff grey or orange, brown clay with occasional gravel
	8 – 18.3	Lower Mineral Horizon (LMH)	Sand and sandy gravels
Solid Geology	+8 - 18.3	White Chalk Sub-Group	White chalk with flints

6.36 A detailed geological cross section across the application site and nearby boreholes is shown on Drawing HQ 6/4. The alignment of the section is shown on Drawing 6/3 with borehole logs in Appendix 6/1.

6.37 Previous sand and gravel quarries in the Hatfield area have generally been restored via landfill and there are landfills to the immediate north of the application site. All landfills within a 2km radius of the application site are shown on Drawing HQ 6/5.

Hydrogeology

Aquifer Characteristics

6.38 The Glacial Drift Deposits of sand, gravel, and clay, (Overburden, UMH and LMH) are classified by the Agency[1] as Secondary (undifferentiated) Aquifers.

6.39 This classification combines Secondary A and Secondary B Aquifers which cannot be distinguished due to the variable characteristics of the geology. Secondary A Aquifers are described as *"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."* and Secondary B Aquifers are described as *"lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering."*

6.40 The small band of alluvium associated with the Nast, which correlates to the current route of the Nast including a culverted section, is classified by the Agency as a Secondary A Aquifer.

6.41 The Chalk is classified as a Principal Aquifer; it is a laterally continuous water body and an important regional supply of potable water as well as supporting base flow in rivers. The aquifer is generally unconfined where the chalk outcrops to the northwest of the application site although where

[1] Magic Map Website (Accessed August 2021) https://magic.defra.gov.uk/

valleys cut into the chalk the aquifer can be locally confined beneath infilling of low permeability superficial drift deposits.

6.42 The Chalk has high matrix porosity but low matrix permeability, with flow mainly occurring through fractures and fissures (secondary permeability), often associated with traceable hard bands.

6.43 Groundwater in the Chalk and the Lower Mineral Horizon (LMH) is regionally extensive and in hydraulically continuity. It is possible that weathering of the upper parts of the chalk have reduced the vertical hydraulic connection between the strata.

6.44 The UMH groundwater is a perched aquifer, resting on the IB (boulder clay) which separates the two mineral horizons and is laterally continuous across the application site and is in hydraulic connection with the alluvium referred to above (Paragraph 6.36). The Overburden rests upon the UMH and consists of clay, silt, sand and gravels and covers the majority of the application site.

The hydrogeological characteristics of the geological strata at the application site and surrounding areas range across 3 orders of magnitude based on literature derived values in presented in

Table 6-5.

- Upper Mineral Horizon – 0.864 to 864m/d
- Lower Mineral Horizon – 8.64 to 8,640m/d

6.45 A 3-day constant discharge pumping test was undertaken in the UMH and the LMH in May-June 2018. A transmissivity between 78 and 84m^2/d was calculated for the UMH from which a hydraulic conductivity of approximately 19m/d has been derived.

6.46 The LMH rests on the chalk and groundwater is in hydraulic continuity across the two geological units. A transmissivity of approximately 800m^2/d was calculated for the LMH using a partial penetration solution that incorporated the underlying productive chalk aquifer. The bulk hydraulic conductivity is approximately 13m/d but is highly variable and sensitive to the 60m assumed aquifer thickness and physical characteristics of the chalk (fissures and fractures) as well as highly permeable sand and gravel zones in the LMH.

6.47 The application site is located within the Total Catchment Zone (SPZ3) and Outer Source Protection Zone (SPZ2) of two public water supply well fields (Hatfield and Colney Heath) located 1,500m south-east and 2,200m south south-east from the application site, respectively (Drawing 6/5). The SPZ2 zone is defined as the 400-day travel time but must have a minimum radius of 250 or 500m around the source depending on abstraction volume.

6.48 The public water supply wells are currently being used for containment of a regional bromate plume so abstracted water is not used for public water supply.

Table 6-5
Hydrogeological Characteristics of Geological Units

Geological Unit	Hydrogeological Characteristics	Groundwater Vulnerability and Aquifer Productivity
Overburden	Comprises clay, silt, sand and gravel deposits with limited thickness. The lithology is mixed and also occurs in discrete lenses therefore permeability is variable depending on grain size and sorting but is generally considered to be low.	Secondary Aquifer (Undifferentiated)
Upper Mineral Horizon (UMH)	Variable lithology (clays, sands and gravels) but largely sands with occasional gravel and clay lenses. Typical hydraulic conductivity 1 x 10^{-5} to 1 x 10^{-2}m/sec[2] (note the on-site pumping test recorded a value of 2.2 x 10^{-4}m/sec so within this range)	Secondary Aquifer (Undifferentiated)
Interburden (Boulder Clay)	Glacial Boulder Clay thought to be laterally extensive and is typical over-consolidated glacial boulder clay. The top of the boulder clay dips eastwards across the application site and laboratory tests have provided a permeability of 5x10^{-11}m/s.	Secondary Aquifer (Undifferentiated)
Lower Mineral Horizon (LMH)	Predominantly sandy gravel with lenses of sand and occasional lenses of clay. Typical hydraulic conductivity 1 x 10^{-4} to 1 x 10^{0}m/sec[2]. Note that a transmissivity of c.800m^2/day was estimated from the on-site pumping test, which is highly influenced by the underlying chalk aquifer.	Secondary Aquifer (Undifferentiated)
Lewes Nodular Chalk Formation (Base of the Upper Chalk)	White chalk with flints. Groundwater storage and flow is associated with secondary porosity and permeability due to fractures and karstic features. Literature gives transmissivity values for the Colne valley in the range of 1,500-3,000m^2/day[3], however, it is noted that repeated freezing and thawing during peri glaciation shattered the chalk in the wider valleys and produced a thick soft weathered layer of chalk. The weathered chalk hydraulic conductivities are estimated to be between 10^{-4} to 10^{-2} m/day[4] with vertical hydraulic conductivities likely to be around 10% of the horizontal values. Weathered soft chalk has been recorded on site and whilst the Chalk and LMH are thought to be in hydraulic continuity, the presence of the weathered chalk causes a lower permeability layer at the interface.	Principal Aquifer

Recharge Mechanisms

6.49 The Agency has provided rainfall data (2010-2012) for a rainfall gauge at Mill Green, approximately 4km east- north-east of the application site. This data indicates that annual rainfall ranges between 456mm and 811mm, with an annual average of approximately 616mm.

6.50 The Institute of Hydrology (Webservice, Map - FEH Web service,ceh.ac.uk);) reports that the Seasonally Adjusted Average Annual Rainfall (SAAR) at the application site is 662mm.

[2] Freeze A and Cherry J. A (1979) Groundwater pp604
[3] BGS 1997, The Physical Properties of Major Aquifers in England and Wales. WD/97/34
[4] C Fitzpatrick, 2010, The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Double-Porosity Effects on Catchment-Scale Evolution

6.51 Groundwater recharge to the Chalk strata occurs where bedrock is exposed at or just below the surface, which occurs approximately 1.5km to the northwest of the application site.

6.52 Recharge to the UMH is thought to be incidental rainfall, infiltration from the Butterwick Brook to the west of the application site, and surface water infiltration from discharges originating offsite to the north.

Groundwater Levels

6.53 The Agency has provided groundwater elevations for three chalk boreholes in the region, the locations of the borehole close to the application site are shown on Drawing HQ 6/5. The data are summarised in Table 6-6 and a hydrograph is included in Appendix 6/2.

Table 6-6
Regional Chalk Groundwater Elevations

Borehole	Period	Groundwater Elevation (mAOD)				Range (m)	Location (km)
		No.	Min	Mean	Max		
Orchard Garage	1988 – 2011	260	73.97	77.05	81.60	7.63	2.5 NW
Mymms Park	1986 – 2015	271	58.76	61.44	66.51	7.75	3.7 SW
Shaws Corner	1986 – 2015	301	75.96	77.09	78.73	2.77	7.6 N

6.54 A review of the data shows that, over the monitoring period, the highest groundwater levels in all three boreholes were recorded in 2001, however, North Mymms and Shaws Corner boreholes show similarly high groundwater elevations in 2014.

6.55 Groundwater levels within the UMH, LMH and Chalk are routinely recorded from monitoring wells on and adjacent to the application site by manual water level dipping during sampling events and using automatic level recording instruments installed in selected wells. Monitoring well locations are shown on Drawing HQ 6/3. Hydrographs are included in Appendix 6/3. **Error! Reference source not found.** is a summary of minimum, maximum and average water elevations.

