

HYDROLOGY AND HYDROGEOLOGY 9

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INTRODUCTION

- 9.1 This chapter details the local hydrology and hydrogeology of the application site and surrounding area and identifies potential hydrological and hydrogeological impacts associated with the proposed development.
- 9.2 This section of the Environmental Statement provides the following:
- a description of the baseline hydrological and hydrogeological conditions of the site;
 - an initial assessment of the impacts of the development assuming no mitigation is in place
 - a description of mitigation measures; and
 - an assessment of residual impacts.

Site Location

- 9.3 The application site is located at New England Quarry in Devon, at National Grid Reference SX 595 547, 3km south-west of Ivybridge and 1km south of the A38 Trunk Road, the principal route between Plymouth and Exeter. The location of the site is shown on Drawing 9/1.

Site Description

- 9.4 New England Quarry has been excavated into the eastern end of a topographic ridge which trends from east to west, falling from over 90m OD in the west to 36m OD in the east adjacent to the River Yealm. A site plan is shown on Drawing 9/2.
- 9.5 The application site was previously used for the quarrying of road stone and aggregate. The existing quarry void is approximately 300m across and 35 to 40 metres deep. It is located in the centre of the site application site and has been worked in a series of four to five sub-vertically cut benches with an individual height of up to 18m high and 40m wide. The quarry is currently flooded with water; water levels were recorded at 49.60m OD on the topographic survey undertaken in May 2008.
- 9.6 To the north of the quarry void is a relatively level, un-vegetated area at an elevation of 63m OD, falling to 55m OD to the north-east. This is the former stockpiling area for the quarry. Ground elevations fall steeply to the south-east of the quarry void to the river Yealm and the original site entrance where there are a number of disused buildings and infrastructure relating to the quarry operations. These include a weighbridge, site office and the partially dismantled mineral processing and loading infrastructure. This area is at an elevation of 36 to 37m OD.

Adjacent Landuse

- 9.7 The quarry is bound on the eastern edge by the River Yealm which flows from north to south. To the north of the site is a small tributary of the River Yealm which flows in a narrow wooded valley and separates the quarry from two former landfill sites. Strashleigh Hams is located approximately 200m north of the quarry and accepted inert quarry waste between 1988 and 2005, Challonsleigh landfill which also accepted inert waste and is now an active waste transfer station taking household, commercial and industrial waste. South and west of the site are characterised by a mixture of farmland and woodland.

Policy Context

- 9.8 The design, construction and operation of the proposed development will be undertaken using technical guidance, relevant Pollution Prevention Guidelines (PPGs) and other codes of best practice in order to limit the potential for contamination of both the ground and surface waters. The development of the site will be in accordance with the following:

- Control of Pollution Act 1974;
- Environment Act 1995;
- The SUDS Manual - C697 (CIRIA, 2007);
- Environmental Good Practice on Site C650 (CIRIA 2005);
- Planning Policy Statement 25: Development and Flood Risk, Published by Department for Communities and Local Government, December 2006.
- The relevant BAT reference document (BREF) for waste incineration.

- 9.9 The Environment Agency Pollution Prevention Guidelines identified below are the principal documents used for guidance on preventing water pollution and erosion from construction activities:

- PPG1: General Guide to the Prevention of Pollution;
- PPG2: Above Ground Oil Storage Tanks;
- PPG3: Use and Design of Oil Separators in Surface Water Drainage Systems;
- PPG5: Works in, Near, or Liable to Affect Watercourses;
- PPG6: Working at Construction and Demolition Sites;
- PPG21: Pollution Incident Response Planning;
- PPG23: Maintenance of Structures over Water.

Methodology

- 9.10 A detailed description of the proposed development and operations is provided in Section 3. For the purposes of this section, a review of the development proposals which may impact the baseline hydrology and hydrogeology of the site is provided below:
- change of site use from quarry to landfill;
 - construction of an EfW plant and associated infrastructure, bottom ash recycling facility, offices and hardstanding areas; and
 - construction of a new access road.
- 9.11 This section identifies the potential impacts of the proposed development on the hydrogeological and hydrological environments. It also assesses the likelihood of occurrence of each identified impact. Impacts are considered separately for the construction and operational impacts of the development.
- 9.12 A qualitative risk assessment methodology has been applied, in which the significance of an impact is determined based on both the probability that an impact will occur and the magnitude of the impact, if it were to occur. This approach provides a mechanism for identifying mitigation measures appropriate to the risk presented by the development. It allows effort to be focused on reducing risk where the greatest benefit may result. Details of the assessment methodology are presented in the sub-section; Impact Assessment

Sources of Information

9.13 This assessment is based on the following sources of information:

- British Geological Survey Sheet 1:50,000 scale, Sheet No. 349 (Solid and Drift Edition) – Ivybridge, 1974;
- Environment Agency Groundwater Vulnerability Map 1:100,000 scale, Sheet 49 – South Devon, 1998;
- Environment Agency Website (www.environment-agency.gov.uk);
- Natural England Website (www.naturalengland.org.uk);
- Centre of Ecology and Hydrology (CEH Wallingford), Flood Estimation Handbook CD ROM (2006);
- Ministry of Agriculture, Fisheries and Food (MAFF) Technical Bulletin 34 Climate and Drainage (1975);
- Information from South Hams District Council Environmental Health Department on private water supplies;
- The Physical Properties of Minor Aquifers in England and Wales, BGS Technical Report.
- British Geological Survey (1975) *British Regional Geology: South-West England*;
- Peter Brett Associates (2008) *New England Quarry, Ivybridge, Devon: Engineering Geological Assessment*, Project Ref: 15932/002; and
- Devon County Council (2004) *Devon County Minerals Local Plan*, June 2004;
- Environment Agency correspondence dated 6th May 2008 and 17th April 2009 (Ref.C/CSC/10473 and C/CSC/11104) for flood levels, licensed abstractions, surface water quality, discharges, and rainfall data;
- Groundwater level and quality data and surface water quality data provided by Viridor Waste Management; and
- Information on private water supplies from South Hams District Council.

BASELINE CONDITIONS

Geology

- 9.14 The published geological map¹ for the area indicates that the proposed development is underlain by igneous diabase or dolerite, which is intruded into the surrounding Middle Devonian Slate. The intrusion has an east to west trend, extends to the west and east of the River Yealm and the slates outcrop on the northern and southern sides of the site. The Middle Devonian Slates regionally dip steeply to the south. Normal faulting in the area is generally north north-east to south south-west. An extract from the published geology map is shown on Drawing 9/3 and further geological details are shown on Drawing 9/2.
- 9.15 The Dartmoor Granite is located approximately 3km to the north-east of the site. The granite was emplaced following intrusion of the quarried Dolerite, although the metamorphic aureole associated with the granite does not extend into the dolerite and slates on site. The slates are locally altered around contact with the dolerite intrusion.
- 9.16 The site has been extensively investigated in the past with three previous ground investigations undertaken in 1965, 1971 and 1977². More recently the drilling and construction of ten boreholes was undertaken in 2005. The locations of the boreholes are shown on Drawing 9/2. The following descriptions are based on the results of these investigations and a walkover survey undertaken by a geologist from SLR. Two geological cross section are shown on Drawings 9/4a and 4b.
- 9.17 The lenticular dolerite intrusion extends east to west through the centre of the site with slate outcropping to the north and south. The outcrop of the dolerite is approximately 250m wide at the quarry void but thins to less than 50m wide to the west and is terminated abruptly by a fault trending north to south, approximately 150m west of the quarry void. To the west of this fault are tuffs (see Drawing 9-2).
- 9.18 Weathering is restricted to the near surface or in rock immediately adjacent to joints. However, immediately to the west of the quarry void is a band of weathered rock trending north-west to south-east, with a band in the centre in which the dolerite is almost completely decomposed. This probably marks the position of a fault.
- 9.19 There is no evidence that the dolerite or surrounding slates have been heavily mineralised, but where present it only occurs along joint and shear faces. The boundary between the dolerite and the slates dips steeply southwards at approximately 70° from the horizontal.

¹ British Geological Survey, Sheet 349, Ivybridge (Solid and Drift), 2002.

² Peter Brett Associates, February 2006, *New England Quarry Ground Investigation Interpretative Report*
New England RRC

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- 9.20 Only small scale faulting was observed within the quarry faces, indicated by slickensided joint faces and some small scale displacement. No major faults are recorded within the site or immediate surrounding area on the 1:50,000 geology map. The boundary between the dolerite and the slates was observed on the upper quarry benches on the south side of the quarry void, trending approximately east-west.
- 9.21 Discontinuity measurements indicate that there are three main joint sets dominating the dolerite within the quarry, although their nature and orientation varied across the area. Locally post tectonic shearing and faulting is evident within the quarry faces.
- 9.22 The majority of the surface area to the north and west of the quarry void was observed to be overlain by weakly or non-vegetated fine to coarse granular made ground assumed to be spoil from the quarry process.
- 9.23 A band of alluvium associated with the River Yealm and its tributaries runs along the eastern and northern boundaries of the application site. It also underlies the low lying former process area in the south-east of the application site.

Hydrogeology

Aquifer Characteristics

- 9.24 The Environment Agency Groundwater Vulnerability Map³ shows that the dolerite intrusion and Devonian slates beneath the application site and the surrounding area are classified as a Secondary (formerly Minor) Aquifer. An extract of the published map is presented as Drawing 9/5.
- 9.25 The primary hydraulic conductivity of the slates and the dolerite is very low and groundwater flow is restricted to open fissures and fractures. As a consequence flow rates will vary spatially and tend to decrease with depth.
- 9.26 Secondary Aquifers are described³ as “having significant resources but with hydraulic properties which limit over-exploitation”. These aquifers would not normally warrant special consideration for the Catchment Abstraction Management Strategy (CAMS) but may still support important abstractions and dependent ecosystems which may be subject to risks associated with pollution pressures.

³ Environment Agency, Groundwater Vulnerability Map, Sheet 49, South Devon.
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Recharge Mechanisms

- 9.27 The application site lies within MAFF Agroclimate⁴ Area 43 which indicates that the annual total rainfall varies from 820 to 1,200 mm/year, with the average rainfall of 1,048mm/year. The effective rainfall reported by MAFF (winter excess rain) is 265mm per annum. Data supplied by the Meteorological Office from their MORECS database indicates an annual aerial rainfall total of 1,471mm and an effective rainfall value of 727mm/yr (1961 to 1990) for MORECS square 188.
- 9.28 The Environment Agency has two rainfall gauges; one at Lutton located at an elevation of 160mOD along the Piall River, a tributary of the Yealm, 5.6 km north-west of the quarry. The other is located adjacent the River Yealm at Cornwood 8km north of New England Quarry at an elevation of 100m OD. The location of the rainfall gauges is indicated on Drawing 9-1.
- 9.29 The data at Lutton covers the period November 1974 to March 2009. Annual rainfall during this period ranges from 1063mm in 1975 to 1,748mm in 2000 with an average of 1,410mm per year.
- 9.30 The data at Cornwood covers the period June 1998 to March 2009 and is comparable to that at Lutton. During this period annual rainfall varies from 1,071mm in 1999 and 1,774mm in 2002 with an average of 1,486mm per year.
- 9.31 The rainfall data for Lutton and Cornwood gauging stations is summarised in Table 9-1 below and full data is included in Appendix 9-1.

Table 9-1
Summary of Daily Rainfall Statistics from Environment Agency Rainfall Gauges at Lutton and Cornwood

Gauging Station	Monitoring Period	Annual Rainfall (mm)		
		Annual Min (Year)	Annual Average	Annual Max (Year)
Lutton	1974-2009	1,063 (1975)	1,410	1,748 (2000)
Cornwood	1998 - 2009	1,071 (1999)	1,486	1,773 (2002)

- 9.32 Due to the steep topographic slopes and the relatively low hydraulic conductivity of the underlying strata the majority of the effective rainfall will run-off.

⁴ MAFF, 1976. Climate and Drainage. Technical Bulletin 34. HMSO, London.

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- 9.33 The bare rock and steep slopes of the quarry void will also locally increase runoff and most of the effective rainfall on the application site will drain to the quarry void where it will evaporate, infiltrate into groundwater or over-top the lip of the quarry and runoff to the River Yealm. The former stockpile area to the north of the quarry void slopes to the north-east promoting runoff to a tributary of the River Yealm to the north and east of the application site.
- 9.34 Typically during the winter water overtop the quarry void and flows down the existing access road to the River Yealm, confirming that infiltration to groundwater is restricted.
- 9.35 Discussions have been held with Graham Hicks from Aggregate Industries the former quarry Manager and John Lewis the former Aggregate Industries geologist responsible for New England quarry. They stated that the site closed in December 1994 and took 6 years to fill. Calculations presented in Appendix 9-2 shows that this rate of filling can be accounted for by the effective rainfall falling on the site, indicating that groundwater flow into the site must be limited. In addition they both stated that there was no appreciable groundwater flow into the quarry and that pumping only had to be undertaken following heavy rainfall.

Groundwater Levels and Flows

- 9.36 The Environment Agency does not monitor groundwater levels in the vicinity of the site⁵.
- 9.37 A series of ten groundwater monitoring boreholes were installed by Viridor in 2006 and have been monitored on a quarterly basis. Details of the boreholes are given in Table 9-2 and their location is shown on Drawing 9-2.

Table 9-2
Summary of Groundwater Monitoring Boreholes

Sample Point	Datum Elevation m OD	Elevation of Base m OD	Depth m	Strata Monitored
NE/101	36.27	12.27	24	Slate
NE/102	44.10	14.10	30	Dolerite
NE/103	49.86	18.86	31	Dolerite
NE/104	48.84	18.84	30	Slate
NE/105	61.42	22.42	39	Slate
NE/106	73.05	22.05	50	Dolerite
NE/107	75.33	20.33	55	Slate
NE/108	58.64	18.64	40	Slate
NE/109	75.08	14.08	61	Slate
NE/110	56.97	18.97	30	Dolerite

⁵ Email from Environment Agency, Maggie Summerfield dated 17/04/09.
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- 9.38 The datum levels of the boreholes range from 36.27m OD in the east (NE/101) to 75.33m OD in the west (NE/107). All ten boreholes were drilled to similar elevations between 12.27m OD (NE/101) to 23.05m OD (NE/106) to ensure that they are all screened below the water table and below the base of the quarry void.
- 9.39 Data obtained between November 2006 and September 2009 is summarised in Table 9-3 below. Hydrographs for the data are included in Appendix 9-3. Indicative groundwater contours are shown on Drawing 9-6.