Table 6-7
Groundwater Elevations (Aug 2013 – April 2021)

Horizon	Borehole	Groundwater Elevation (mAOD)				
		Count	Minimum	Mean	Maximum	Range (m)
Upper Mineral Horizon (UMH)	BH101	39	71.84	73.75	75.84	4.01
	BH102	39	74.02	75.27	77.28	3.26
	BH103	38	72.59	74.22	76.77	4.19
	BH104	39	71.86	72.79	74.61	2.76
	BH105	6	72.50	72.93	74.46	1.96
	BH105x	28	70.55	71.58	72.44	1.89
	BH106	39	71.37	72.44	73.90	2.53
	BH107	31	73.15	74.46	76.90	3.76
	BH108	28	71.01	71.89	73.64	2.63
	FT101	37	72.98	74.35	76.42	3.45
	FT102	39	72.94	74.45	76.86	3.92
	FT103	36	72.99	74.40	76.83	3.84

Horizon	Borehole	Groundwater Elevation (mAOD) Count	Minimum	Mean	Maximum	Range (m)
Lower Mineral Horizon	BHA	33	71.62	72.50	73.87	2.26
	BHC	25	71.16	71.89	72.65	1.50
	BHD	26	70.91	71.89	72.87	1.95
	BHE	32	71.28	72.31	73.64	2.37
	BHF	26	73.46	75.13	78.51	5.05
	BHH	21	72.90	74.70	76.71	4.96
	BHI	5	72.98	73.68	75.43	2.44
	BHJ	21	71.79	72.38	73.16	1.37
	BHK	23	73.14	74.20	75.36	2.22
	GMW101	5	74.59	75.63	76.50	1.92
	GMW102	6	74.49	74.76	74.95	0.46
	GMW103	16	72.28	73.36	75.07	2.79
	GMW103 L	15	70.78	72.39	74.96	4.18
	GMW104	15	72.22	73.38	75.09	2.87
	GMW105	12	71.79	73.04	76.55	4.76
	GMW106	15	70.38	71.50	73.96	3.58
	GMW107	16	74.05	75.52	76.43	2.38
	GMW108	11	75.33	76.25	76.74	1.41
	GMW109	16	73.73	75.38	76.50	2.77
	GMW110	15	71.25	71.42	72.33	3.81
	GMW111	15	71.55	72.19	73.20	1.65
	GMW112	16	72.53	73.74	75.17	2.64
	GMW113	16	73.32	74.53	75.65	2.33
	GMW114	15	74.61	75.25	76.41	1.80
	BH306 U	15	71.18	71.70	72.39	1.21
	BH307 U	13	70.57	71.71	72.42	1.85
	BH101	38	65.21	66.45	68.36	3.15
	BH102	37	67.06	68.95	71.55	4.49
	BH103	37	67.28	69.35	71.68	4.41
	BH104	37	66.31	67.96	70.26	3.95
	BH105	38	65.46	67.35	69.42	3.96
	BH106	39	63.50	64.68	66.53	3.03
	BH107	27	66.71	67.75	69.62	2.91
	BH108	27	66.27	68.16	71.70	5.43
	BH201S	28	65.88	66.98	68.73	2.85
	BH201D	28	65.75	66.90	68.62	2.87
	BHB	34	63.29	64.55	66.67	3.39
	BHG	31	67.55	69.27	71.63	4.08
	BH301 L	12	68.45	69.51	72.69	4.24
	BH302 L	15	68.73	69.73	72.85	4.12
	BH305 L	14	68.32	69.31	72.56	4.24
Chalk	BH101	39	65.21	66.41	68.36	3.15
	BH102	38	67.04	68.89	71.50	4.47
	BH103	37	67.28	69.50	71.87	4.59
	BH104	38	66.24	67.87	70.20	3.96
	BH105	36	65.88	67.50	69.39	3.51
	BH106	39	63.28	64.65	66.54	3.26
	BH107	27	66.69	67.76	69.62	2.92
	BH108	28	66.28	67.68	69.65	3.38
	BH301 C	11	68.44	69.52	72.68	4.24
	BH302 C	15	68.76	69.76	72.91	4.15
	BH305 C	14	68.31	69.29	72.56	4.25

Note: BH101-BH108, 301, 302 and 305 are nested wells. Suffix indicates the monitored horizon

6.56 A review of the groundwater level data indicates the following groundwater levels at the application site:

- Highest recorded groundwater elevation:
  - UMH – 76.25mAOD (GMW101) on west boundary and 76.5mAOD (GMW109) on CEMEX boundary
  - LMH – 72.85mAOD (BH302L) northwest of application site
  - Chalk – 72.91mAOD (BH302C) northwest of application site
- Lowest recoded groundwater elevation:
  - UMH – 71.25mAOD (GMW110) southeast of application site
  - LMH – 63.29mAOD (BHB) east of application site
  - Chalk – 63.28mAOD (BH106C) southeast of application site

6.57 The UMH is unconfined for most of the year and depends on the presence or absence of overburden and the seasonal fluctuation of groundwater levels.

6.58 Groundwater levels in the LMH and the Chalk in the nested wells are at the same elevation and closely correlate indicating that the LMH and Chalk are in hydraulic continuity.

6.59 The highest recorded groundwater levels in all aquifers during the monitoring period occurred in March 2014 and April 2021 when they reached similar elevations. Lowest groundwater levels were recorded in November 2017 and August 2019.

Groundwater Flow

6.60 Groundwater level contours (piezometric surface) for the UMH (2019 & 2021) and the LMH and Chalk in 2021 are shown on Drawings HQ6/6 through HQ6/9.

6.61 Groundwater flow beneath the mineral development site within the UMH is broadly west to east with a hydraulic gradient of c.0.004 which drops to c.0.006 when water levels are naturally lower in the perched aquifer.

6.62 Drawing HQ6/6 also illustrate that groundwater flow from CEMEX is occurring across the northernmost site corner into the proposed mineral processing area and into Home Covert. This local feature appears to be related to shallow water infiltration from CEMEX silt lagoons, but also from a surface discharge pipe located at SW11 as shown on Drawing HQ6/6.

6.63 It is noted that the highest groundwater levels recorded in the UMH in March 2014 and 2021 were close to ground level along the southwest side of Home Covert where a lack of stream bed and culvert maintenance in this part of the site contributes to water ponding and backing up.

6.64 Groundwater flow within the LMH and Chalk is north-west to southeast across the application site and is being influenced by the Affinity Water plc (Affinity) Bishops Rise chalk aquifer boreholes located c.1.6km east-southeast of the site (Drawing HQ6/5). The hydraulic gradient is approximately 0.001.

6.65 The LMH and Chalk aquifer beneath the site is on occasion confined or unconfined both spatially and temporally. This is due to:

- seasonal fluctuation of piezometric water levels,
- non uniform elevation of the IB horizon (confining unit),
- variation in abstraction rates, and distance from the Bishops Rise abstraction boreholes.

Groundwater Quality

6.66 Brett has built a groundwater quality data base for the three aquifer units beneath the site and adjacent land spanning the period 2013 to 2021 for bromate and bromide, and from 2013 to 2019 for other analytes.

6.67 Monitoring data spanning this period is presented in tabular form in Appendix 6/5.

Bromate

6.68 The Agency are monitoring a regionally extensive plume of bromate dissolved in the chalk aquifer that extends southeast from its source in Sandridge (4km northwest of the site).

6.69 The natural flow path of the bromate plume in the chalk extends northwest to southeast from Sandridge towards the northern end of the Aerodrome, heading toward the River Lea.

6.70 Affinity has been actively pumping the chalk aquifer to capture the plume for several years which is causing the plume to veer to the south, departing from its natural course. The plume location has been stable for several years in its location east of the Application site during a relatively low natural groundwater level period, as illustrated on Drawing HQ 6/8 (October 2019 data).

6.71 The southern edge of the plume in the chalk and to a lesser extent the overlying LMH is present beneath the northern corner of the application site, as defined by BH301 Chalk and BH104 Chalk. This area forms part of the proposed mineral processing area and is not a mineral extraction area.

6.72 The southern perimeter of the bromate plume in the LMH sits further northeast than in the chalk. Drawing HQ 6/9 (April 2021) illustrates the location of the bromate plume edge in the LMH northeast of the Application boundary.

6.73 A summary of bromate detections in **onsite** boreholes is given below. The complete bromate testing set is included in Appendix 6/5.

- UMH - Sporadic trace level detections have been recorded in monitoring wells installed in the UMH, but nothing consistent or at a significant level.
- LMH - Sporadic, trace level detections have been measured in several LMH monitoring wells, however, the most consistent has been from BH104 but none exceeded the Drinking Water Standard (DWS)

- Chalk - Sporadic, trace level detections have been recorded in several chalk monitoring wells, the most consistent being BH104 and BH301 but none exceeded the DWS.

6.74 A summary of bromate detections in offsite boreholes is given below:

- UMH - There have been sporadic trace level detections in monitoring wells installed in the UMH, but nothing consistent or at a significant level.
- LMH - There have been bromate detections more than the DWS in five offsite monitoring wells to the east of the Site (BH105, 108, 201, 305 and BH B)
- Chalk - There have been bromate detections in excess of the DWS in 3 offsite monitoring wells (BH105, 108 and 305 – note that BH201 and BH-B referenced above do not monitor the chalk aquifer)

6.75 In summary the bromate plume is considered stable in both the chalk and the LMH due to the intervention of containment pumping by Affinity.

Other Analytes

6.76 A high-level summary of analyte detections across a broad range of chemical testing suites is presented in Table 6-8 and

6.78 Table 6-9, once again splitting On-Site and Off-Site sampling locations, and by aquifer unit.

On Site Monitoring Data

6.79 Slightly elevated concentrations of metals (iron, manganese, nickel) have been recorded in groundwater in the north, northwest, and west side of the site in all three aquifer units being monitored.

6.80 Inorganic compounds, particularly ammoniacal nitrogen is elevated relative to background in the same site areas. These areas are noted to be hydraulically down-gradient of historic offsite landfills.

6.81 There is no evidence of significant on-site impacts to groundwater in all three aquifer units from organic compounds (petroleum hydrocarbons, solvents, pesticides etc.

Off Site Monitoring Data

6.82 Brett installed five UMH, four LMH and three chalk aquifer monitoring wells east of the application site. The primary purpose of the wells was to delineate the edge of the bromate plume, but analysis was also undertaken for metals, inorganics, and organic compounds.

6.83 Impacts to groundwater quality was identified in the UMH aquifer from several metals, chromium, cadmium and traces of nickel and zinc (BH105X, 108, 306) and from chlorinated solvents in the same wells plus BH307.

6.84 Impacts to groundwater quality were identified in the LMA from the same metals stated above, plus solvent in BH105, 108 and 201.

6.85 Impacts to groundwater quality were identified in the chalk from cadmium, chromium, and solvents in BH105 and 108.

6.86 These offsite detections are unrelated to the application site and would not significantly impact upon mineral operations. The source of these analytes is not defined.

Water Framework Directive

6.87 The Water Framework Directive requires that natural water bodies achieve a 'good' status by 2027 in accordance with its chemical, ecological and physical condition based on several 'supporting elements'. New schemes that could compromise achievement of goals are contrary to the Directive. Appendix 6/6 is a WFD compliance assessment report.

6.88 The WFD Compliance Assessment assessed aspects of the development relating to river diversion, groundwater quality and dewatering, against ecological and chemical status and determined the likelihood of significant effect to be low based on mitigation measures identified within the ES, the Flood Risk Assessment (App 6/9) and Hydrogeological Risk Assessment (HRA, submitted with the environmental permit application December 2016 ref. 422.01009.00140/HRA).

6.89 The WFD Compliance Assessment report concluded that none of the four WFD Objectives would be compromised by the proposed scheme.

Table 6-8
On Site Monitoring Wells

Upper Mineral Horizon	Analyte	Monitoring Wells	Location
Metals	Iron	GMW104, GMW105, GMW107	NW Site Boundary
	Manganese	BH103, GMW104, GMW105, GMW107	
		BH102, GMW113, GMW114	West site boundary
		BH-A	East/Lagoons area
	Nickel	BH102	West site boundary
Inorganics and MNA parameters	Ammoniacal Nitrogen	BH102, GMW103	NW site boundary
TPH, EPH, GRO, BTEX	None Detected	-	-
VOCs, SVOCs, Phenols, Pesticides	VOC solvent. Trace	BH-A	East/Lagoon area
Lower Mineral Horizon	**Analyte**	**Monitoring Wells**	**Location**
Metals	Iron	BH302	NW site boundary
	Manganese	BH301, BH302, GMW103	North and NW site boundary
		BH102, BH103	West site boundary
	Nickel		
Inorganics and MNA	Ammoniacal Nitrogen	BH102, BH103, BH302	West and north site boundary
TPH, EPH, GRO, BTEX	None identified	-	-
VOCs, SVOCs, Phenols, Pesticides	None Identified	-	-
Chalk	**Analyte**	**Monitoring Wells**	**Location**
Metals	Iron,	BH102, BH302	West and north site boundary
	Manganese,	BH102, BH103, BH301, BH302	
	Nickel	BH302	
	Zinc	BH102	
Inorganics and MNA	Ammoniacal Nitrogen	BH103, BH302	
	Nitrate	BH102	
TPH, EPH, GRO, BTEX	None identified	-	-
VOCs, SVOCs, Phenols, Pests'	None Identified	-	-

Table 6-9
Off Site Monitoring Wells

Upper Mineral Horizon	Analyte	Monitoring Wells	Location
Metals	Chromium	BH105X, BH108	Off site and hydraulically down gradient of Home Covert Wood
	Cadmium	BH108 Trace	
	Manganese	BH306	
	Nickel	BH108 Trace	
	Zinc	BH108 Trace	
Inorganics and MNA	Non-significant	-	
TPH, EPH, GRO, BTEX	None identified	-	
VOCs, SVOCs, Phenols, Pest'	VOC solvent	BH105X, BH108, BH306, BH307	
Lower Mineral Horizon	**Analyte**	**Monitoring Wells**	**Location**
Metals	Chromium	BH105, BH108	Off site and hydraulically down gradient of Home Covert Wood
	Cadmium	BH108	
	Manganese	BH108, BH305	
	Nickel	BH108	
	Zinc	108 Trace	
Inorganics and MNA	Non-significant	-	
TPH, EPH, GRO, BTEX	None identified	-	
VOCs, SVOCs, Phenols, Pest'	VOC solvents	BH105, BH108, BH201	
Chalk	**Analyte**	**Monitoring Wells**	**Location**
Metals	Chromium	BH105, BH108	Off site and hydraulically down gradient of Home Covert Wood
	Cadmium	BH108	
Inorganics and MNA	Non-significant	-	
TPH, EPH, GRO, BTEX	None identified	-	
VOCs, SVOCs, Phenols, Pesticides	VOC solvents	BH105, BH108 Trace	

Hydrology

Catchment Overview

6.90 The application site and surrounding area are shown on Drawing HQ 6/4 and 6/5. The general topography shows the western boundary of the application site at an elevation of c. 79-78mAOD and the ground falls slightly to the north, east and south with the lowest point at the southeast corner next to the A1057 at around 74mAOD.

6.91 Demolition of the former aerodrome runway, however, which was orientated southwest to northeast across much of the central part of the application site and crossed the eastern site boundary, causes localised high ground associated with this feature up to 83m AOD.

6.92 The application site and immediate area is situated within the headwaters of the River Colne catchment. The River Lea catchment is to the northeast and east of the application site.

6.93 The River Colne flows east to west and is approximately 1.8km to the south of the application site at its closest point. The River Lea flows northwest to east and is approximately 3.3km to the northeast of the application site at its closest point.

Site and Surrounding Surface Water

6.94 The Nast flows seasonally (ephemeral) in an open channel in a southeast direction across the northern part of the application site (the proposed mineral processing area) as shown on Drawing HQ 6/6 and 6/7.

6.95 The Nast originates within the application site close to the northwest boundary and is understood to receive surface water runoff from land and ponds to the immediate north of the application site, as well as from shallow groundwater when seasonal levels rise high enough.

6.96 An unnamed ditch within Home Covert Wood is sourced from a water discharge pipe from CEMEX at its boundary with Home Covert wood (SW11 on Drawing HQ6/6 and 6/7). There is no flow typically between April and Oct/Nov but when discharge is occurring it flows to the south along the western side of Home Covert until it combines with flow from the Nast.

6.97 The Home Covert dich continues south and discharges to a culvert passing beneath the former airfield runway, but a lack of stream bed maintenance in this area causes water to pond and back up so water does not reach the culvert. The intended culvert route crosses the eastern part of the application site and University playing fields, and daylights on the northern side of the A1057 Hatfield Road.

6.98 The Ellenbrook is a stream east of the site that is culverted beneath the University of Hertfordshire De Havilland Campus. The culvert is exposed 20m southeast of the A1057/Ellenbrook Lane roundabout which then returns to culvert as it flows south along the eastern side of Ellenbrook Lane. The Ellenbrook then meanders to the River Colne in a general southwest direction in an open channel once it is clear of the urban area.

6.99 The Nast culvert on the northern side of the A1057 Hatfield Road discharges to the Ellenbrook on Ellenbrook Lane.

6.100 A tributary (man-made channel) of the Ellenbrook north of the A1057 roundabout aligns with the eastern side of the former Aerodrome at c. 200m east of the application site at its closest point.

6.101 The tributary channel is mostly fed by storm water lagoons associated with nearby housing and is predominantly dry upstream of the storm water lagoon discharge into the channel. The invert level of the channel is typically higher than the UMH groundwater level (based on BH-C data on the Application site), so shallow groundwater is therefore not discharging to the tributary channel.

6.102 Other water bodies in the area comprise:

- Lagoons from previous mineral workings to the immediate north of the site and a small stream
- A roadside lagoon adjacent to the southern boundary of the site parallel to Hatfield Road (A1057) located west of Popefield Farm entrance,
- Butterwick Brook approximately 0.5km to the southwest of the application site at its closest point. The brook flows south and joins the Ellenbrook c. 1.5km south of Smallford.

Surface Water Levels

6.103 The Agency website shows no surface water monitoring points within a 2km radius of the application site.

6.104 Surface water monitoring has been undertaken by SLR since August 2019, the locations are shown on Drawing HQ 6/5. Water levels have been taken monthly for the first year followed by quarterly although no flow data has been gathered. Results are summarised in Table 6-10 below and shown in full in Appendix 6/7.