Table 9-3
Summary of Groundwater levels Beneath New England Quarry

Sample Point	Groundwater level (m OD)				Range (m)
	Count	Min	Average	Max	
NE/101	5	33.93	34.12	34.19	0.26
NE/102	5	36.14	36.45	37.09	0.95
NE/103	3	41.2	41.52	41.97	0.77
NE/104	5	39.33	39.68	40.04	0.71
NE/105	9	52.19	53.16	55.01	2.82
NE/106	2	54.73	56.48	58.23	3.50
NE/107	5	64.94	66.43	67.94	3.00
NE/108	5	52.41	52.61	52.94	0.53
NE/109	9	62.37	65.82	68.26	5.89
NE/110	5	47.51	47.62	47.71	0.20

Notes: Erroneous values from blocked borehole on 2903/09 ignored

- 9.40 There is considerable variation in the range of water level in different boreholes, from 0.20m to 5.89m. The extreme range in borehole NE/109 appears to be due to a long term decline in water level over a period of 2 years following the installation of the boreholes. Typically the range of water level fluctuation is less than 1m reflecting the limited groundwater recharge and flow. Boreholes that exhibit larger variations in flow are located close to the northern contact between the dolerite and the slates.
- 9.41 The variation on the range of water levels is probably not a reflection of the different lithologies of the variable nature of the groundwater regime in fractured rocks. There is however a consistent pattern of groundwater levels across the slate and dolerite strata. Groundwater levels are highest in the west, c55 to 65m OD and lowest in the east, c 35-40m OD. Levels along the eastern boundary of the site are similar to those in the River Yealm indicating a flow direction from west to east with groundwater discharge to the river. The hydraulic gradient is steep reflecting the low hydraulic conductivity of the strata. From the centre of the void to the River Yealm water levels fall by 15m over a distance of 150m, a gradient of 1:10.

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- 9.42 The quarry void is below the groundwater table and has flooded up to a level of 49-50m OD, over-topping the lip of the quarry and discharging to the River Yealm during the winter months. The water in the void will be a mixture of groundwater and rainfall from the site and surrounding area. Rainwater forms the majority of the water in the void due to the low rate of groundwater flow in the dolerite.
- 9.43 A series of hydraulic conductivity test were undertaken by Carnon Contracting⁶ in nine of the ten groundwater monitoring boreholes in May to June 2005, the results of which are summarised in Table 9-4 below. A second series of hydraulic conductivity tests were undertaken by SLR in September 2009; results summarised in Table 9-5.
- 9.44 Both tests used the Hvorslev method of analysis for calculating hydraulic conductivity, following the guidance in BS 5930:1999⁷. The Carnon tests used the constant head method and the SLR tests used the variable head method.
- 9.45 The constant head method involves the purging of three times the well volume before stabilising the pumping rate in order to keep the water level at between 0.5m and 1m below the resting water level.

**Table 9-4
Summary of Hydraulic Conductivity Test Results (Constant Head)**

BHID	Main Strata	Hydraulic conductivity (based on December 05 tests)
NE/101	Slate	5.94×10^{-7}
NE/102	Dolerite	1.45×10^{-6}
NE/103	Dolerite	3.05×10^{-6}
NE/104	Slate	1.85×10^{-6}
NE/105	Slate	3.13×10^{-6}
NE/106	Dolerite	2.65×10^{-6}
NE/107	Slate	6.42×10^{-7}
NE/109	Slate	6.30×10^{-8}
NE/110	Dolerite	1.18×10^{-7}

The hydraulic conductivity results demonstrate a low hydraulic conductivity across the site ranging from 6.30×10^{-8} m/sec to 3.13×10^{-6} m/sec. These tests will only give an order of magnitude estimate of the average hydraulic conductivity of the section of aquifer. tested in the boreholes

⁶ Carnon Contracting (2005) *Factual Report on New England Quarry Ground Investigation*

⁷ BSI (1999) *BS5930:1999 Code of Practice for Site Investigations, Section 4: Field Tests*
New England RRC

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- 9.46 The SLR hydraulic conductivity tests were conducted in September 2009 based on a variable head test; this involved lowering the water level in the borehole through pumping until the water level had fallen by at least 1m. The rate of groundwater recovery is then recorded. The hydraulic conductivity is calculated using the general approach, using the following calculations, as per guidance in BS 5930:1999⁸. Details of the analysis are given in Appendix 9-4.

Table 9-5
Summary of Geological Hydraulic Conductivity (Variable Head Test)

BHID	Main Strata	General Approach
NE/101	Slate	5.07x10 ⁻⁸
NE/102	Dolerite	1.40x10 ⁻⁷
NE/104	Dolerite	1.50x10 ⁻⁷
NE/105	Slate	1.09x10 ⁻⁶
NE/107	Slate	9.65x10 ⁻⁸
NE/108	Slate	6.29x10 ⁻⁸
NE/109	Slate	3.71x10 ⁻⁸
NE/110	Dolerite	1.83x10 ⁻⁷

Note: Due to blockages BH's NE/103 and NE/106 could not be tested

- 9.47 The results have yielded comparable results although the constant head method consistently gives higher values. A summary of the all the results is given below:

- Minimum hydraulic conductivity 3.7E-08ms⁻¹
- Maximum hydraulic conductivity 3.1E-06ms⁻¹
- Mean hydraulic conductivity 7.8E-07ms⁻¹

- 9.48 The nature of the aquifer, the steep hydraulic gradient and the low hydraulic conductivity rates indicates that groundwater flow in the aquifer is limited. As previously described, a review of files held by Aggregate Industries and discussions with Graham Hicks, the manager of the quarry site from 1988 until its closure in December 1994 and John Lewis, the former geologist responsible for the quarry, indicates that groundwater flow into the quarry was not an issue. Mr Hicks stated that the quarry did not make groundwater and that the sump at the base of the quarry only had to be pumped out after rainfall.

⁸ BSI (1999) *BS5930:1999 Code of Practice for Site Investigations, Section 4: Field Tests*
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- 9.49 The hydraulic conductivity results summarised above represent the average hydraulic conductivity over the saturated thickness of the borehole tested (up to 54m thick). In fractured aquifers the hydraulic conductivity decreases with depth as the number and openness of the fractures decreases. Flow to the River Yealm will be concentrated within the zone of groundwater fluctuation and within the blast fracture zone adjacent to the quarry base and walls. Flow at depth is likely to be negligible.
- 9.50 An estimate of the flow rate from the dolerite intrusion to the River Yealm has been made and is presented in Appendix 9-6. A summary of the results is given below:
- Minimum hydraulic conductivity 0.00002 cumecs
 - Maximum hydraulic conductivity 0.001 cumecs
 - Mean hydraulic conductivity 0.0004 cumecs
- 9.51 A comparison of the estimated groundwater flow rate to the Q₉₅ flow in the River Yealm is given in Table 9-6.

**Table 9-6
Comparison of Groundwater Flow with Flow in River Yealm**

Flow Statistic*	River Flow (cumecs)	Mean Groundwater Flow (cumecs)	Groundwater Flow as percentage of River Flow
Q ₉₅	0.156	0.0004	0.3%
Mean flow	1.29	0.0004	0.003%
Maximum flow	18.3	0.0004	0.002%

Notes: * See table 9-9

- 9.52 The comparison shows that groundwater flow does not provide a significant or important contribution to flows in the River Yealm, even at low river flows.

Groundwater Quality

- 9.53 Groundwater quality has been monitored in the ten on-site boreholes on a quarterly basis since March 2007. Full results tables and selected chemographs are included within Appendix 9-6.
- 9.54 Groundwater quality is typical of a clean groundwater system. All determinand concentrations are below their respective EQS or drinking water standards. The results are summarised below:
- Conductivity values range between 200µs/cm and 770µs/cm. Groundwater from the dolerite is characterised by relatively low values and the slate by higher.
 - Analysis of major ionic species indicates that the groundwater is calcium dominant, calcium concentrations ranging from 37.5mg/l to 110mg/l. The concentrations are higher in the groundwater from the slates.
 - pH levels range from 7.2 to 8.3, indicating the groundwater to be slightly alkaline in nature.

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- Ammoniacal Nitrogen concentrations have been recorded as high as 1.14mg/l in borehole NE/101, although concentrations are routinely below the Drinking Water Standard (DWS) of 0.39mg/l within all other boreholes..
- 9.55 The Environment Agency Water Framework Directive map of the region shows that the aquifer as a whole is “at risk” of failing to meet the standards as set out in the European Water Framework Directive by 2015⁹. The quantitative assessment, i.e. the impact from abstractions and discharge to groundwater, is classified as “good” and not at risk of failing to meet the standards however the chemical standard is “poor” and at risk of not meeting the standards. The principal reason for regionally poor water quality is diffuse discharges from agriculture.

Groundwater Abstractions

- 9.56 The Environment Agency has confirmed that the proposed development area does not fall within a Source Protection Zone¹⁰.
- 9.57 There are four licensed groundwater abstractions and two private groundwater abstractions within 3km of the site as confirmed by the Environment Agency and South Hams District council: these are detailed in Appendix 9-7 and their locations are shown on Drawing 9-1.

Hydrology

Local Hydrology

- 9.58 New England quarry is located within the surface water catchment of the River Yealm and its tributaries, which includes an unnamed stream running along the northern site boundary and several further streams which flow through the woodland to the east of the Yealm. The surface water catchment of the Yealm down to Yealmpton Bridge is shown on Drawing 9-1.
- 9.59 The River Yealm runs along the eastern boundary of the site and flows in a southerly direction. The river originates on Dartmoor at an elevation 430m OD and falls nearly 400m in just 10km, passing the application site at an elevation of between 37.5m OD and 35m OD. The river continues to flow to the south through the town of Yealmpton before entering the estuary. The normal tidal limit (NTL) is approximately 1km down stream of Yealmpton. Down stream of the NTL the estuary is designated as the Yealm Estuary Site of Special Scientific interest (SSSI) and part of the Plymouth Sounds and Estuary Special Area of Conservation (SAC). These conservation sites are 5km down stream of the application site.
- 9.60 The main part of the application site is outside of the flood plain of the River Yealm except for;

⁹ Environment Agency Website (2009) What's in your backyard: Water Framework Directive – River basin management Plans – Groundwater, <http://maps.environment-agency.gov.uk/> Accessed on 04/08/09
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- a low lying area adjacent to the current quarry site entrance in the south-east of the site; and
 - a strip of land along the northern boundary.
- 9.61 Parts of the proposed access to the north of the site are also within the flood plain of the River Yealm. A map of the published flood plain of the River Yealm is shown on Drawing 9-7. Further details of the flood plain can be found in Section 9.67 and Appendix 9-8.
- 9.62 There are no surface water courses on the application site, except for some drains in the north-west that drain a low lying field. Rainfall on the void itself and on an area to the west will drain to and collect in the void. This is an area of 85,000m² and annually will receive between 20,000 and 60,000m³ of effective rainfall. Due to the low hydraulic conductivity of the dolerite, water over-tops the lip of the quarry, runs down the former haul road and discharges eventually to the River Yealm. Rainfall on the northern part of the application site, the former stocking yard, runs off in a north-east to easterly direction to the River Yealm.
- 9.63 Site runoff has been calculated using the Institute of Hydrology Report 124 (IoH124) method using the following parameters:
- Catchment Area: 8.95Ha (measured using AutoCad from the site survey);
 - Average Annual Rainfall (SAAR): 1225mm/year (from Flood Estimation Handbook CD-ROM);
 - Soil: 0.3;
 - Total Impermeable Areas: 0%; and
 - FSR Region No.: 8a.

Table 9-7
Calculated Pre-Development Site Runoff

Annual Probability (Return Period, years)	Pre-development site runoff (l/s)
50% (2)	30.3
3.3% (30)	73.6
1% (100)	100.7
1% + Climate Change	131.0

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Surface Water Flows

- 9.64 Surface Water flow data has been provided by the Environment Agency for the River Yealm at Puslinch, approximately 4km downstream of the application site and at Cornwood, on the Yealm approximately 5km north of the application site. The data is summarised in Table 9-8 below and the full data and river hydrographs are included in Appendix 9-8.

Table 9-8
Summary of Surface Water Flow within the Yealm at Puslinch and Cornwood

Map Ref. (Drawing 9/1)	Gauging Station	River Flow Rate (m ³ /sec)			
		Monitoring Period	Q ₉₅	Mean	Maximum
F1	Puslinch	1966 - 2009	0.206 ^{*1}	1.70	24.2
F2	Cornwood	1998 - 2009	NA	0.68	16.1
	Popples Bridge	NA	0.147	1.21	17.2

Notes: ^{*1} From CEH National River Flow Archive
^{*2} Estimated from ratio of catchments from FEH-CDROM

- 9.65 Flows in the River Yealm at Puslinch typically range from 0.2m³/sec to a maximum of 10-20m³/sec. The Q₉₅ value for the gauging station is 0.206m³/sec. An estimate of the flows at Popples Bridge has been made using the ratio of the catchment area to each location. (56.9km² to Puslinch and 40.5km² to Popples Bridge). The results are given in Table 9-8. This provides an indication of the likely flows at Popples Bridge but does not take into account variations in the catchment characteristics or the inflow of tributaries.
- 9.66 The hydrographs are typical of 'flashy' stream response as expected from a low aquifer hydraulic conductivity and steep catchment. Hydrographs and rainfall data given in Appendix 9-9 demonstrate the rapid response of flows to rainfall events. Calculation of groundwater flow rates indicate that groundwater from the strata beneath New England only contribute a small proportion of flow in the stream, much less than 1% of the Q₉₅ flow at Puslinch gauging station (see Table 9-8).

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Surface Water Quality

- 9.67 The Environment Agency monitors the quality of the River Yealm at several locations. Surface water quality data has been provided for the following three locations within 3km of the site;
- Popples Bridge immediately down gradient from the application site;
 - Yealm Bridge 3km south and down stream of the application site; and
 - Fardell Mill Bridge 3km up-stream of the application site.
- 9.68 The results are summarised in Table 9-9 below and chemographs are included in Appendix 9-10.