Table 6-10
Surface Water Elevations (August 2013 – March 2017)

Monitoring Location	Water Elevation (mAOD)					
	Count	Dry	Min	Mean	Max	Range (m)
SW1	19	12	75.229		75.402	0.173
SW2	19	0	71.98	72.44	>72.74	0.76
SW3	19	8	74.27	74.69	74.99	0.715
SW4	22	0	73.66	73.85	74.04	0.409
SW5	22	0	73.20	73.34	73.50	0.295
SW6	22	0	71.36	71.45	71.57	0.21
SW7A	21	13	71.83	71.88	71.93	0.101
SW7B	21	15	71.90	71.91	71.91	0.013
SW8	16	0	77.24	77.41	>77.60	0.26
SW9	19	13	73.81	73.93	74.30	0.56
SW10	7	6	-	-	-	-
SW11	5	4	-	-	76.69	-

6.105 A review of data shows the Nast (SW1), the culvert beneath the former runway (SW9) and the discharge from the site to the Ellenbrook (SW7A and SW7B) is predominantly dry throughout the monitoring period supporting its ephemeral status.

6.106 The surface water management pond for Ellenbrook Park appears to be providing a small amount of baseflow into the Ellenbrook tributary. The greatest ranges of water level fluctuation occur within an onsite pond and the upstream Ellenbrook tributary.

Surface Water Quality

6.107 The Water Framework Directives River Basin Management Plan indicates that the 2019 ecological status of the Upper Colne and Ellenbrook (Waterbody ID GB106039029820) was 'moderate'. The watercourse is considered to be at risk. It is noted that the Agency designate only the culverted arm of the Ellenbrook and not the Ellenbrook tributary.

6.108 The chemical quality of the Upper Colne and Ellenbrook was assessed as "fail" in the most recent assessment round of 2019 due to the presence of Polybrominated diphenyl ethers (PBDEs) and Perfluoro-octane sulphonate (PFOS).

6.109 The Nast is not included in the Water Framework Directives River Basin Management Plan. However, it is noted the Agency classify the Nast within the culvert on the application site as a main river and extend this main river up the Home Covert ditch, even though there is no natural flow supplying the ditch from the north. The two Ellenbrook sources are not considered to be main rivers up-gradient of the A1057 roundabout.

6.110 Surface water monitoring data for selected determinants for the period August 2013 to May 2019 are summarised in Table 6-11. Monitoring locations are shown on Drawing HQ 6/5. Results for all tested determinants are included within Appendix 6/8.

6.111 The network of surface water monitoring locations is divided into streams along flow route or ponds or lagoons.

- Nast – SW1, SW9, SW10, SW7A and SW7B
- Upstream Ellenbrook – SW3, SW5 (upstream of SW balancing lagoon, and downstream of Ellenbrook and balancing lagoon mixing)
- Downstream Ellenbrook - SW6 (after Nast has mixed with Ellenbrook)
- Storm water balancing lagoon discharge - SW4 (prior to mixing with Upper Ellenbrook)
- Home Covert Ditch - SW11 (discharge from Cemex prior to mixing with Nast)
- On site Lagoon – SW2 (Upper Mineral Aquifer (UMA), immediately south of home Covert)
- Home Covert Pond (offsite) - SW8
- Ephemeral Pond by Fire Training Area – SW12 (LMA)

6.112 A review of data in Table 6-11 can be summarised as follows:

- Bromate – two isolated trace level detections in Ellenbrook tributary at offsite locations SW3 and SW6.
- Ammoniacal nitrogen concentrations that are elevated above the relevant UK EQS in the upstream Nast (SW1 – maximum 2.5mg/l) and an offsite pond in Home Covert wood (SW8) – maximum 4.3mg/l)
- Metals – cadmium, chromium, iron, manganese, and lead exceed EQS in SW1 (1 event) and trace levels of cadmium in SW2 (UMA pond) and SW3 (Ellenbrook tributary)

6.113 The surface water quality monitoring data to date indicates that most locations record a calcium-bicarbonate type water typical of chalk areas, as illustrated on Figure 6-1.

6.114 The piper diagram illustrates that SW4 and SW5 represent a different sodium-chloride based hydrochemistry (rather than bicarbonate) – this is due to the water feeding the Ellenbrook being mainly rainfall runoff from adjacent housing estates and roads rather than shallow groundwater.

6.115 Despite the above most of the water quality results are comparable upstream and downstream, although it is noted the water quality in the ponds varies slightly from the watercourses. This is due to the ponds being predominantly ephemeral and groundwater fed.

Table 6-11
Surface Water Quality – Determinants and Environmental Quality Standards/DWS

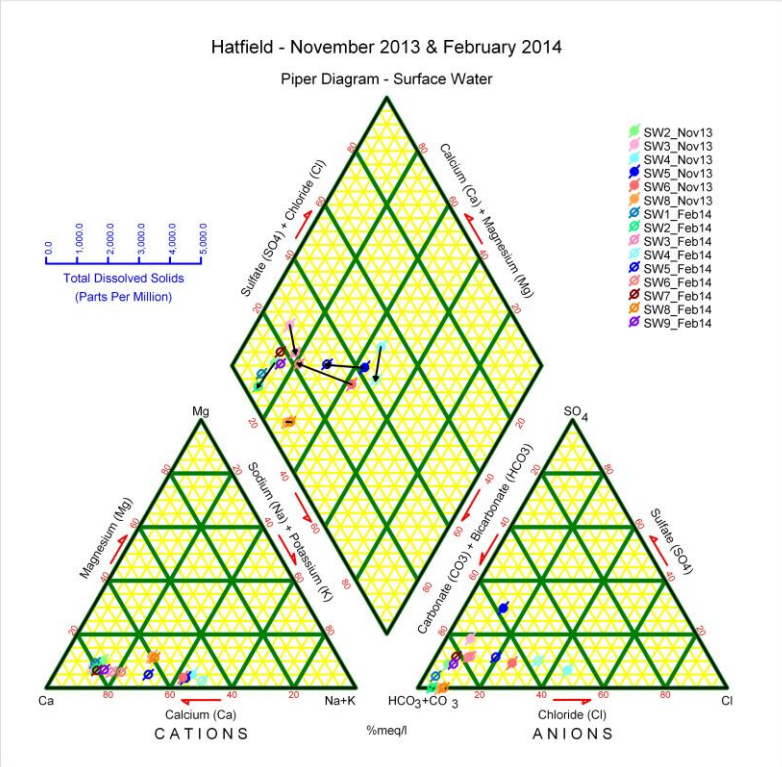
Location		Bromate	Bromide	Bicarb Alkalinity	Ammoniacal Nitrogen	Cadmium	Chromium	Iron	Manganese	Lead	Zinc
Freshwater EQS/DWS		0.01	-	-	0.3	0.00008	0.0047	1	0.0012	0.012	0.0109
SW1 – Upstream Nast	Count	5	5	4	4	4	4	4	2	4	4
	Min	<0.0005	0.12	200	0.13	<0.00003	<0.002	0.027	0.086	<0.0004	0.0034
	Max	<0.0005	0.2	260	**2.5**	**0.00019**	**0.0059**	**2.4**	**0.23**	**0.0055**	0.023
	Mean	<0.0005	0.164	223	0.778	0.00006	0.0017	0.669	**0.158**	0.0017	0.0096
SW2 – Pond onsite	Count	9	9	3	4	4	4	3	-	4	4
	Min	<0.0005	0.018	110	0.033	<0.00003	<0.002	0.073	-	<0.0004	0.003
	Max	<0.0005	0.058	150	0.16	**0.00015**	0.00028	0.34	-	0.0022	0.0015
	Mean	<0.0005	0.034	130	0.086	0.00025	0.0002	0.228	-	0.0007	0.0025
SW3 – Upstream Ellenbrook	Count	7	7	3	3	3	3	3	-	3	3
	Min	<0.0005	0.025	140	0.049	<0.00003	<0.002	0.074	-	0.0021	0.0062
	Max	0.0018	0.082	230	0.07	**0.00014**	0.00031	0.28	-	0.0033	0.0097
	Mean	0.0002	0.054	193	0.059	0.00004	0.00017	0.15	-	0.0028	0.008
SW4 – SUDs Pond offsite	Count	13	13	3	4	4	4	4	-	4	4
	Min	<0.0005	0.025	87	0.11	<0.00003	<0.002	0.023	-	<0.0004	0.012
	Max	<0.0005	0.362	89	0.37	<0.00003	0.0001	0.15	-	0.002	**0.034**
	Mean	<0.0005	0.165	88	0.29	0.000015	0.00016	0.101	-	0.0011	0.024
SW5 – Midstream Ellenbrook Tributary	Count	13	13	3	3	-	-	-	-	-	-
	Min	<0.0005	0.025	89	0.076	-	-	-	-	-	-
	Max	<0.0005	0.274	120	0.31	-	-	-	-	-	-
	Mean	<0.0005	0.147	103	0.225	-	-	-	-	-	-
	Count	13	13	3	3	-	-	-	-	-	-