Table 9-9
Surface Water Quality in the River Yealm at Popples Bridge (1990 -2009)

Determinand	Count	River Yealm Quality			EQS / DWS
		Min	Mean	Max	
pH	741	5.6	7.48	8.3	
Conductivity (µS/cm)	202	47	132.2	284	
BOD (mg/l)	640	<1	1.18	10.9	
Ammoniacal Nitrogen (mg/l as N)	775	<0.01	0.025	0.25	0.39
T.O.N (mg/l)	459	<0.2	1.59	4.6	
Nitrate (mg/l)	755	0.19	1.67	4.58	50
Nitrite (mg/l)	756	<0.004	0.0076	0.1	0.1
Suspended Solids (mg/l)	475	<0.4	10.05	333	
Alkalinity (mg/l)	446	<10	30.54	116	
Chloride (mg/l)	184	8	16.67	35	250
Ortho Phosphate (mg/l)	756	<0.01	0.033	0.28	2.2
Sulphate (mg/l)	184	<5	8.78	15	400
Sodium (mg/l)	125	5	10.2	21.1	170
Potassium (mg/l)	296	<0.2	1.86	4.36	
Magnesium (mg/l)	415	0.79	3.12	25	50
Calcium (mg/l)	415	<1	12.56	49.7	250
Chromium (µg/l)	92	<1	0.77	3	5 – 250
Arsenic (µg/l)	64	<10	5.2	20	50
Manganese (µg/l)	92	2	19.64	187	50
Iron (µg/l)	74	<50	272.8	3520	1000
Copper (µg/l)	386	<1	1.83	12	1 - 28
Zinc (µg/l)	466	<1	6.81	57.2	8 - 500
Nickel (µg/l)	94	<1	1.06	7	50 - 200
Dissolved Oxygen (mg/l)	642	7.3	10.58	14.9	

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- 9.69 The surface water quality data shows that the quality of the River Yealm is good and has remained so throughout the last 19 years with no sign of degradation. There are occasional exceedences of the EQS or drinking water standard for iron, manganese and some heavy metals. These probably relate to high suspended solids when the river is in flood.
- 9.70 The biological and chemical standard of the river is generally good. The quality of the river between Popples Bridge and Yealm Bridge classed as A by the Environment Agency¹⁰. The results are summarised below.
- biological oxygen demand (BOD) has exceeded the typical range for a clean river (1-5mg/l) on several occasions in the past with a peak of 10.9mg/l in June 1992. These exceedences are however infrequent and values typically range between 1mg/l and 2mg/l;
 - dissolved oxygen levels remain consistently high at all locations with values typically ranging between 10mg/l and 12mg/l (90% - 100%). There is noticeable seasonal variation with higher concentrations recorded in the summer and lower in winter, as is typical of a clean river;
 - ammoniacal nitrogen concentrations do not exceed the DWS. A seasonal trend is noticeable with peak concentrations generally occurring between September and November, probably related to agricultural activity ;
 - total oxidised nitrogen (TON), including nitrate and nitrite levels are generally low with a peak of 4.6mg/l. A seasonal variation is noticeable with higher concentrations in the winter months, this is likely to be related to local agricultural activity; and
 - concentrations of major ions such as sodium, potassium, magnesium and calcium and major anions such as chloride and sulphate are all low and well below their respective Environmental Quality Standards (EQS);
- 9.71 A sample of the water in the Quarry Void was collected on 27th October 2009 and analysed for a range of determinands. The laboratory certificate is included within Appendix 9-10. None of the determinands exceed the freshwater EQS or drinking water standards and the water has a relatively low concentration of dissolved constituents such as alkalinity and chloride, indicative of rainwater.
- 9.72 The River Basin Management Plan for the South-West, which helps deliver the European Water Framework Directive, was published in December 2009. A summary of the quality of the River Yealm from the plan is given below:
- | | |
|-----------------------------------|----------|
| • Current ecological quality | Moderate |
| • Current chemical quality | Pass |
| • 2015 ecological quality | Moderate |
| • 2015 predicted chemical quality | Pass |
| • Overall risk | At risk |

¹⁰ Environment Agency Website, <http://maps.environment-agency.gov.uk/wiyby/wiybyController?latest=true&topic=riverquality&ep=query&lang=e&x=258960.3541666666&y=51957.770833333336&scale=4&layerGroups=2&queryWindowWidth=25&queryWindowHeight=25>, Accessed on: 22/04/09

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- 9.73 The plan indicates that the chemical quality of the Yealm is good, the ecological quality is moderate and that the water body is at risk of not achieving good ecological status by 2015.

Water Features Survey

- 9.74 A water features survey (WFS) was undertaken by SLR Consulting in September 2009, as requested by the Environment Agency in their scoping opinion dated 9th February 2009 (ref. DC/2009/104684/01-L01).
- 9.75 The WFS involved the identification of all groundwater and surface water features within 3Km of the application site. The sources of information include:
- licensed groundwater and surface water abstractions provided by the Environment Agency¹¹;
 - licensed groundwater and surface water discharges provided by the Environment Agency;
 - private groundwater and surface water abstraction provided by South Hams District Council¹²;
 - q site / area walkover undertaken by SLR on 29th September 2009; and
 - letter and questionnaire for local residents
- 9.76 Results from the WFS indicate the presence of six groundwater abstractions, eight surface water abstractions and ten surface water discharges. These are summarised in Appendix 9-7 and their locations are indicated on drawing 9-1.
- 9.77 Groundwater and surface water abstractions are both used primarily for agricultural or horticultural purposes and in relatively small quantities. Details on private surface water supplies indicate four farms which use surface water for domestic supply, however information obtained during the WFS suggests that all residential housing has mains supply and it is therefore unlikely that these are being used as potable water supplies.
- 9.78 The Environment Agency has confirmed the presence of ten licensed discharges to the river Yealm and its tributaries. These are summarised in Appendix 9-7. These include a South West Water sewage treatment and storm water overflow discharge from Lee Mill Sewage treatment Works, located 1km up-stream of the site.

¹¹ Email from Environment Agency, Maggie Summerfield dated 17/04/09.

¹² Email from Pete Smith, Environmental Health officer, South Hams District Council, Dated: 22/04/09

Land Quality

- 9.79 A preliminary land quality report has been undertaken involving a walkover survey and review of published information on the history and setting of the site.¹³ It is concluded in the report that there is no evidence of significant land contamination at the site. The site has been used historically as landfill but this was for quarry waste from the nearby Moorcroft Quarry. There are also other areas of made ground but these are derived from quarry waste from the application site.

¹³ SLR Proposed Energy from Waste Facility New England Quarry. Preliminary Land Quality Risk Assessment. Ref. 402.0036.00350. October 2009
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ASSESSMENT OF POTENTIAL IMPACTS

Methodology

9.80 A detailed description of the proposed development and operations is provided in Section 3. For the purposes of this section, a review of the development proposals which may impact the baseline hydrology and hydrogeology of the site is provided below:

- change of site use from quarry to landfill;
- construction of an EfW plant and associated infrastructure, bottom ash recycling facility, offices and hardstanding areas; and
- construction of a new access road.

9.81 This section identifies the potential impacts of the proposed development on the hydrogeological and hydrological environments. It also assesses the likelihood of occurrence of each identified impact. Impacts are considered separately for the construction and operational phases of the development.

9.82 A qualitative risk assessment methodology has been applied, in which the significance of an impact is determined based on both the probability that an impact will occur and the magnitude of the impact, if it were to occur. This approach provides a mechanism for identifying mitigation measures appropriate to the risk presented by the development. It allows effort to be focused on reducing risk where the greatest benefit may result. The assessment of significance is outlined in Table 9-10.

Table 9-10
Matrix used to Identify the Significance of an Impact

Probability of Occurrence	Magnitude of Potential Impacts			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near zero
Low	Medium	Low	Low	Near zero
Negligible	Low	Near zero	Near zero	Near zero

9.83 The generic classification describing the magnitude of the potential impacts in terms of hydrogeology and hydrology is provided in Table 9-11.

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Table 9-11
Magnitude of Potential Hydrogeological and Hydrological Impacts

Magnitude	Potential Impact
Negligible	No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; No alteration to groundwater recharge or flow mechanisms; and No pollution or change in water chemistry to either groundwater or surface water.
Mild	Minor or slight changes to the watercourse, hydrology or hydrodynamics; Changes to site resulting in slight increase in runoff well within the drainage system capacity; Minor alteration to groundwater recharge or flow mechanisms; Minor changes to erosion and sedimentation patterns; and Minor changes to the water chemistry.
Moderate	Some fundamental changes to watercourses, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff within system capacity; Moderate alteration to groundwater recharge or flow mechanisms; Moderate changes to erosion and sedimentation patterns; and Moderate changes to the water chemistry of surface runoff and groundwater.
Severe	Wholesale changes to watercourse channel, route, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff with flood potential and also significant changes to erosion and sedimentation patterns; and Major alteration to groundwater recharge or flow mechanisms; Major changes to the water chemistry or hydro-ecology.

9.84 Mitigation is considered necessary where potential impacts are assessed as 'medium' or higher.

Construction Impacts

- 9.85 A summary of the unmitigated impacts of the proposed development during construction is given in Table 9-12 and a description of the impacts is given below.

Pollution of Controlled Waters from use of Hazardous Substances

- 9.86 The construction of the EfW and landfill will involve the use of materials that if not managed properly, could derogate the quality of groundwaters the site and the River Yealm and its tributaries. Due to the low hydraulic conductivity of the aquifer beneath the site, the poor connection between the site and the river and the lack of use of the aquifer for water supply, the significance of the contamination of groundwater is low, however, due to the proximity of the site to the River Yealm the significance of an impact on surface water quality is considered 'high' and this has been used in the significance rating.

Pollution of Surface Waters due to Earthworks

- 9.87 The development of the site will involve significant earthworks. Cuts will have to be made to provide a level platform for the EfW at 60mOD, material from the cuts will be placed within the quarry void to provide a suitable landform for the installation of a landfill liner system. Cut material will also be placed to form landscaping of the site and in the preparation of the access road. A preliminary land quality assessment¹³ indicates that there are unlikely to be contaminated soils at the site. However, unless managed carefully surface water runoff from the areas subject to earthworks could transport sediment to the River Yealm or its tributaries. Due to the significant earthworks at the site, the proximity of the site to the River Yealm and the sensitivity of the River Yealm, the potential significance of any impact is rated as 'high'.

Effect on Surface Water and Groundwater Resources due to Dewatering

- 9.88 The Quarry void and the waste bunker are below the water table and will need to be dewatered during construction. Based on a volume of water in the quarry void of approximately 150,000 m³ and a pumping rate of 50 litres per second, it will take approximately 35 days to empty the void. The following considers the potential for this operation to have an adverse effect on surface and groundwater.
- 9.89 The base of the quarry void is below the groundwater table. Data from the testing of boreholes on site and operational experience of the quarry indicates that groundwater only occurs sporadically in fissures and fractures and flow rates are low. Calculations using the Darcy equation indicate that flow from the entire dolerite dyke to the River Yealm is less than 2 litres per second (see Appendix 9-5) and radial flow analysis (Appendix 9-11) indicates that the rate of groundwater seepage to the quarry void will be of the order of only 0.3 litres per second.

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- 9.90 Dewatering of such low volumes of groundwater will not have a significant effect on groundwater resources or on flows in the Yealm (see flow statistics in paragraph 9.95). The probability and magnitude of an impact are therefore rated as '**low** and **negligible**' respectively and no mitigation is considered necessary. Notwithstanding this, dewatering water will be discharged to the River Yealm mitigating any potential impact on flows in the river.
- 9.91 Although the volume of dewatering discharge will be low it will locally reduce groundwater levels in the area. The significance of this is that it could affect water levels beneath the water dependant New England Fields County Wildlife Site (CWS), 250m to north-west of the centre of the quarry void. An estimate of the likely drawdown at the CWS is presented in Appendix 9-11 the results indicate that a significant effect is unlikely; and it is relevant that the CWS was identified during the dewatering operations previously undertaken during the operation of the quarry. The assessment is a reasonable worst case as it assumes no recharge for 200 days and ignores the recharge boundary effect of the River Yealm: both will reduce the extent of the cone of influence.

Effect on the Quality of River Yealm due to Discharge of Quarry Void Water

- 9.92 The current quarry contains water up to an elevation of approximately 50m OD. It is estimated that there is 150,000m³ of water within the void. The void will be dewatered to allow the base of the quarry to be engineered as a lined landfill. The water from the void will be discharge to the River Yealm and if not managed properly could derogate the quality of the river. An analysis of the water in the void (Appendix 9-10) indicates that the water is uncontaminated. However, this is a surface water sample and may not be indicative of the quality of the full water column; for example, deeper waters may have a low dissolved oxygen content. The probability of an impact is rated a '**low to medium**' and the consequence as '**severe**' due to the sensitive nature of the River Yealm. Mitigation is therefore required.

Increased Risk of Flooding Due to the Dewatering of Quarry Void

- 9.93 The quarry void contains 150,000m³ of water. If it is assumed that the site will be dewatered at a rate of 50 litres per second over a period of approximately 35 days. A summary of the flow in the River Yealm at Puslinch gauging station is given below:
- Mean flow 1,670 litres per second
 - Q₉₅ 206 litres per second
 - Q₁₀ 3,856 litres per second
- 9.94 The discharge is a very small proportion (3% of mean flow) of the capacity of the River Yealm. The significance of the potential impact is rated as '**medium**' and therefore mitigation is still required to ensure that the discharge stops when the river is in or near flood conditions.

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Summary of Unmitigated Potential Impacts

The unmitigated potential impacts are summarised in Table 9-12 below

Table 9-12
Summary of Unmitigated Construction Phase Impacts

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Pollution of controlled waters from use of hazardous substances during construction (concrete, fuels, oil etc)	Regional/local short term	Medium	Severe	High	Yes
Pollution of surface waters due to earthworks (including disturbance of contaminated soils)	Regional/local short term	Medium	Severe	High	Yes
Derogation of surface water and groundwater resources as a result of dewatering of quarry void and other deep excavations	Local short term	Low	Negligible	Near zero	No
Derogation of the quality of controlled waters due to discharge of quarry void water	Regional/local short term	Low	Severe	Medium	Yes
Increased risk of flooding due to discharge of quarry void water	Regional/local short term	Medium	Moderate	Medium	Yes

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Operational Impacts

- 9.95 A summary of the operational impacts are given in Table 9-13 and a description of the impacts is given below.

Water Abstraction and Discharges

- 9.96 The development will obtain its water supply from a connection to the South West Water municipal supply. There will be no discharges direct of process waters from the EfW or of leachate from the landfill to the environment. The EfW is operated on a closed loop system and there will be no process water discharges. Leachate from the landfill will be discharged either to foul sewer or tankered off-site. Sewage effluent from the offices will be discharged to foul sewer.

Pollution of Controlled Waters from Use of Hazardous Substances

- 9.97 The operation of the EfW will involve the handling of hazardous materials which if released to the environment could derogate the quality of groundwater or surface water.
- 9.98 As has been discussed earlier there is relatively low flux of groundwater beneath the site and the infiltration rates are low. The probability that a release of a hazardous substance impacting groundwater quality is rated as '**low**'. However, due to the proximity and sensitivity of the River Yealm the significance of an impact is rated as '**high**', requiring mitigation measures.

Contamination from Vehicle Movements and from Parked Vehicles

- 9.99 During the operational phase of the site there will be significant vehicle movements and hardstanding for the parking of cars and lorries. There is a risk that petrol or diesel from these vehicles could contaminate controlled waters. The significance of this impact is rated as '**medium**'.