Location		Bromate	Bromide	Bicarb Alkalinity	Ammoniacal Nitrogen	Cadmium	Chromium	Iron	Manganese	Lead	Zinc
Freshwater EQS/DWS		0.01	-	-	0.3	0.00008	0.0047	1	0.0012	0.012	0.0109
SW6 – Downstream Ellenbrook	Min	<0.0005	0.025	82	0.069	-	-	-	-	-	-
	Max	0.0014	0.274	170	0.23	-	-	-	-	-	-
	Mean	0.021195	0.14	113	0.153	-	-	-	-	-	-
SW7A – Pipe Outfall into ditch next to A1057	Count	4	4	3	3	-	-	-	-	-	-
	Min	<0.0005	0.025	180	0.06	-	-	-	-	-	-
	Max	<0.0005	0.144	250	0.19	-	-	-	-	-	-
	Mean	<0.0005	0.08	217	0.113	-	-	-	-	-	-
SW8 – Home Covert Pond offsite	Count	9	9	3	4	-	-	-	-	-	-
	Min	<0.0005	0.025	37	**1.16**	-	-	-	-	-	-
	Max	<0.0005	0.094	87	**4.3**	-	-	-	-	-	-
	Mean	<0.0005	0.04	83	3.07	-	-	-	-	-	-
SW9 – Midstream Nast	Count	3	3	1	1	-	-	-	-	-	-
	Min	<0.0005	0.038	170	0.21	-	-	-	-	-	-
	Max	<0.0005	0.093	170	0.21	-	-	-	-	-	-
	Mean	<0.0005	0.071	170	0.21	-	-	-	-	-	-
SW- 10	Count	-	-	-	-	-	-	-	-	-	-
	Min	-	-	-	-	-	-	-	-	-	-
	Max	-	-	-	-	-	-	-	-	-	-
	Mean	-	-	-	-	-	-	-	-	-	-
SW-11 - Home Covert Ditch (Cemex)	Count	3	3	4	2	-	-	-	-	-	-
	Min	<0.0005	0.08	140	0.08	-	-	-	-	-	-
	Max	0.0006	0.24	190	0.05	-	-	-	-	-	-
	Mean	0.000156	0.135	170	0.21	-	-	-	-	-	-

Location		Bromate	Bromide	Bicarb Alkalinity	Ammoniacal Nitrogen	Cadmium	Chromium	Iron	Manganese	Lead	Zinc
Freshwater EQS/DWS		**0.01**	**-**	**-**	**0.3**	**0.00008**	**0.0047**	**1**	**0.0012**	**0.012**	**0.0109**
SW- 12 - Pond by former FTA	Count	3	3	2	3	-	-	-	-	-	-
	Min	<0.0005	0.03	41	0.6	-	-	-	-	-	-
	Max	<0.0005	0.066	53	1.6	-	-	-	-	-	-
	Mean	<0.0005	0.048	47	1.6	-	-	-	-	-	-
SW- 14 Home Covert Ditch (upstream of Nast)	Count	1	1	1	1	-	-	-	-	-	-
	Min	<0.0005				-	-	-	-	-	-
	Max	<0.0005	0.11	91	2.1	-	-	-	-	-	-
	Mean	<0.0005	0.11	91	2.1	-	-	-	-	-	-

Notes: *Environmental Quality Standards (EQS)*
UK Drinking Water Standards (DWS)
Figures in bold exceed relevant standards.
SW7B and SW10 were dry during sampling events, therefore no data
FTA – Fire Training Area.

Figure 6-1
Piper Diagram of Surface Water Quality in and around Hatfield Aerodrome



6.116 The Groundsure report lists one active licensed discharge within 1km of the application site boundary the details of which are in

6.117 Table 6-12.

Table 6-12
Licensed Discharges within a 1km radius of the application site

Drawing ID	Consent Number	Location	Grid Reference	Purpose	Distance from Site (m)
D1	CTWC.3104	Beech Farm, Coopers Green	519030 208920	Sewage Discharges – Final/Treated	433 NW

Flood Risk

6.118 Potential sources of flooding to the application site have been considered and assessed in the FRA provided in Appendix 6/9.

6.119 The primary flood risk associated with the proposed development is from fluvial flooding, from the Nast, and overland flow, conveyed from the slightly higher ground adjacent to the north and east of the Site.

6.120 However, no works are proposed within the area shown to be at risk of fluvial flooding. The proposed works are therefore considered to lie in Flood Zone 1. Moreover, based upon the low vulnerability of the proposed development land uses, any localised and shallow ponding of surface

water towards the fringes of the application site poses minimal impact upon the function of the application site.

6.121 A summary of the potential sources of flooding and a review of the potential risk posed by each source at the Site is presented in Table 6-13.

Table 6-13
Potential Sources of Flood Risk

Potential Source	Potential Flood Risk at the Site	Reason
Fluvial flooding	Yes	Application site located partly in within Flood Zone 2.
Tidal flooding	No	Inland location.
Overland flow flooding	Yes	Potential higher ground adjacent to the west and northwest of the application site
Flooding from rising / high groundwater	No	Elevated terrain and lack of historic evidence suggest that groundwater emergence poses no flood risk to the Site. Any flooding associated with excavating below ground level would be managed through pumping.
Flooding from artificial drainage systems	No	Floodwater from surcharging sewers in the vicinity of the application site is likely to follow the general topography and drain towards the Ellenbrook. Therefore, flows would not accumulate to a sufficient depth to give rise to a flood risk.
Flooding due to infrastructure failure	No	The Site is not reliant upon any flood defence infrastructure; therefore, no flood risk is posed by failure of infrastructure. Moreover, EA mapping confirms that the Site is not located in an area identified at risk of flooding from a reservoir.

Designated Ecological Site

6.122 Details of the ecology of the site and including the location of sites designated for their ecological value (SSSI's, SPA's etc.) are given in the ecology chapter of the ES (Chapter 11). There are five water dependant designated ecological sites within 2km of the site, a Local Nature Reserve and four Local Wildlife Sites. A summary of the sites is given in Table 6-14.

Table 6-14
Water Dependant Ecological Sites

Reference	National Grid Ref.	Name	Direction and Distance from Site Boundary (km)	Description of Water Dependant Habitat
68/040	TL 176 096	Jersey Farm Estate Houses Lane	1.6 NW	Pond

Reference	National Grid Ref.	Name	Direction and Distance from Site Boundary (km)	Description of Water Dependant Habitat
68/015	TL 185 081	Oaklands Gravel Pit	0.7 SW	Flooded gravel pit with wetland
68/003	TL 193 068	Smallford Pit	0.6 S	Seasonal wet hollows
69/003	TL 202 064	Sleapshyde Gravel Pit	1.1 S	Open water and wet neutral grassland
69/001	TL 201 058	Colney Heath*	1.8 S	Marshy grassland

Note: * Also designated as Local Nature Reserve.

6.123 In addition to these sites an ecological survey undertaken as part of the baseline assessment has identified five ponds (P1, P3, P5, P6 and P9) that support a great crested newt population, four of which are within the application site boundary. Further details and plans showing the locations of ecological features can be found in the ecology chapter of the ES.

PROPOSED DEVELOPMENT

6.124 The proposed development is described in detail in Chapter 3 of this volume and summarised below:

- building of a mineral processing plant and excavation/construction of infiltration lagoons.
- excavation of mineral from 7 phases (A-G).
- infilling with inert materials; and
- restoration to recreational/conservation land.

6.125 The proposals would involve the winning and working of c. 8Mt of sand and gravel over a period of around 30 years (based on an annual output of around 250,000 tpa). In parallel with the extraction of minerals, low permeability inert material would be the used to infill the mineral workings and facilitate restoration of the site. The inert material would be site derived IB and overburden supplemented with imported material typically comprising excavation waste from construction and engineering projects (soils, overburden, clays etc.) within the region.

6.126 Phasing and restoration drawings (including cross sections) are shown on Drawings HQ 3/6 to 3/12. The quarry would be worked on a phased basis to allow for progressive restoration. Sand and gravel would be worked from the two discrete horizons described above. The UMH is overlain by a clayey material (referred to as 'overburden'), above which is the soil horizon. The two mineral horizons are separated by a laterally continuous layer of boulder clay (referred to as 'IB'): the overburden and IB would be used to control groundwater ingress and to infill the base of the workings (i.e. the excavated LMH and IB) to provide a suitable low permeability geological barrier on which the imported material would be placed within the void of the UMH and overburden.

6.127 Two infiltration lagoons, an UML and a LML would be constructed to manage water discharge during operation of the application site.

6.128 The mineral would be extracted, and each phase backfilled using a staged approach. Each phase would be isolated from the UMH by the construction of perimeter bunds before the UMH is worked. This would involve local dewatering of the UMH to allow the bund to be constructed in a dry

excavation. A back-drain would be installed behind the bund to reduce the maximum historically recorded groundwater level by 1m in order to maintain the stability of the bund prior to restoration.

6.129 When the bund is complete the UMH in the relevant phase would be dewatered and worked dry and the IB used as a working platform to wet dig the LMH.

6.130 Careful monitoring of groundwater levels in the LMH would be required in advance of working the LMH in each phase, together with sharing of data and reviews with the Agency, HCC and Affinity as set out in the GWMP.

6.131 Once the mineral has been excavated the phases would be progressively restored. The LMH void would be backfilled with site derived materials and an engineered geological barrier with a minimum thickness of 1m formed from site derived clay and keyed into the remaining overburden/phase perimeter bunds. The remaining void adjacent to the IB and LMH with be restored with imported material typically comprising excavation waste from construction and engineering projects (soils, overburden, clays etc.) within the region.