Loss of Recharge to Controlled Waters

- 9.100 The development will involve the construction of significant areas of hardstanding. This will intercept rainfall that may have infiltrated into the ground and percolated to groundwater which would eventually discharge to the River Yealm. This would have an impact on groundwater and surface water resources. However, as discussed previously there is relatively low flux of groundwater beneath the site and the infiltration rates are low. Only a small proportion of rainwater percolates to groundwater and groundwater does not provide an important contribution to other water dependant ecosystems. The construction of impermeable surfaces is unlikely to significantly affect groundwater or surface water resources. The probability and magnitude of impact are therefore rated as '**low**'. Notwithstanding this, the rainwater falling on the hardstanding areas will be discharged to the River Yealm mitigating any potential impact.

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Pollution of Controlled Waters due a Sudden Release from Liner Failure or Gradual Seepage through Liner

- 9.101 The following waste streams will be deposited in the landfill; incinerator bottom ash that cannot be recycled, out of specification items that cannot be incinerated and non-hazardous wastes during scheduled maintenance of the EfW or any unforeseen shut down. Rainwater infiltrating into these wastes will form a leachate which if allowed to migrate from the landfill could impact the quality of surface waters and groundwaters beneath the site in the event that a release occurs. This could occur suddenly due to a failure of the liner system or gradually due to the seepage of leachate through the liner. Full consideration of this issue is contained within the Hydrogeological Risk Assessment within the Environmental Permit, but given the relatively low flux of groundwater and the low infiltration rate, the impact on regional groundwater is likely to be low. However, given the location of the site adjacent to the River Yealm the probability and magnitude of any release is rated as '**medium**' and '**severe**' respectively. Mitigation measures are therefore required.

Creation of Barriers to Groundwater Flow

- 9.102 The lining of the quarry void and the construction of a concrete waste bunker, both below the regional groundwater table, could create barriers to groundwater movement, adversely affecting groundwater flow and indirectly surface water flows. This assessment has shown that groundwater flux is very low and does not provide an important contribution to surface water flows in the River Yealm. The significance of an impact is therefore rated as '**low**' and no mitigation is required.

Generation of Leachate from Temporary Storage of Waste and from Bottom Ash Recycling Facility

- 9.103 The waste received by the site and the bottom ash from the EfW have the potential to generate leachate that could affect the quality of controlled waters if the waste and leachate are not managed correctly. The probability is rated as '**high**' and the magnitude of impact as '**moderate**'. Mitigation is therefore required.

Increased Flood Risk due to Change in Surface Water Runoff Regime and Construction in the Flood Plain

- 9.104 The construction of hardstanding, access roads, impermeable roof surfaces and surface water drains at the site will rapidly convey rainwater to the river and could cause or exacerbate flooding on the River Yealm and its tributaries. Due to the relatively low infiltration capacity of the exiting site the probability is rated as '**medium**' but the magnitude of flooding on the Yealm as '**severe**'. Mitigation is therefore required.

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- 9.105 A flood risk assessment and fluvial modelling has been undertaken to confirm the extent of the flood plain (details are provide in Appendix 9-8). The majority of the development is not in the flood plain but two parts of the access road are within the flood plain. Without mitigation this could result in an increase in flooding and the significance of this impact is rated as potentially '**severe**'.

Contamination of Controlled Waters with Fire Fighting Water

- 9.106 In the event of a large fire there is risk that fire fighting water may escape uncontrollably to the River Yealm. The significance of this occurring is rated as '**high**' and mitigation is required. Given that the EfW is mainly on hardstanding and the relatively low permeability the aquifer the probability and magnitude of the impact of fire fighting water on the aquifer is considered low and negligible respectively.

Heave of Landfill Lining System caused by High Groundwater Levels

- 9.107 Groundwater levels are above the base of the quarry. Unless these heads are controlled the up-ward pressure could rupture the liner and cause it to fail. This would cause groundwater to enter the waste forming leachate. Leachate heads would rise and eventually leachate could migrate out of the site. Although the likelihood of this is low, the significance of this occurring is rated as '**high**' and mitigation is required.

Derogation of Licensed and Private Water Supplies

- 9.108 The nearest groundwater supply to the application site is 1km to the north-east of the site, on the eastern side of the River Yealm. Due to their location no impacts are predicted on groundwater supplies. The nearest surface water abstraction is located adjacent to the application site and is licensed to Viridor Waste Management. It is not proposed to use this licence to supply water to the site. The next nearest abstractions on the River Yealm are 1km and 2km down stream of the site. Mitigation proposed to protect groundwater and surface water resources as a whole (during both construction and operation) would ensure that these abstractions are protected and no specific mitigation measures are considered necessary.

Summary of Unmitigated Potential Impacts

The unmitigated potential impacts are summarised in Table 9-13 below

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**Table 9-13
Summary of Unmitigated Operational Phase Impacts**

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Water abstraction and discharges	Regional/local long term	Negligible	Negligible	Near zero	No
Pollution of controlled waters from use of hazardous substances (fuels, oil etc)	Regional/local short term	Medium	Severe	High	Yes
Contamination from vehicle movements and from parked vehicles	Regional/local long term	Medium	Moderate	Medium	Yes
Loss of recharge to controlled waters	Regional/local long term	Low	Negligible	Low	No
Pollution of controlled waters due sudden release from liner failure or gradual seepage through liner.	Regional/local long term	Medium	Severe	High	Yes
Creation of barriers to groundwater flow	Regional/local long term	Low	Negligible	Low	No
Generation of leachate from temporary storage of waste and from bottom ash recycling facility	Regional/local long term	High	Moderate	High	Yes
Increased flood risk due to change in surface water runoff regime and construction in the flood plain	Regional/local long term	Medium	Severe	High	Yes
Contamination of controlled waters with fire fighting water	Regional/local long term	Medium	Severe	High	Yes
Heave of landfill liner caused by high groundwater levels	Local short term	Medium	Severe	High	Yes
Derogation of licensed and private water supplies	Regional/local long term	Low	Negligible	Low	No

PROPOSED MITIGATION

9.109 Mitigation measures to address the potential impacts detailed above 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. A number of operational mitigation measures and best available techniques have been incorporated into the scheme design, which will reduce the potential risk to ground and surface water.

Construction Mitigation Measures

9.110 The residual construction impacts after mitigation are summarised in Table 9-14 and described below.

Pollution of Controlled Waters from use of Hazardous Substances

9.111 The relevant Pollution Prevention Guidelines listed in Section 9-12 will be adhered to, to ensure construction works are undertaken in an environmentally responsible manner. Any environmentally hazardous material used during the operational phase of the site will be kept in dedicated stores and storage tanks will have appropriate secondary bunding.

Pollution of Surface Waters due to Earthworks

9.112 Earthworks will be undertaken according to the guideline given in PPG6: Working at Construction and Demolition Sites.

9.113 A construction management plan will be prepared which will include the following measures as required to prevent pollution from earthworks;

- erosion control measures – these aim to prevent runoff from flowing across exposed ground and becoming polluted with sediments;
- sediment control measures – these aim to slow runoff and allow for settlement of sediment as close to the source as possible; and
- site measures – these aim to provide end of pipe treatment for polluted water, for example reed beds or settlement ponds.