6.132 Each phase would take approximately 4 years to work with phases being worked progressively, moving east to west (see Drawing HQ 3/1).

6.133 Details of the restored landform are shown on Drawing HQ 3/11. It is proposed that back-drains to phases E and G would be retained as a 500mm deep open channel to intercept groundwater levels exceeding that monitored in the Spring of 2014, 2020 and 2021 and extended as shown on Drawing No. HQ 3/10. This drain would discharge to swales on site and then to the recharge lagoons in the UMH. This would prevent groundwater levels from rising above historical levels.

6.134 The working of the site would involve the management of groundwater and surface water. Estimates of the volumes that would need to be managed and the capacity of the recharge lagoons are presented in Appendix 6/10 and summarised in Table 6-15.

Table 6-15
Potential Water Volumes

Source of Water	Volume Range m^3/d	Discharge Location
1) **Dewatering discharge for clay buttress construction**	55 - 350	UMH/LMH Lagoon
2) **Phase Back Drain Flow**	110 - 360	UMH/LMH Lagoon
3) **UMH groundwater in storage and rainfall within each phase**	110 -150	UMH/LMH Lagoon
4) **Back-drain discharge from restored site**	200 – 1,300	UMH Lagoon
5) **UML Recharge Capacity**	725 – 1,400	UMH Lagoon
6) **LML Recharge Capacity**	6,000+	LMH Lagoon
7) **Restored UML Recharge Capacity**	1,300 – 2,000	UMH Lagoon

ASSESSMENT OF POTENTIAL IMPACTS

6.135 This sub-section identifies the potential impacts of the proposed development on the hydrogeological and hydrological environments prior to mitigation. It also assesses the likelihood of occurrence of each identified impact. The results of this assessment are summarised in Table 6-16
. It should be noted that the significance of the impact has been assessed as described in Table 6-2.

6.136 The proposed design and operation of the application site would incorporate measures to mitigate potential impacts on the water environment. These measures are not included in the initial assessment of impacts so that they can be explicitly stated in the mitigation section of this chapter of the ES.

6.137 In this assessment the sensitivity of the potential receptors is designated as follows:

- UMH Groundwater – Medium sensitivity as it is of local to regional importance only.
- LMH and Chalk Groundwater – High sensitivity as it is of national importance for water supply.
- Surface Water (Nast and Ellenbrook) – Medium sensitivity as it is of local to regional importance only, is frequently culverted and is urban in character.

Groundwater

Groundwater Quality

6.138 During construction, operation, and restoration of the proposed mineral extraction work there is the potential for adverse impacts on the groundwater quality within the UMH and LMH/Chalk aquifers, unless mitigation measures are adopted.

6.139 Construction and operation present a risk of impact to groundwater quality via direct emission into one or both aquifers from accidental spillage of raw materials, uncontrolled surface water run-off entering the active phase, fuel, and lubricants from storage and from the vehicles moving around the application site. The magnitude of the potential impact is 'moderate' for both the UMH and LMH/Chalk and therefore the significance of potential effect would be 'moderate' for both aquifers.

6.140 There is a potential for groundwater in the UMA and the LMA to mix during construction. The LMA/Chalk to the northeast of the site is impacted by bromate, which does not occur in the UMA beneath the site. Therefore, the magnitude of impact for the UMA groundwater to enter the LMH/Chalk aquifer is **'minor'**. This gives a potential effect of '**minor**' significance.

6.141 The magnitude of impact created by LMA/Chalk groundwater entering the UMA aquifer is '**high**' due to the risk of bromate contamination levels. Monitoring results, however, indicate that bromate occurrence on site in the LMA/Chalk is restricted to the northeast corner of the site beyond the active mineral working area; detections are inconsistent, and are at low trace level concentration. Bromate concentrations in the LMA in the northernmost corner of the mineral processing area could experience a marginal increase if LMA/Chalk groundwater levels fall lower than recorded on site so far. The potential effect would be of '**moderate**' significance so mitigation would be required.

6.142 Partial replacement of granular LMH with site won cohesive material could cause a marginal increase in groundwater head in the LMA at the hydraulically up-gradient side of the filled site. During high groundwater levels, the LMA pressure head could exceed the top of the IB but the

vertical migration pathway would be restricted by the AGB. Additionally, groundwater flow approaching from the northwest side of the site has not been impacted by bromate during the most extreme groundwater level 'lows' in the past and is even less likely to be impacted during groundwater highs which is when the LMA head could be above the upper surface of the IB. If levels were to rise then the potential effect to UMA water quality would be **'minor'**.

6.143 The application site would be restored with site derived cohesive materials and imported inert waste above the AGB. Although inert waste should not produce a leachate it is recognised that percolating water could be affected, which if leakage occurs could impair groundwater quality. The potential magnitude of any impact is '**moderate**' and hence the significance of any effect on groundwater quality in the UMH and LMH/Chalk is rated as '**moderate**'.

6.144 By design, lagoon operation would mix water from the UMA and the LMA. The sensitivity of LMA water mixing with UMA in the UMA is water is as described in Paragraph 1.134 ('**High**') but the risk of it occurring is reduced to '**minor**' by design of the lagoons and by always maintaining a downward vertical gradient from the UMA to LMA, for instance:

- The LMA groundwater head has always been >3m below the top of the IB
- The maximum fill elevation for the LML would be set below the lowest groundwater level recorded in the UMA at the location of the LML
- The UML sidewalls would be sealed around the whole LML
- Groundwater quality would be tested in advance of discharge
- Operation of the LML overflow would be subject to stakeholder approval.

Groundwater Levels and Flow

6.145 During construction and operation of the site there is the potential to impact on groundwater levels and flow direction within the UMH and LMH/Chalk.

6.146 Construction and operational phases of the development would require temporary dewatering of the UMH at various stages and times of the year, including:

- construction of the recharge lagoons
- installation of phase perimeter bunds in the UMH
- installation of back-drain to reduce maximum water levels behind the bund, and
- dewatering of the UMH so it can be worked dry to gain access to the IB and the LMH.

6.147 The impact of dewatering activities on water resources in the UMH is considered **'moderate'** and therefore the significance of the effect is **'moderate'**.

6.148 During operation, the UMH perimeter bunds would create a barrier to groundwater flow within the UMH that could cause groundwater levels to rise and locally alter flow direction. During certain seasons, groundwater within the UMH is close to the ground surface and the barrier effect could result in local groundwater flooding. The magnitude of the impact of increased water levels in the UMH is **'moderate'** giving a significance of effect of **'moderate**' so mitigation would be required.

6.149 After the removal of the mineral from the LMH the void would be backfilled with onsite material from the overburden and IB. As stated in Paragraph 6.135 this is a lower hydraulic conductivity than the mineral and could locally alter groundwater levels and flow directions in the LMH. However, given that at least 1m of unworked LMH would be left in place and the underlying Chalk is in

hydraulic connection with the LMA, the impact on water levels and flow directions in the LMA would be '**minor**' and the overall significance of any effect is also '**minor'**.

6.150 The UML would be used to return water to the UMA during various operational phases of the site including bund construction, disposal of incident rainfall and back drain water flow. The performance of the UML is dependent upon the physical properties of the aquifer, location and scale, and groundwater level at the time of discharge. Groundwater level is a seasonal variable, and the potential magnitude of impact is '**moderate**' and the significance of effect is rated as '**moderate**'.

Surface Water

Surface Water Quality

6.151 Without the incorporation of mitigation measures the proposed mineral extraction works, including processing plant, and restoration works have the potential to impact on the quality of surface water from the following potential runoff sources:

- Accidental spillage of raw materials, fuels, and lubricants from the processing plant and from the vehicles moving around the application site
- Increase in suspended solids in runoff
- Runoff impacted by hydrocarbon compounds from the weighbridges and vehicle movement areas; and
- Impacted runoff from the management and handling of waste materials.

6.152 Short term, hydrocarbon pollution from untreated runoff associated with roads and car parking areas could cause issues for surface water quality without suitable mitigation.

6.153 Accidental release of raw materials, fuels, other liquids, and runoff during the construction and operation of the processing/recycling facility with the potential to cause an impact to surface water.

6.154 Overall, the magnitude of impact associated with the construction and operation of the facility is considered '**moderate**' due to ground disturbance associated with construction or hydrocarbon pollution from vehicles over a relatively short timeframe. The potential effect significance is therefore considered '**moderate'** so further mitigation is required.

6.155 There is potential for surface water to entrain suspended solids during construction and landscaping activities associated with the restoration scheme owing to surface runoff from working areas and soil stockpiles. The magnitude of impact is **'moderate'** and the potential significance of the effect is therefore considered to be '**moderate**'.

Surface Water Flow Regime

6.156 The restoration scheme would involve the infilling of the mineral void with inert materials and covering with restoration soils, thereby potentially increasing the rate and volume of surface water because of the proposed development.

6.157 In the absence of mitigation, the magnitude of impact due to a potential change in the flow regime and increase in flood risk, both within and outside the application site boundary, is considered '**major'**. This assessment reflects the area of the application site occupied by the capped waste. The potential effects are considered '**moderate**' and further mitigation is required.