9.114 Attenuation ponds will be constructed in the north-western and southern parts of the application site to control surface water runoff from the operational development. These ponds will be constructed at an early stage in the construction programme and will be used as a containment and settlement pond for runoff from the construction of the landfill and EfW. Other temporary ponds will be constructed as necessary to allow the settlement of sediment.

Derogation of the Quality of River Yealm due to Discharge of Quarry Void Water

- 9.115 A water sampling programme will be undertaken prior to the dewatering of the quarry void to confirm that the water is uncontaminated and suitable for discharge to the River Yealm. This will include the collection of samples from the full depth of the water column. Treatment will be provided if the quality is found to be unacceptable for discharge. The most likely problem could be low dissolved oxygen content at depth. If this is the case the water will be aerated prior to its discharge to the River Yealm.

Increased Risk of Flooding Due to the Dewatering of Quarry Void

- 9.116 Dewatering will be undertaken when flows in the River Yealm are low. The construction management plan for the site will include a system for monitoring the flows in the River and/ or using the Environment Agency flood warning system to ensure the discharge is reduced or stopped when flows in the river are high and there is a risk of flooding.

Table 9-14
Summary of Construction Phase Mitigation and Residual Effects

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Proposed Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Significance of Impact
Pollution of controlled waters from use of hazardous substances	Regional/ local short term	Medium	Severe	High	Construction management plan, bunding, spill response kits etc.	Negligible	Severe	Low
Pollution of surface waters due to earthworks	Regional/ local short term	Medium	Severe	High	Construction management plan, erosion control, settlement ponds etc.	Negligible	Severe	Low
Derogation of the quality of controlled waters due to discharge of quarry void water	Regional/ local short term	Low	Severe	Medium	Programme of water quality analysis and treatment of water as required	Negligible	Mild	Near zero
Increased risk of flooding due to the dewatering of quarry void and other excavations	Regional/ local short term	Medium	Moderate	Medium	Monitoring of flows in Yealm and/or link to Environment Agency Flood Warning scheme	Negligible	Moderate	Near zero

Operational Mitigation Measures

Pollution of Controlled Waters from use of Hazardous Substances

- 9.117 The operation of the plant will involve the use of various materials which if not managed properly could impact controlled waters. The site will follow good practice and all potentially hazardous substances will be stored in chemical stores and tanks will be bunded. In addition, spill response kits will be available. Potential impacts will also be mitigated by the use of attenuation lagoons for surface water runoff which will temporarily retain any spillage allowing clean-up to be undertaken.

Contamination from Vehicle Movements and from Parked Vehicles

- 9.118 A traffic management system will be put in place with strict speed limits to reduce the risk of collision. Runoff from external kerbed hardstanding will be passed through a hydrocarbon and silt interceptor prior to discharge via the SuDS system.

Pollution of Controlled Waters due to Gradual Seepage through Liner or Sudden release from Liner Failure

- 9.119 The landfill will be lined with a robust composite lining system. The design of the system will be based on the results of a Hydrogeological Risk Assessment (HRA) undertaken in support of the Environmental Permit application for the site. The HRA will confirm that the lining systems will minimise leachate seepage so that controlled waters will be protected from pollution. In addition, after the first cell has been completed groundwater levels outside of the site will be allowed to recover so that the landfill will be hydraulically contained, further reducing the potential leachate migration to controlled waters.

Generation of Leachate from Temporary Storage of Waste and Bottom Ash

- 9.120 Waste, prior to its incineration will be stored in a sealed and covered concrete bunker. The bunker for bottom ash will be uncovered to promote its weathering prior to being recycle. Any water from these bunkers will be collected and directed to the site's 'industrial waste water pit' and then disposed of to foul sewer under a trade effluent consent.

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Increased Flood Risk due to Change in Surface Water Runoff Regime and Construction in the Flood Plain

- 9.121 Surface water will be managed by the use of sustainable drainage techniques. The current rate of runoff from the site, and the increased rate from the developed site, have been estimated. A collection, conveyance and storage system has been designed to ensure that the rate of runoff from the site is not increased by the development, thereby ensuring surface water runoff does not cause or exacerbate flooding from the River Yealm. Details of the flood risk assessment and the proposed mitigation measures are given in Appendix 9-8.
- 9.122 Two attenuation ponds will be constructed to attenuate surface water flows from the EfW and the landfill. These have been sized to control run-off from the worst case when the landfill is fully restored. Two further ponds will be constructed adjacent to the access road to attenuate runoff from the road.
- 9.123 The majority of the development is not in the flood plain but two parts of the access road are within the flood plain. Measures are proposed at these locations to mitigate any impact on flooding. In the north the land will be re-graded to maintain conveyance and adjacent to Strashleigh Landfill the road will be on a bridge spanning the flood plain and the area will also be re-graded to maintain conveyance. Details of these impacts and the proposed mitigation are given in the flood risk assessment in Appendix 9-8.

Contamination of Controlled Waters with Fire Fighting Water

- 9.124 The surface water drainage system and the falls on the site have been designed so that fire fighting water from the EfW will drain via the drainage system to the attenuation ponds in the north-west of the site. The attenuation ponds have been sized and will be lined to retain water from fire fighting. The ponds will also be fitted with outlet controls so that the fire fighting water can be held on site and disposed of appropriately.

Heave of Landfill Liner Caused by High Groundwater Levels

- 9.125 Groundwater levels will be controlled by the installation of a drainage blanket which will maintain groundwater levels beneath the base of the landfill until sufficient waste has been deposited to ensure the stability of the liner.

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**Table 9-15
Summary of Operational Phase Mitigation and Residual Effects**

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Proposed Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Significance of Impact
Pollution of controlled waters from use of hazardous substances (fuels, oil etc)	Regional/ local short term	Medium	Severe	High	Good site practice, bunding, spill response kits, SuDS etc.	Low	Mild	Low
Contamination from vehicle movements and from parked vehicles	Regional/ local long term	Medium	Moderate	Medium	Hydrocarbon and silt separator, use of water attenuation lagoon	Low	Mild	Low
Pollution of controlled waters due gradual leachate seepage or sudden release from liner failure	Regional/ local long term	Medium	Severe	High	Composite landfill liner to minimise seepage, hydraulic containment and under site drainage blanket to collect any sudden release	Low	Mild	Low
Generation of leachate from temporary storage of waste/ ash	Regional/ local long term	High	Moderate	High	Sealed bunkers, any discharge to foul sewer	Negligible	Mild	Near zero

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Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Proposed Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Significance of Impact
Increased flood risk due to change in surface water runoff regime	Regional/ local long term	Medium	Severe	High	Adoption of SuDS techniques	Low	Mild	Low
Contamination of controlled waters with fire fighting water	Regional/ local long term	Medium	Severe	High	Adoption of SuDS techniques and discharge controls	Negligible	Severe	Low
Heave of landfill liner caused by high groundwater levels	Local short term	Medium	Severe	High	Dewatering and emplacement of waste	Negligible	Severe	Low

RESIDUAL EFFECTS

- 9.126 Overall it is concluded that, with respect to impacts on groundwater and surface water, the proposed mitigation measures will ensure that there will be no significant residual impacts associated with the development.

CONCLUSIONS

- 9.127 The groundwater and surface water regimes at the application site have been assessed with reference to information held by the British Geological Survey, the Environment Agency, Local Authorities and others. This information has been supplemented with site specific investigation information.
- 9.128 The potential impacts of the proposed development upon hydrogeological and hydrological environment have been identified and assessed, and where appropriate, mitigation measures have been incorporated into the design of the development.