6.158 The Nast is an ephemeral stream and would be diverted along the northern and eastern perimeter of the mineral processing area (Drawing HQ 6/6) to enable construction of the proposed processing plant. Flow from the Nast would enter a new culvert constructed along the western side of the infiltration lagoons, like the route of the existing culvert. As the diverted reach is relatively short, flow conveyed along the Nast is expected to be low and the magnitude of impact is considered '**negligible**' resulting in an overall significance of '**negligible**'.

6.159 **Table 6-16** presents a summary of potential impacts associated with the proposed development and identifies where mitigation measures are required to reduce potential impacts to acceptable levels.

Ecological Sites

6.160 The nearest water dependent designated ecological sites are between 0.7 and 1.8km from the site boundary. As dewatering of the UMH (see details below) is spatially constrained and low permeability bunds would isolate its impact it is unlikely to significantly affect the identified sites.

6.161 There are ponds within and close to the development site which are undesignated but support a population of great crested newts. These are ephemeral ponds that dry in the summer period when water levels in the UMH fall. Pumping from the UMH would take place in the summer months when groundwater levels are low and ponds are dry, and on a limited scale to allow the installation of clay bunds. Water pumped to facilitate bund construction would be recharged back into the UMA.

6.162 The clay bunds would prevent the drawdown of groundwater levels outside of the mineral phase extraction area during the excavation of sands and gravels from the UMH. The magnitude of impact on water dependant ecological features would be '**minor**' resulting in an overall '**minor**' significance.

Table 6-16
Summary of Unmitigated Potential Impacts

Potential Impact	Spatial and Temporal Impact	Magnitude of Impact	Sensitivity of Receptor	Potential Effect	Mitigation Required?
Groundwater Quality					
UMH Aquifer					
Spillage of pollutants, oils, fuels etc. and uncontrolled surface water	Local, Short Term (Adverse)	Moderate	Medium	Moderate	Yes
Mixing of LMH/Chalk groundwater and UMH groundwater	Local, Short Term (Adverse)	Major	Medium	Moderate	Yes
LMA water entering the UMA via the lagoons	Local, Short Term (Adverse)	Moderate	High	Minor	Yes (by design)
Potential contamination from restoration landfill	Local, Long Term (Adverse)	Moderate	Medium	Moderate	Yes
LMH/Chalk Aquifer					
Spillage of pollutants, oils, fuels etc.	Local, Short Term (Adverse)	Moderate	High	Moderate	Yes
Mixing of UMH groundwater with LMH/Chalk groundwater	Local, Short Term (Adverse)	Minor	High	Minor	No
Interception of bromate contaminated groundwater	Regional, Short Term (Adverse)	Major	High	Major	Yes
Barrier to groundwater flow	Local, Long Term (Adverse)	Minor	High	Minor	No
Potential contamination from restoration landfill	Regional, Long Term (Adverse)	Moderate	High	Moderate	Yes

Potential Impact	Spatial and Temporal Impact	Magnitude of Impact	Sensitivity of Receptor	Potential Effect	Mitigation Required?
Groundwater Levels and Flow					
UMH Aquifer					
Dewatering reduces groundwater levels and changes flows	Local, Short Term (Adverse)	Moderate	Medium	Moderate	Yes
Barrier to groundwater flow	Local, Short Term (Adverse)	Moderate	Medium	Moderate	Yes
LMH/Chalk Aquifer					
Barrier to groundwater flow	Local, Long Term (Adverse)	Negligible	High	Negligible	No
Surface Water Quality					
Contaminated runoff entering surface waters during construction phase	Regional, Short Term (Adverse)	Moderate	Medium	Moderate	Yes
Suspended solids entering surface water	Regional, Short and Long Term (Adverse)	Moderate	Medium	Moderate	Yes
Surface Water Flow Regime					
Flooding from increased runoff	Local, Short, and Long Term (Adverse)	Major	Medium	Moderate	Yes
Management of shallow groundwater adjacent to UML	Local, Short, and Long Term (Adverse)	Moderate	Moderate	Moderate	Yes
Diversion of the Nast	Local, Short, and Long Term (Adverse)	Negligible	Medium	Negligible	No
Water Dependant Ecological Sites					

Potential Impact	Spatial and Temporal Impact	Magnitude of Impact	Sensitivity of Receptor	Potential Effect	Mitigation Required?
Reduction in water levels	Local, Short, Term (Adverse)	Minor	Medium	Minor	No

PROPOSED MITIGATION MEASURES

6.163 Mitigation measures to address potential impacts detailed in Table 6-16 are described below. These measures either reduce the likelihood of an event occurring or reduce the magnitude of the consequences if the event does occur. The reduction in likelihood is reflected in the overall rating of significance. It should be noted that several of the mitigation measures proposed below would have a positive effect on more than one potential impact.

6.164 Several operational mitigation measures and best available techniques have been incorporated into the scheme design, which would reduce the potential risks identified to ground and surface water.

Groundwater and Surface Water Quality

Spillages and Contaminated Runoff

6.165 The operation and restoration of the quarry would be undertaken using current technical guidance, relevant Pollution Prevention Guidelines, other codes of best practice and consents to limit the potential for contamination of both ground and surface waters.

6.166 Best practice techniques would be incorporated within the management procedures for construction and operation activities onsite to protect the water environment from pollution incidents. The mitigation measures can be summarised as follows:

- Heavy plant and machinery would be required on site during construction and as a result it is appropriate to adopt best working practices and measures to protect the water environment, including those set out in the Guidance for Pollution Prevention (GPP1)
- In accordance with GPP2 all above ground on-site fuel and chemical storage would be bunded
- An emergency spill response kit would be maintained on site
- A traffic management system / road marking would be put in place wherever possible to reduce the potential conflicts between vehicles and thereby reduce the risk of collision
- A speed limit would be imposed on site to reduce the likelihood and significance of any collisions
- The proposed restoration scheme is subject to an Environmental Permit which includes appropriate measures to avoid unacceptable impact on the environment including water; and
- Surface water runoff would be contained within the excavation areas and all water discharged to a recharge lagoon; this would reduce the risk of suspended solids entering surface waters.

6.167 A groundwater and water management plan has been prepared and agreed with the Agency and Affinity (Version 5). An updated version (V6) is included in Appendix 6/10.

6.168 The combined effect of the measures above would significantly reduce the likelihood of pollutants, including suspended solids, being discharged from the application site, such that the magnitude of impact is reduced to 'minor' and the potential effect is 'minor' for both surface and groundwaters.

Mixing of Aquifer Waters

6.169 There would be no pumping of LMA groundwater and therefore no LMA groundwater discharge so the risk of LMH groundwater mixing with UMH groundwater is extremely low.

6.170 The engineering design being proposed would isolate and keep separate the LMA and the UMA through the placement of an artificial geological barrier (AGB) that would in essence replace the IB. The AGB would be keyed into the IB at the outer edge of each phase maintaining the vertical separation of the UMA and the LMA.

6.171 A side wall barrier resting upon the IB at the flanks of each phase would complete the lateral seal and isolate the void above the AGB from the UMA beyond its boundary. Placement of the AGB and sidewall barrier would be monitored in accordance with a Construction Quality Assurance Plan (CQA) approved by the Agency.

6.172 The LMA piezometric surface may be within or just above the upper surface of the IB during extreme groundwater level situations for the two western phases (Phases E and G). The operational plan is to not undertake any excavation of the IB whenever groundwater in the LMA exceeds or could exceed the IB surface. Therefore, the risk of LMA mixing with UMA groundwater is maintained at low.

6.173 There is a provision for discharge of excess UMA groundwater into the LML and therefore the LMA. This discharge and would only be undertaken following discussion and agreement by the stakeholders of the GWMP (Appendix 6-10). Design and operation of the lagoons has been described in Paragraph 6.137 and no further mitigation measures are required.

Interception of Bromate Contaminated Water

6.174 Groundwater in the LMA/Chalk to the northeast of the site is impacted by bromate at low levels resulting from a historical release.

6.175 As there would be no pumping of groundwater from the LMA the potential for drawing impacted groundwater into the site is low.

6.176 Extreme seasonal groundwater level lows and stable pumping of groundwater by Affinity has been experienced in recent years and has not resulted in plume migration onto the mineral site, nevertheless, a 100m excavation standoff from the closest known bromate impacted groundwater monitoring well (BH104) would be implemented in the LMH to further mitigate against lateral plume migration.

6.177 Wet digging of mineral from the LMH, however, could create short lived local changes in groundwater levels which could conceivably induce a local hydraulic gradient towards the site. The significance of this potential effect is mitigated to a 'minor' significance by the following design and operational measures:

- The groundwater in the LMH in the proposed mineral extraction area is not impacted by bromate and the location and direction of plume migration is parallel to rather than towards the excavation areas

- The 100m standoff from BH104 for LMH excavation, as described above
- The lagoons located would be constructed early in the site development and their operation would form a hydraulic barrier with flow being directed towards the east, thereby isolating Phase A and B from the offsite plume
- Infilling of the LMH in Phase A and B with low permeability material would form a barrier to flow from the eastern side of the site further reducing a pathway for bromate migration reaching the mineral site, and
- A GWMP to be agreed with the Agency and Affinity prior to works commencing includes a comprehensive water level monitoring system and groundwater quality monitoring programme, as well as a mechanism for stakeholder engagement in advance of and during mineral works. Together this would ensure that mitigation measures described above are effective and if not, to agree contingency actions, as necessary.

Contamination from Restoration Operations

6.178 The restoration operations would be operated under an Environmental Permit that ensures activities do not pollute the water environment. The phases would be lined with a minimum thickness of 1m of clay with a maximum hydraulic conductivity of 1 x 10^{-7}m/s.

6.179 A hydrogeological risk assessment (HRA) has been undertaken as part of the application for an Environmental Permit to demonstrate that essential and technical precautions and requisite surveillance would be undertaken to ensure the installation complies with the Environmental Permitting Regulations 2016.

6.180 The potential impact has been assessed in detail and mitigation provided as set out the hydrogeological risk assessment that accompanied the successful permit application for the restoration of the site with inert materials (December 2016, ref. 422.01009.00140/HRA). Mitigation reduces the significance of any effect to 'negligible'

Groundwater Levels and Surface Water Flow

Groundwater Flow

6.181 Groundwater abstracted from the UMA during Phase preparation would be used for mineral processing and managed via silt/water recycling lagoons in the processing plant site, with any excess recharged back into the UMA via the UML

6.182 Table 6-15 presents approximate water volumes generated during various operational phases together with recharge lagoon capacity. Calculations behind the estimates are presented in Appendix 6/10.

6.183 The results presented in Table 6-15 indicate that there is a scenario whereby a recharge capacity shortfall of c.15% could be realised in the UML. This could occur if the initial three water discharge sources listed in Table 6-15 occur simultaneously during an extreme high UMA groundwater level (excluding abstraction for mineral washing).

6.184 Reconfiguring of the Nast in the mineral processing area, and management of drainage channels including the replacement of the Nast culvert would all result in improvements to drainage in the vicinity of Home covert.

6.185 Although the UML capacity shortfall could be absorbed by operational adjustments, as a responsible operator Brett wishes to increase its available infiltration capacity by at least 150% of that determined for the UML in order that they can operate the site during periods of lagoon maintenance or for any other unforeseen circumstance. The infiltration capacity of the LMH lagoon more than compensates for the UMH lagoon.

6.186 Data presented in Table 6-15 demonstrates that groundwater can be managed at the site and the significance of the effect given this mitigation is reduced to 'minor'.

6.187 Restoration of the void with imported inert material would create a barrier to groundwater flow within the UMH. A back-drain is therefore included in the design to ensure groundwater levels do not increase above historically high elevations. Groundwater from the back-drain would be used in the same manner described above (for mineral processing), with any excess discharged to the UMA/LMA lagoons reducing the significance of the impact to 'minor'.

6.188 On completion of the site the back-drain in phases E and G would be maintained as an open channel to manage groundwater levels in the long term. The drain would be modified to be an open channel and would be linked into the surface water swales and ponds ultimately discharging to an enlarged UMA recharge lagoon.

Surface Water Flooding

6.189 A flood risk assessment has been prepared and is presented in Appendix 6-9. With reference to Section 3, the application site would be restored to approximately 76.0m AOD following extraction works with a slope in a general north-easterly direction towards the infiltration lagoon. The infill would potentially increase surface water runoff rates.

6.190 It is proposed that surface water runoff be discharged offsite using a 2-tier approach. Surface water runoff would be intercepted by a network of lined swales and ponds before discharging to the infiltration lagoon in the east of the site. All of these features provide an element of water storage and hence delay the discharge for surface water from the site, reducing flood risk.

6.191 However, if the water level within the infiltration lagoon reaches 74.5m AOD, it is proposed that an overflow be provided into the Nast at the southeast boundary of the application site, albeit attenuated to the 100% AEP greenfield runoff rate of 117.5 l/s for the application site (c.85.94ha). This would be achieved using a flow control device (orifice plate, hydrobrake or similar).

6.192 The above measures would significantly reduce the likelihood of surface water flooding, such that the magnitude of impact is reduced to 'minor' and the potential significance of any impact also to 'minor'.

RESIDUAL EFFECT

6.193 A summary of the potential impact of the development after consideration of mitigation measures is given in Table 6-17. This demonstrates that the implementation of appropriate preventive

measures and mitigation significantly and appropriately limits the identified hazards to surface water and groundwater from the proposed site activities to acceptable levels.

6.194 Overall, it is concluded that, with respect to groundwater and surface water, there would be no significant residual effects of the proposed development after inclusion of the identified mitigation measures.

Table 6-17
Summary of Mitigated Impacts and Residual Effects

Potential Impact	Spatial and Temporal Impact	Magnitude of Impact	Significance of Impact	Mitigated Magnitude of Impact	Mitigated Significance of Impact
Groundwater Quality					
Spillage of pollutants, oils, fuels etc, and uncontrolled surface water runoff to UMH	Local, Short Term (Adverse)	Moderate	Moderate	Minor	Minor
Mixing of LMH/Chalk groundwater and UMH groundwater	Local, Short Term (Adverse)	Major	Moderate	Minor	Minor
LMA water entering the UMA via the lagoons	Local, short term, (Adverse	Moderate	Moderate	Minor	Minor
Potential contamination of UMH and LMH from landfilling	Local, Long Term (Adverse)	Moderate	Moderate	Negligible	Negligible
Interception of bromate contaminated water	Regional, Short Term (Adverse)	Major	Major	Minor	Minor
Spillage of pollutants, oils, fuels etc., and uncontrolled surface water runoff to LMH/ Chalk	Local, Short Term (Adverse)	Moderate	Moderate	Minor	Minor
Groundwater Levels and Flow					
Dewatering reduces groundwater levels and change flows in the UMH	Local, Short Term (Adverse)	Moderate	Moderate	Minor	Minor

Barrier to groundwater in UMH	Local, Short Term (Adverse)	Moderate	Moderate	Minor	Minor

Surface Water Quality and Flow					
Contaminated runoff entering surface waters during construction phase	Regional, Short Term (Adverse)	Moderate	Moderate	Minor	Minor
Suspended solids entering surface water	Regional, Short Term (Adverse)	Moderate	Moderate	Minor	Minor
Flooding from increased runoff	Local, Short and Long Term	Major	Moderate	Minor	Minor
Management of shallow groundwater adjacent to UML	Local, Short, and Long Term (Adverse)	Moderate	Moderate	Minor	Minor

CONCLUSIONS

6.195 The groundwater and surface water regimes at the application site have been assessed with reference to information held by the BGS, the Agency, Affinity, the Local Authority, and others, and by the consideration of site-specific investigations and reports for the application site.

6.196 The potential impacts of the proposed development upon the hydrogeological and hydrological environments have been identified and assessed, and where appropriate, mitigation measures have been accommodated into the design of the proposed development.

6.197 The operation and restoration of the application site would be undertaken using current technical guidance, relevant Pollution Prevention Guidelines, other codes of best practice and consents, to limit the potential for contamination of both ground and surface waters. Best practice techniques would be incorporated within the management procedures for construction and operation activities onsite in order to protect the water environment from pollution incidents.

6.198 Groundwater encountered during the works would be returned to the UMA via a recharge lagoon, with an additional contingency lagoon that discharges to the LMA, if required.

6.199 A hydrogeological risk assessment has been completed to assess the proposed restoration of the site with imported inert wastes. The risk assessment has confirmed that the proposed development of the quarry (and the backfilling of the void) would not have a significant effect on the water quality. No additional mitigation measures are therefore required over and above the technical precautions that are proposed for the construction and management of the site.

6.200 Groundwater in the LMA/Chalk to the northeast of the site is impacted by bromate from an offsite historical source. There is to be no pumping of groundwater from the LMA so there is no potential for actively drawing the plume towards the site, although wet digging could have a minor but insignificant effect.

6.201 It is unlikely, but if LMA/Chalk groundwater levels fall below the lowest historically recorded levels on site then this could affect the location of the plume edge. Nine years of monitoring results, however, indicate the plume is stable but precautionary measures incorporated into the design and operation of the site mitigate this risk which would not be significant.

6.202 All groundwater pumped from the UMH would be recharged back into the UMH aquifer via the UML with the option for discharge into the LML if needed. There would therefore be no significant loss of resource. The recharge area is relatively close to the points of abstraction, and it is not envisaged that there would be a significant impact on water resources.

6.203 Restoration of the void with imported inert fill may result in a local rise in groundwater levels, but this would be mitigated by a perimeter back drain to manage water levels during historically high groundwater periods during the operational and restored phases of the site.

6.204 A flood risk assessment has been prepared to assess the risk that the development itself would be affected by flooding or would exacerbate flood risk elsewhere. Mitigation measures are presented to ensure flood risk is not significantly increased. This includes the recharge of water back into the aquifer during the operational and restored phases of the development.

6.205 A Water Framework Directive compliance assessment has been undertaken and is included as an appendix to the ES. This concludes that the proposals would not have a significant impact on the objectives of the WFD.

6.206 Overall, it is concluded that there would be no significant residual effects to groundwater and surface water from the proposed development after inclusion of the identified mitigation measures.